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

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Contents

i Executive summary

The ICES Working Group on Southern horse mackerel, anchovy and sardine (WGHANSA) assessed the status of anchovy in Atlantic Iberian waters (ane.27.9a; western and southern components) and horse mackerel in Atlantic Iberian waters (hom.27.9a) in the May meeting and of anchovy in Bay of Biscay (ane.27.8), sardine in southern Celtic Seas and the English Channel (pil.27.7), sardine in Bay of Biscay (pil.27.8abd) and sardine in Cantabrian Sea and Atlantic Iberian waters (pil.27.8c9a) in the November meeting. In addition, to answer a special request from Portugal and Spain, in May the working group updated the assessment of sardine in Atlantic Iberian waters (pil.27.8c9a) based on the most recent data available and included as catch scenarios, the harvest control rule evaluated in the Workshop for the evaluation of the Iberian sardine harvest control rules (WKSARHCR 2021). Deviations from the stock annex caused by missing surveys and deteriorated catch data due to the Covid-19 were described and sensitivity analyses of their impact were provided whenever possible.

The stock of **anchovy in Bay of Biscay** (ane.27.8) has been above B_{lim} since the re-opening of the fishery in 2010. SSB in 2021 has been estimated as the largest in the time-series. Recruitment (age 1 biomass at the beginning of the year) in 2022 is estimated slightly below the average of the time-series. Harvest rates (catch/SSB) show a decreasing trend in the last five years.

The stock of **anchovy in Atlantic Iberian waters** (ane.27.9a) is composed by the western component (distributed in areas 9.a North, Central–North, and Central–South) and the southern component (distributed in area 9.a South). The advice is provided for the two components separately for the management calendar from June to July next year. For the western component, the index ratio (1-over-2 rule) based on the PELACUS and PELAGO surveys showed a 117% increase of the stock in 2021 in comparison to the mean of the two previous years, and the 80% uncertainty cap was applied. For the southern component, the relative SSB from an analytical assessment conducted with GADGET was used as the index of stock size development. Stock size has been above B_{pa} for the last four years. The index ratio (1-over-2 rule) indicated that the relative SSB in 2021 was 37% lower than in the two previous years.

In the last years **sardine in the Bay of Biscay** (pil.27.8abd) shows a decreasing trend in SSB. Spawning-stock biomass is estimated below MSY $B_{trigger}$, B_{pa}, and B_{lim} in 2021. Since 2013 fishing mortality has been oscillating above F_{MSY} and F_{pa} and below F_{lim}. The lack of the PELGAS survey in 2020 due to Covid-19 pandemic and the results of the PELGAS survey in 2021 (decrease of mean weight-at-age, low maturity-at-age 1 and high proportion of age 1) have led to a change in the stock status with respect to past assessments. The reference point F_{pa} has been updated according to the new ICES definition of F_{pa} as F_{P05} (the F that leads to SSB ≥ B_{lim} with 95% probability).

Sardine in southern Celtic Seas and the English Channel (pil.27.7) was benchmarked in 2021 and the stock was upgraded from Category 5 to Category 3. Advice for this stock is based on the 1-over-2 rule with symmetric 80% cap and biomass safeguard. The PELTIC biomass index in the total area is used as the index of stock size development. The index ratio (1-over-2 rule) showed a 36% decrease of the stock in 2021 in comparison to the mean of the two previous years. No uncertainty cap and no further reduction based on the biomass safeguard were applied. For the first application of the rule, initial catch was taken as the average of catch in 2019 and 2020. Relative indicators from a SPiCT model based on quarterly landing data and a biomass index derived from the core area of the acoustic survey PELTIC, indicate that fishing pressure on the stock is below F_{MSY} and stock size is above MSY $B_{trigger}$.

The SSB of **horse mackerel in Atlantic Iberian waters** (hom.27.9a) fluctuated from 1992 (the beginning of the assessment) to 2013 and afterwards increased continuously to historical maximum values between 2019 and 2021. In 2021 SSB is estimated at 981 870 tonnes, well above MSY $B_{trigger}$, B_{pa}, and B_{lim}. Fishing mortality has been below F_{MSY} over the whole time-series, with a decreasing trend in the last years. Since 2018, recruitment is considered very uncertain due to the lack of the survey index in 2019 and 2020. ICES has redefined F_{pa} as F_{P05} (the F that leads to SSB ≥ B_{lim} with 95% probability) and this has led to an update of F_{pa} and F_{MSY}.

The biomass (age 1+) of **sardine in Atlantic Iberian waters** (pil.27.8c9a) in 2021 is estimated to be above MSY $B_{trigger}$, B_{pa}, and B_{lim} for the second consecutive year. Fishing mortality in 2020 is the second lowest of the time-series and has been below F_{MSY} since 2018. Biological reference points for this stock were revised by WKSARHCR 2021 using a management strategy evaluation framework. The stock was interbenchmarked in 2021 and now the stock assessment includes a recruitment index from the autumn acoustic surveys that allows to estimate the interim year recruitment within the assessment model. The catch options explored for 2022 include several harvest control rules that were assessed as precautionary using the management strategy evaluation strategy framework.

ii Expert group information

Expert group name	**Working Group on Southern Horse Mackerel Anchovy and Sardine (WGHANSA)**
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chair	Leire Ibaibarriaga, Spain
Meeting venues and dates	24–28 May 2021, Online meeting (14 participants)
	22–26 November 2021, Online meeting (17 participants)

1 Introduction

1.1 Terms of reference

The Working Group on Southern Horse Mackerel Anchovy and Sardine (WGHANSA), chaired by Leire Ibaibarriaga, Spain, will meet by correspondence on 24–28 May 2021 (WGHANSA1) and on 22–26 November 2021 (WGHANSA2) to:

a) Address generic ToRs for Regional and Species Working Groups for relevant stocks (hom.27.9a and ane.27.9a in WGHANSA1 and pil.27.7, pil.27.8abd ane.27.8 and pil.27.8c9a in WGHANSA2);
b) Address the special request from Portugal-Spain on a revised advice on fishing opportunities for 2021 for pil.27.8c9a in WGHANSA1. The revised advice will be derived using the results of an updated assessment with evaluations of the most recent data available. The headline advice will be based on MSY but a catch scenario based on the new HCR evaluated in WKSARHCR 2021 will be included if the HCR is shown to be precautionary.

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 2021 ICES data call.

WGHANSA1 will report by 5 June 2021 and WGHANSA2 will report by 2 December 2021 for the attention of ACOM.

The generic ToRs for Regional and Species Working Groups are the following:

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 on the following for the fisheries relevant to the working group:
   i) descriptions of ecosystem impacts on fisheries
   ii) descriptions of developments and recent changes to the fisheries
   iii) mixed fisheries considerations, and
   iv) emerging issues of relevance for management of the fisheries;
c) Conduct an assessment on the stock(s) to be addressed in 2021 using the method (assessment, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, providing summaries of the following where relevant:
   i) Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with COVID-19 pandemic disruption and the linked template that formulates how deviations from the stock annex are to be reported.
   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 2020.

iv) Estimate MSY reference points or proxies for the category 3 and 4 stocks

v) Evaluate spawning-stock biomass, total-stock biomass, fishing mortality, catches (projected landings and discards) using the method described in the stock annex;

1) for category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

2) b. If the assessment is deemed no longer suitable as basis for advice, consider whether it is possible and feasible to resolve the issue through an interbenchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

vi) The state of the stocks against relevant reference points;

Consistent with ACOM's 2020 decision, the basis for Fpa should be Fp.05.

1) 1. Where Fp.05 for the current set of reference points is reported in the relevant benchmark report, replace the value and basis of Fpa with the information relevant for Fp.05

2) 2. Where Fp.05 for the current set of reference points is not reported in the relevant benchmark report, compute the Fp.05 that is consistent with the current set of reference points and use as Fpa. A review/audit of the computations will be organized.

3) 3. Where Fp.05 for the current set of reference points is not reported and cannot be computed, retain the existing basis for Fpa.

vii) Catch scenarios for the year(s) beyond the terminal year of the data 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 associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time-series of recruitment, spawning-stock biomass, and fishing mortality rate. 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.

i. In the section 'Basis for the assessment' Table 3 under input data align the survey names with the ICES survey naming convention

e) Review progress on benchmark issues and processes of relevance to the Expert Group.
   i) update the benchmark issues lists for the individual stocks;
   ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2022 for conclusion in 2023;
   iii) determine the prioritization score for benchmarks proposed for 2022-2023;
   iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

f) Prepare the data calls for the next year's update assessment and for planned data evaluation workshops;

g) Identify research needs of relevance to the work of the Expert Group.

h) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

i) If not completed in 2020, complete the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate-change, could be considered in the advice.

1.1.1 The WG work in relation to the ToRs

WGHANSA1 addressed ToR a) for anchovy in Division 9.a (ane.27.9a) and horse mackerel in Division 9.a (hom.27.9a) and addressed ToR b) to answer the special request from Portugal and Spain regarding sardine in divisions 8c and 9a (pil.27.8c9a). WGHANSA2 addressed ToR a) for anchovy in Subarea 8 (ane.27.8), sardine in divisions 8a-b and 8d (pil.27.8abd), sardine in Subarea 7 (pil.27.7) and sardine in divisions 8c and 9a (pil.27.8c9a). 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. Any deviations from the stock annexes caused by missing information from Covid-19 disruption were described and analysed in detail. The assessments were audited during the meeting (Annex 4). Consistent with ACOMs 2020 decision, the basis for F_{pa} should be $F_{p.05}$. Accordingly, the WG updated the reference points for horse mackerel in 9.a, for sardine in 8.c and 9.a and for sardine in 8.a-b and 8.d. WGHANSA1 reported by 5 June 2021 and WGHANSA2 reported by 2 December 2021 for the attention of ACOM.

Stock	Stock code	Stock coordinator 1	Stock coordinator 2	Advice to be provided in 2021	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	Yes	1	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 2021–30 June 2022.
Horse mackerel (*Trachurus trachurus*) in Division 9.a (Atlantic Iberian waters)	hom.27.9a	Gersom Costas	Hugo Mendes	Yes	1	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 and to include the long-term management plan as catch scenario.
Anchovy (*Engraulis encrasicolus*) in Subarea 8 (Bay of Biscay)	ane.27.8	Leire Citores	Leire Ibaibarriaga	Yes	1	December	1	Management plan	Benchmarked in 2013.
Sardine (*Sardina pilchardus*) in Subarea 7 (Southern Celtic Seas, and the English Channel)	pil.27.7	Rosana Ourens	Erwan Duhamel	Yes	1	December	3	PA	Benchmarked in 2021. Stock upgraded from category 5 to category 3. Advice can now be provided annually.

Stock	Stock code	Stock coordinator 1	Stock coordinator 2	Advice to be provided in 2021	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	Yes	1	December	1	MSY	Interbenchmarked 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	Yes	1	December	1	MSY	Benchmarked in 2017 and Interbenchmarked in 2021; reference points changed in 2019 and 2021, in the context of the evaluation of a management and recovery plan. In 2021 ICES received a request from Portugal and Spain EU members to evaluate a harvest control rule that will be part of a management plan for 2021–2026. ICES found that the generic harvest control rule was precautionary with maximum allowed catches between 30 000 and 50 000 tonnes. For 2022, the EU Commission requested ICES to provide advice based on the MSY approach.
Jack mackerel (*Trachurus pictoratus*) in Subdivision 10.a.2 (Azores grounds)	jaa.27.10a2	Dália Reis		No	2	December	5	PA	

1.2 Report structure

Ad hoc and generic ToRs relative to the stocks for which assessment is required are dealt stock by stock in respective chapters of the report: anchovy in Subarea 8 (Section 3), anchovy in Division 9.a (Section 4), sardine in divisions 8.a-b and 8.d (Section 6), sardine in Subare 7 (Section 7), sardine in divisions 8.c and 9.a (Section 8) and horse mackerel in Division 9.a (Section 9). Each section includes a subsection to describe all the deviations from the stock annexes caused by missing information from Covid-19 disruption. The work conducted during WGHANSA1 to address the special request from Portugal-Spain on a revised advice on fishing opportunities for 2021 for sardine in divisions 8.c and 9.a is available in Annex 6.

The list of participants, the working documents presented, the stock annexes, the audits and a summary of the joint WGACEGG-WGHANSA session conducted on 24th May are provided as annexes.

1.3 Conduct of the meeting

WGHANSA1 took place by correspondence from 24 to 28 May 2021 and WGHANSA2 took place by correspondence from 22 to 26 November 2021.

1.3.1 List of participants

The full lists of participants to WGHANSA1 and WGHANSA2 are given in Annex 1. All the participants abided with the ICES code of conduct, and none had conflicts of interest that prevent them acting with scientific independence, integrity and impartiality.

1.3.2 Timing of the meeting

WGHANSA continues to have two meetings per year, in June, by correspondence, to address generic 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, but consider that the timing and duration of the meeting is adequate. This year due to the Covid-19 pandemic both meetings were conducted by correspondence.

This year, ICES was asked to address a special request from Portugal-Spain. This required ICES to evaluate a harvest control rule that will be part of a management plan for 2021–2026 in a dedicated workshop (WKSARHCR 2021) and to revise advice on fishing opportunities for 2021 for sardine in 8.c and 9.a based on an assessment carried out in the correspondence meeting in May (ToR b for WGHANSA). 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. In addition, WGHANSA members participated in two benchmark processes during 2021: the benchmark for sardine in Subarea 7 (ICES WKWEST 2021) and the interbenchmark for sardine in divisions 8.c and 9.a (ICES IBPIS 2021). This extra effort was put on top of the disturbance created by the Covid-19 pandemic situation.

1.3.3 Interactions with other expert groups

Although it has not been possible to agree with WGACEGG a format for partly joint annual meetings, the two groups continue improving interaction by creating dedicated time-slots during their own meetings. On the first day of WGHANSA1, there was a joint session between the two groups where the results of the PELAGO and PELACUS spring surveys and the sardine biological parameters from the DEPM surveys were presented and discussed (see Annex 5). Similarly, on the first day of WGACEGG, there was a joint session between the two groups where the results of the surveys were presented and discussed. In addition, the main decisions on the use of surveys for assessment purposes from the benchmark for sardine in Subarea 7 (ICES WKWEST 2021) and the interbenchmark for sardine in divisions 8.c and 9.a (ICES IBPIS 2021) were presented to WGACEGG. Beyond improving communication and promoting joint discussions, these joint sessions allowed to have the acceptance of WGACEGG on the survey results before their inclusion in the stock assessment.

During WGHANSA1, the work conducted by other two expert groups was presented and discussed. On the one hand, the main results of the Workshop for the evaluation of the Iberian sardine HCR (WKSARHCR) carried out in April 2021 were summarised. Given that the generic harvest control rule with maximum allowed catches between 30 000 and 50 000 tonnes was assessed as precautionary, these options were included in the catch scenarios. On the other hand, the work carried out in the Workshop on Atlantic chub mackerel (*Scomber colias*) (WKCOLIAS and WKCOLIAS2) in 2020 and 2021 was presented. The WG considered the recent developments towards collating and analysing data on chub mackerel very promising and welcomes any future interaction with this expert group.

During WGHANSA1 and WGHANSA2, the new methodologies developed during the benchmark for sardine in Subarea 7 (ICES WKWEST 2021) and the interbenchmark for sardine in divisions 8.c and 9.a (ICES IBPIS 2021) were presented.

Inter-seasonally, WGHANSA replied to a questionnaire sent by the ICES Working Group on biological parameters (WGBIOP).

1.4 Quality of the fisheries data

The differences between the WG estimates and official data in 2020 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 sampling activities

The 2020 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	7367	48%	54	4214	2542
Portugal	5484	100%	12	377	245
Total	12 852	70%	66	4591	2787

Horse Mackerel 9a

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	14626	100%	510	2770	336
Spain	15539	11%	13	668	570
Total	30166	54%	523	3438	906

Sardine 8c9a

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	15416	100%	84	6113	676
Spain	6727	23%	48	4971	2468
Total	22143	77%	132	11084	3144

Anchovy 8

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Spain	25685	19%	215	32000	1091
France	138	0	0	0	0
Total	25823	19%	215	32000	1091

Sardine 8abd

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
France	24596	100%	96	6627	1927
Spain	6772	100%	333	43913	896
Total	31368	100%	429	50540	2823

1.6 Benchmarks and interbenchmarks

In 2021, sardine in Subarea 7 has been benchmarked and has been upgraded from Category 5 to Category 3. In addition, an interbenchmark for sardine in 8.c and 9.a was carried out in October with the aim of including the autumn juvenile acoustic survey results into the stock assessment. Both updated stock annexes were applied for the first time during WGHANSA2 in November 2021.

The WG updated the benchmark issues lists for the individual stocks, reviewed the progress conducted and identified potential benchmarks to be initiated in 2022 or 2023 (Table 1.6.1). The

WG proposed to initiate a benchmark in 2022 for anchovy in Subarea 8 and to conduct an inter-benchmark in 2022 for horse-mackerel in division 9.a with the aim of investigating changes in the selectivity of the fishery in the assessment model. For both stocks the scoring sheet was completed for consideration of the Benchmark Oversight Group (BOG).

Table 1.6.1 History of benchmarks and proposals by WGHANSA.

Stock	Stock code	History of Benchmarks	WGHANSA 2021 Proposal 2022-2023
Anchovy (*Engraulis encrasicolus*) in Division 9.a (Atlantic Iberian waters)	ane.27.9a	Full Benchmark 2018	Benchmark to be proposed for 2023-2024
Horse mackerel (*Trachurus trachurus*) in Division 9.a (Atlantic Iberian waters)	hom.27.9a	Full benchmark 2011 Full benchmark 2017	Interbenchmark proposed for 2022
Anchovy (*Engraulis encrasicolus*) in Subarea 8 (Bay of Biscay)	ane.27.8	Full benchmark 2013	Benchmark proposed for 2022-2023
Sardine (*Sardina pilchardus*) in Subarea 7 (Southern Celtic Seas, and the English Channel)	pil.27.7	Full benchmark 2013 Full benchmark 2017 Full benchmark 2021	-
Sardine (*Sardina pilchardus*) in divisions 8.a–b and 8.d (Bay of Biscay)	pil.27.8abd	Full benchmark 2013 Full benchmark 2017 Interbenchmark 2019	Benchmark to be proposed for 2023-2024
Sardine (*Sardina pilchardus*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	pil.27.8c9a	Full benchmark 2013 Full benchmark 2017 Reference points updated in 2021 Interbenchmark 2021	-
Jack mackerel (*Trachurus pictoratus*) in Subdivision 10.a.2 (Azores grounds)	jaa.27.10a2	-	-

1.7 Mohn's rho

Mohn's rho values for Category 1 and 2 stocks have been uploaded at https://community.ices.dk/ExpertGroups/Lists/Retrobias2021/AllItems.aspx and they are summarised in Table 1.7.1. Further details and corresponding plots are provided in the respective chapters of the report.

Table 1.7.1. Mohn's rho values calculated by WGHANSA for Category 1 and 2 stocks.

Stock	Stock code	Terminal year of catch data	Number of retrospective assessments used	F_{bar} who value	SSB rho: was the intermediate year used as the terminal year?	SSB rho value	R rho: was the intermediate year used as the terminal year?	R rho value
Horse mackerel (*Trachurus trachurus*) in Division 9.a (Atlantic Iberian waters)	hom.27.9a	2020	5	0.211	No	0.002	No	-0.215
Sardine (*Sardina pilchardus*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)[1]	pil.27.8c9a	2020	5	0.166	Yes	-0.188	No	-0.34
Sardine (*Sardina pilchardus*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters) [2]	pil.27.8c9a	2020	5	0.345	Yes	-0.255	Yes	-0.144
Sardine (*Sardina pilchardus*) in divisions 8.a–b and 8.d (Bay of Biscay)	pil.27.8abd	2020	5	-0.232	No	0.42	No	0.512
Anchovy (*Engraulis encrasicolus*) in Subarea 8 (Bay of Biscay)	ane.27.8	2021	5	-0.12	Yes	0.14	Yes	-0.28[3]

[1] Stock assessment conducted during WGHANSA1 to answer a special request.

[2] Stock assessment conducted during WGHANSA2 after the Interbenchmark process to include a recruitment index (IBPIS, 2021).

[3] Corresponds to the harvest rate Mohn's rho.

1.8 Transparent assessment framework (TAF)

The Transparent Assessment Framework (TAF) is an online open resource of ICES stock assessments for each assessment year. All data input and output are fully traceable and versioned using a sequence of R scripts. This enables anyone to easily find, reference, download, and run the assessment.

None of the stocks assessed by WGHANSA have been fully implemented in TAF. In 2021, some progress towards implementing the assessment into TAF has been done for some of the stocks, but the work is not finished yet. In addition, some initial work to automatically generate the working document on the assessment of the western component of anchovy in 9.a from the stock assessment results have been uploaded into TAF. During WGHANSA2, after a presentation from ICES on TAF, the group discussed the next steps to implement all stock assessments into TAF. The WG identified that some technical support might be needed to implement the AMISH model used for horse mackerel in division 9.a and the GADGET model used for the southern component of anchovy in division 9.a. In addition, the WG noticed that different repositories might be needed for each of the stock components of anchovy in 9.a (southern and western components). Some members showed interest on the trainings planned for 2022. Further efforts towards implementing the assessment of all stocks into TAF were planned for 2022.

1.9 Ecosystem overviews

The audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' has been completed for all the stocks.

No additional progress has been made on this ToR.

1.10 Fisheries overviews

No additional progress has been made on this ToR.

1.11 Research needs

Beyond the specific issues identified for each stock, the WG identified the following topics of general interest for future research:

- For the stocks assessed using Stock Synthesis, explore the possibility of conducting the short-term forecast within Stock Synthesis.
- Evaluate of possibility of conducting stochastic short-term forecasts. This would allow to estimate the probability of SSB or F being below/above PA and MSY reference points.
- Continue exploring methods to provide management advice for short-lived stocks in Category 3. In particular, explore alternative methods for the initial catch for the first year of the 1-over-2 and test them within a management strategy evaluation (MSE) framework.
- For stocks for which a management strategy evaluation framework is available, further investigate potential discrepancies between ICES MSY advice rule and alternative precautionary harvest control rules. Approaches to better communicate these alternative options to managers and stakeholders are needed.

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 Southwestern 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 2021 the Council established the TAC in 2021 for the Bay of Biscay anchovy stock at 33 000 tonnes (Council Regulation No 92/2021), 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 2021 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. These exemptions have been extended until 2023 through various regulations (Commission Delegated Regulation 2018/188, Commission Delegated Regulation 2020/2015, Commission Delegated Regulation 2020/2015).

3.2 The fishery in 2021 and 2022

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 (operating mainly during the second half of the year but with decreasing catches along years).

Since the reopening of the fishery in 2010 the number of fishing licences for anchovy in Spain 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 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 the last years a shift has occurred on the French anchovy fishery. Pair pelagic trawlers mainly targeted tuna between July and October, and single pelagic trawlers didn't catch anchovy. In 2020, there were very low catches by the French fisheries. Only 138 tons were caught by the French fleet in 2020, 90% by purse-seiners and 10% by pelagic trawlers. According to the very low price (anchovies were too small for the market), vessels have reported their fishing effort on other species, particularly tuna and sardine.

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 2020 were 25 823 tonnes, from which 25 685 corresponded to Spain and 138 to France. In 2020, the French landings of anchovy drastically decreased because vessels found only small or medium-size individuals, and the price was very low, so vessels stopped targeting anchovy. From the Spanish catches, 24 tonnes corresponded to anchovy used as live bait for tuna fishing. Discards are less than 1% 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 2020, 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 2020 are given in **Table 3.2.2.3**. Most of the catches took place in the second quarter (56.6%), followed by the third quarter (39.8%) and with lower catches in first and fourth quarters (1% and 2.5% respectively). The major fishing activity of the Spanish fleet occurred in the second quarter (56.9%) followed by the third quarter (39.6%), whereas the French fleet operated mainly in the third quarter (90.6%). Regarding fishing areas, most of the Spanish catches in the first semester corresponded to ICES division 8.c East, whereas in the second semester catches occurred in division 8.c East and West. 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 2020 only 98 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

Sampling of the Spanish catches is carried out jointly by IEO and AZTI. While sampling coordinated by AZTI was carried out as usual in 2020, sampling programmes coordinated by IEO (Spain) were suspended in most 2020 due to administrative problems and to the Covid-19 disruption. The percentage of Spanish catches corresponding to the IEO in 2020 were 91%. Numbers-at-age for these catches were derived from the sales notes by commercial size category. Biological samples from commercial catch collected by AZTI and from various research surveys were used to convert the commercial sizes into ages and to estimate the weight-at-age. This methodology has been used previously by the working group to obtain preliminary catch-at-age estimates for the first semester of the assessment year and it is considered reliable.

In 2020 there were no length and age samples available from the French fishery due to the low level of catches. Catch numbers-at-age of the French catches were estimated assuming that the percentage of numbers-at-age per quarter were equal to the percentage of numbers-at-age of the Spanish catches in divisions 8.a and 8.b, where the French fishery occurs.

Catch numbers-at-age by quarter in 2020 for Spain and France are given in **Table 3.2.3.1**. Age 1 individuals were predominant in all the quarters. Age 0 individuals appeared in third and fourth quarters, representing the 9.3% and 12% of the total of each quarter respectively.

Table 3.2.3.2 records the age composition of the international catches since 1987, on a half-yearly basis. In 2020, the one-year-old anchovies dominated in the catches in both semesters, representing the 66% in the first semester and the 82% in the second semester.

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 2020, is shown in **Table 3.2.4.1**. See the stock annex for methodological issues.

3.2.5 Preliminary fishery data in 2021

The provisional catches during the first semester of 2021 were 23 580 t, from which 23 576 t corresponded to Spain and 4 t to France. 46% of the catches (in mass) during the first semester were age 1. During the second semester provisional catches until the end of October were 4367 t, from which 4307 t corresponded to Spain and 60 t to France. Overall, the total catches in 2021 from France were very low (64 t).

It must be emphasised that 2021 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, 2021 November and December catches were assumed to be 0 t for Spain (the fishery was closed in mid-August due to quota exhaustion) and 4 t for France (6.3% of the total annual French catch which is the average percentage of the French catches in November and December in 2010–2020, after the re-opening of the fishery). Therefore, the total catch in November and December was estimated at 4 t, resulting in 4371 tonnes for the second semester 2021.

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	0			141
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	138	25,661	24			25,823
2021 (Up to end of Octo	64	27,883				27,947
AVERAGE (1960-2004)	6,394	26,337				32,824
AVERAGE (2010-2020)	3,238	17,777				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
2020	19	20	220	4090	9896	626	2670	3878	3729	224	405	24	25800

Table 3.2.2.3. Bay of Biscay anchovy: Catches in the Bay of Biscay by country and divisions in 2020 (without live bait catches).

		QUARTERS				CATCH (t)	
COUNTRIES	DIVISIONS	1	2	3	4	ANNUAL	%
SPAIN	8abd	93	575	49	234	951	3.7%
	8cE	164	14005	4940	416	19525	76.1%
	8cW	1	21	5162	1	5185	20.2%
	TOTAL	258	14601	10151	651	25661	100.0%
	%	1.0%	56.9%	39.6%	2.5%	100.0%	
FRANCE	8abd	0	11	125	2	138	100.0%
	8cE	0	0	0	0	0	0.0%
	8cW	0	0	0	0	0	0.0%
	TOTAL	0	11	125	2	138	100.0%
	%	0.0%	8.1%	90.6%	1.4%	100.0%	
INTERNATIONAL	8abd	93	587	174	236	1090	4.2%
	8cE	164	14005	4940	416	19525	75.7%
	8cW	1	21	5162	1	5185	20.1%
	TOTAL	258	14612	10276	653	25800	100.0%
	%	1.0%	56.6%	39.8%	2.5%	100.0%	

Table 3.2.3.1. Bay of Biscay anchovy: catch-at-age in thousands for 2020 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	58 312	4 202	62 514
	1	9 319	518 309	516 966	27 790	1 072 383
	2	4 884	230 752	47 938	3 680	287 255
	3	819	29 740	1 473	129	32 160
	4	0	171	3	0	174
	5	0	0	0	0	0
	TOTAL(n)	15 021	778 972	624 692	35 800	1 454 486
	W MED.	17.17	18.51	16.44	18.24	17.61
	CATCH. (t)	258	14612	10276	653	25800
	SOP	258	14423	10271	653	25605
	VAR. %	100.00%	98.70%	99.95%	99.99%	99.24%

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		2020	
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
0	0	37 068	0	443	0	74 571	0	23 725	0	1 770	0	373	0	62 514
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	527 627	544 756
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	235 637	51 618
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	30 559	1 601
4	4 271	0	173	0	231	0	2 339	0	292	0	440	0	171	3
5	0	0	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	793 994	660 492

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		2020	
Sources:	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
Age 0	na	16.1	0.0	9.4	na	14.3	na	8.5	na	12.5	na	11.9	na	9.3
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	16.5	16.8
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	21.6	21.9
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	28.4	28.7
4	26.0	na	25.5	na	32.6	na	29.9	na	27.8	na	27.7	na	29.3	29.4
5	na	na	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	18.5	16.5

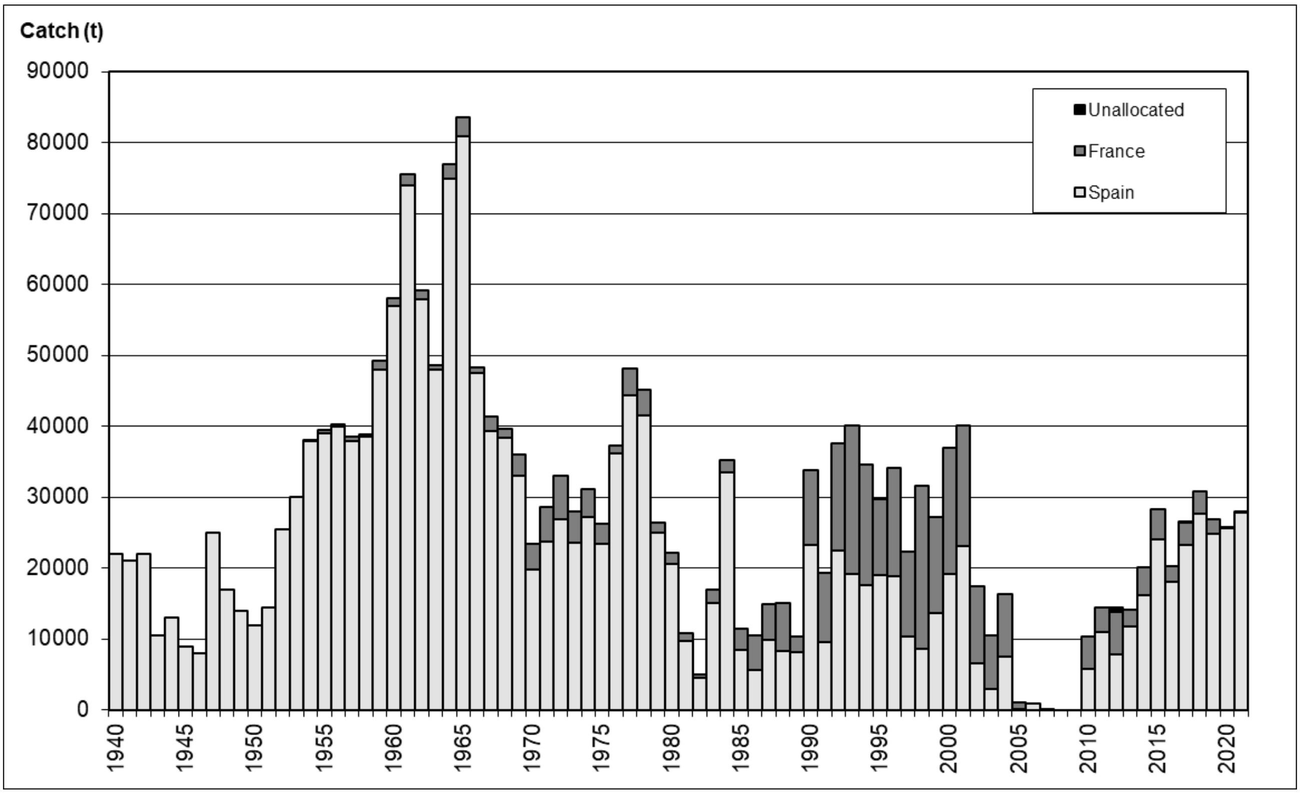


Figure 3.2.2.1. Bay of Biscay anchovy: Historical evolution of catches in Division 8 by countries. 2021 data are preliminary.

3.3 Fishery independent data

3.3.1 BIOMAN DEPM survey 2021

All the methodology for the survey and the estimates performance are described in detail in the stock annex - Bay of Biscay Anchovy (Subarea 8). A detailed report of the survey and results 2021 is presented as a working document to ICES WGACEGG 2021 (Santos Mokoroa. M *et al*. BIOMAN 2021).

3.3.1.1 Survey description

The 2021 anchovy DEPM survey was carried out in the Bay of Biscay from 30th of April to the 24th of May, covering the whole spawning area of the species, following the procedures described in the stock annex. Two research vessels were used at the same time and place: the R/V Vizconde de Eza to collect the plankton samples and the pelagic trawler R/V 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 740. From those, 591 had anchovy eggs (80%) with an average of 360 eggs m^{-2} per station in the positive stations, and a maximum of 3510 eggs m^{-2} in a station. A total of 26 587 anchovy eggs were encountered and classified in the PairoVET stations. The number of CUFES samples (horizontal sampling) obtained was 1709. Frome those 1320 (77%) stations had anchovy eggs with an average of 24 eggs m^{-3} per station and a maximum of 445 eggs m^{-3} in a station.

This year 25% of the anchovy eggs were found in the Cantabrian Coast, that was covered until 6º20’W. There were eggs all over the French platform up to Garonne river. From there, there were eggs passed the 200 m depth isoline and from the coast to the 100 m depth isoline. There were very few eggs from the 100m to 200m isoline. (**Figure 3.3.1.1.1**). The total area covered was 111 715Km^2 and the spawning area for anchovy was 86 831Km^2, 78% of the total.

In relation with the adult samples, 50 pelagic trawls were performed, from which 42 provided anchovy and all were selected for the analysis. This year two additional anchovy adult samples were obtained from the Basque purse-seines. In total, there were 44 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 as well as in the French platform between Arcachon and the Gironde, whereas the smallest anchovy were found all along the French coast. Spatial distribution of mean length and mean weight for anchovy is shown in **Figure 3.3.1.1.3**. The most abundant species in the trawls were: anchovy, sardine, mackerel and horse mackerel. Anchovy adults were found in the same places where the anchovy eggs were found.

This year the mean sea surface temperature of the survey was 14.0ºC, which was lower than last year (15.8ºC), the minimum was 12.6ºC and the maximum 15.6ºC. The mean sea surface salinity (35.4) was higher than last year (34.6) with a minimum of 33.7 and a maximum of 36.0. **Figure 3.3.1.1.4** shows the maps of sea surface salinity and temperature found during the survey. The weather conditions during the survey were good the first 10 days, but once past the Gironde in the following 14 days there were several storms.

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 2021 was estimated at 1.30 E+13 with a CV of 0.0766, lower than last year and the second highest of the historical series since 1987. **Figure 3.3.1.2.2** shows the historical series of P_0, z, spawning area 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 these parameters. This year there were no problems in estimating these parameters. The results for 2021 are showed in **Table 3.3.1.3.1** and the historical series are shown in **Figure 3.3.1.3.1**. The final **total biomasss** obtained as the quotient between Ptot and DF was **199,490t with a CV of 0.1040.**

3.3.1.4 Population at age

In order to estimate the numbers-at-age, the age readings based on 2312 otoliths from 44 samples, well distributed over the spawning area, were available. Six strata were defined based on the egg abundance, the adult distribution and the mean size, mean weight and age of adult anchovy: Cantabric (Ca), South (S), East(E), Central East (CE), Central West (CW) and West(W) (**Figure 3.3.1.4.1**). 77% of the anchovy in numbers were estimate as individuals of age 1 (66% in mass), 22% of the individuals in numbers were of age 2 (32% in mass) and 1% of the individuals in numbers were of age 3+ (2% in mass) (**Table 3.3.1.4.1**). This was a high recruitment year. The anchovy age composition by haul 2021 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+ are shown in **Figure 3.3.1.4.4** and **Table 3.3.1.4.1.**

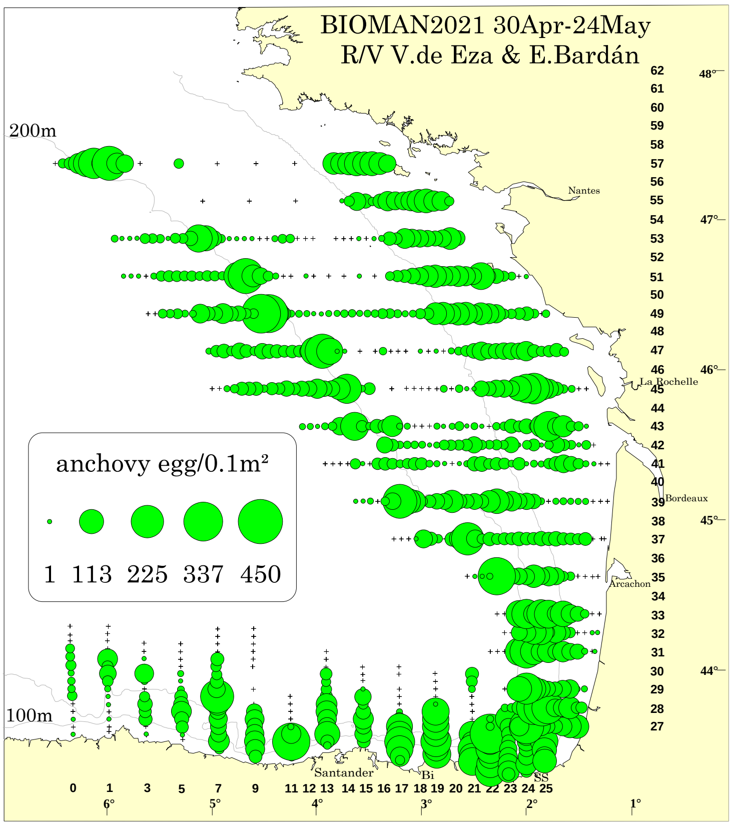


Figure 3.3.1.1.1. Bay of Biscay anchovy: Spatial distribution of anchovy egg abundance (eggs per 0.1 m2) from the DEPM survey BIOMAN2021 obtained with PairoVET (vertical sampling net).

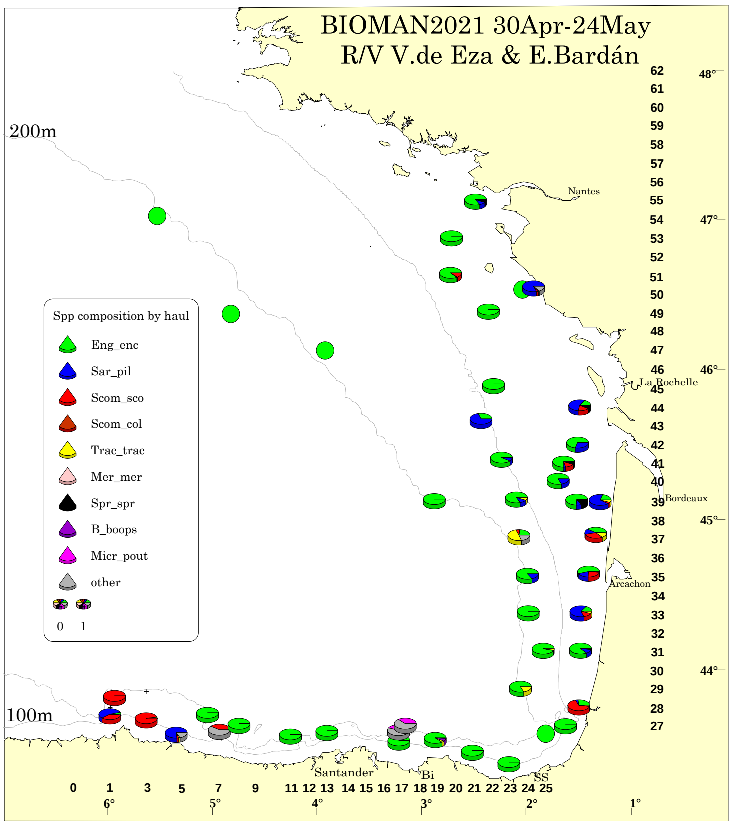


Figure 3.3.1.1.2. Bay of Biscay anchovy: Species composition of the 44 pelagic trawls and 2 hauls from the purse-seines during BIOMAN2021.

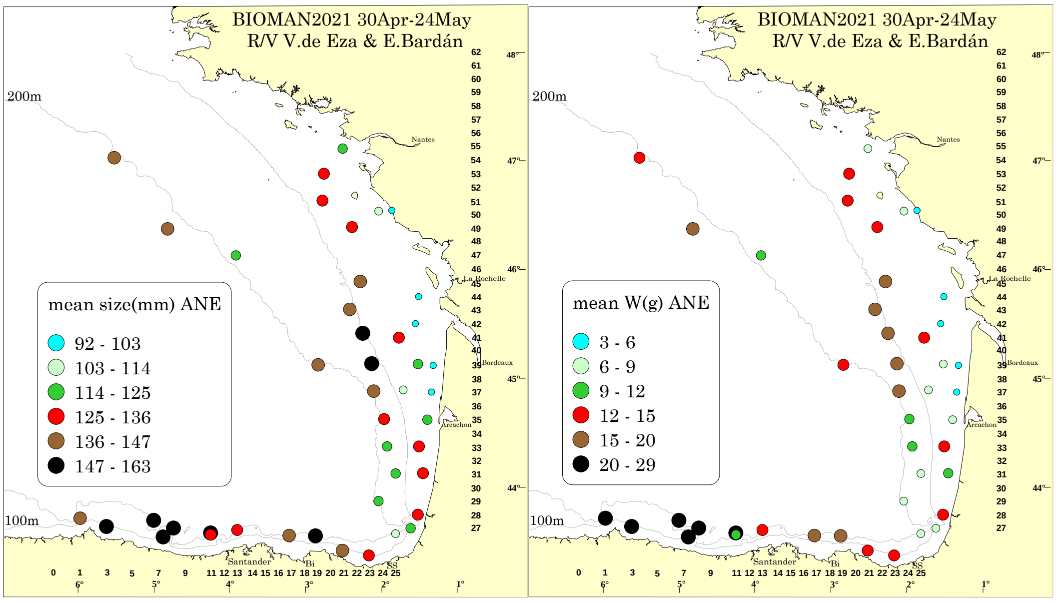


Figure 3.3.1.1.3: Bay of Biscay anchovy. Spatial distribution of anchovy mean length (left) and mean weight (right) (males and females) during BIOMAN2021.

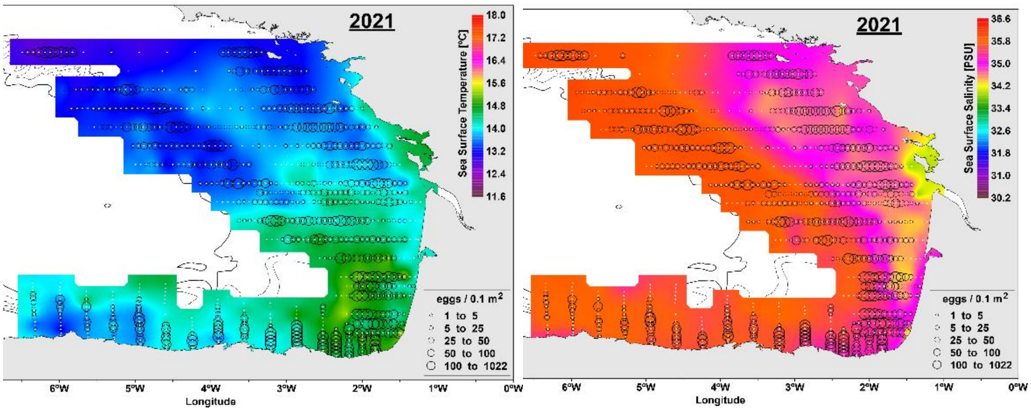


Figure 3.3.1.1.4: Bay of Biscay anchovy: From left to right spatial distribution of sea surface temperature and sea surface salinity during BIOMAN 2021. The circles represent the spatial distribution of the anchovy egg abundance.

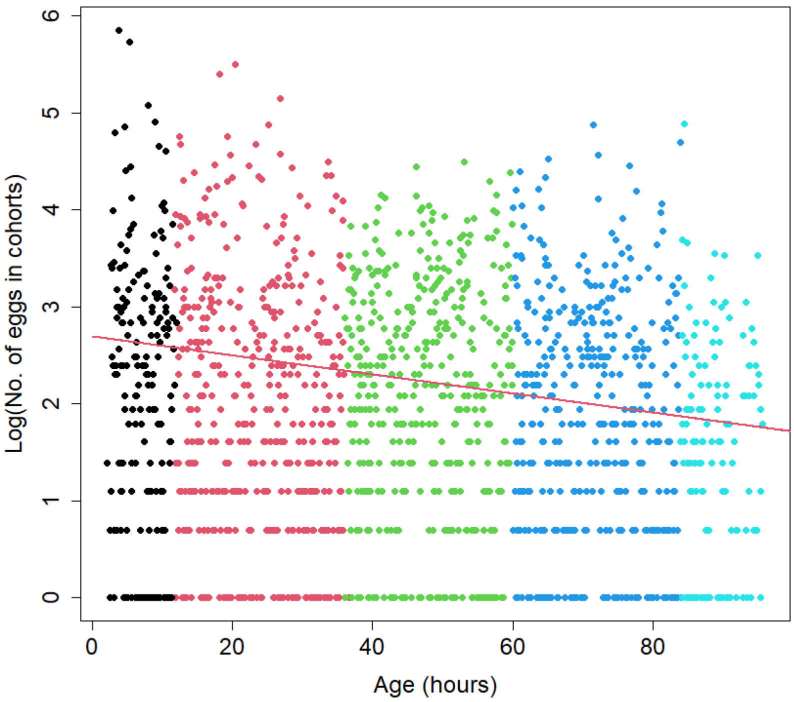


Figure 3.3.1.2.1: Bay of Biscay anchovy: Exponential mortality model in log scale adjusted applying a GLM to the data obtained in the Bayesian egg ageing (spawning peak at 23:00h GMT). The red line is the adjusted line. The coloured dots represent the different daily cohorts.

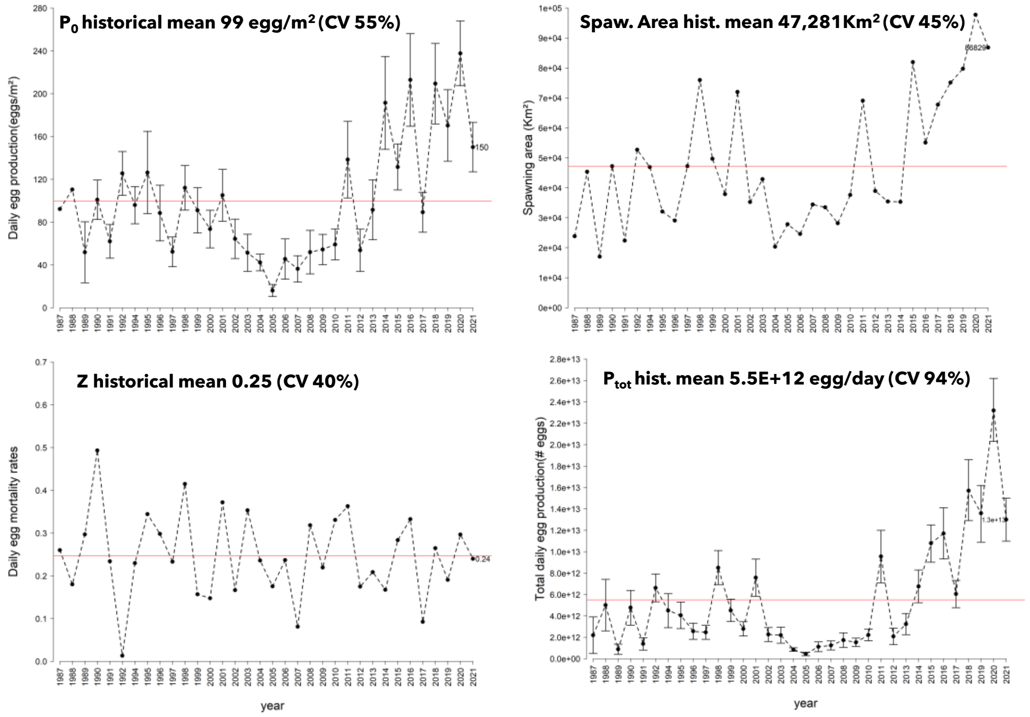


Figure 3.3.1.2.2: Bay of Biscay anchovy: historical series including 2021 estimates for daily egg production (P0) (egg/m2/day), spawning area (Km2), daily mortality rates (z) and total daily egg production (Ptot)(eggs/day) for anchovy in the Bay of Biscay (ICES 8abcd). The red line is the historical mean, the value showed in bold is the historical mean and CV is de coefficient of variation over time for each parameter.

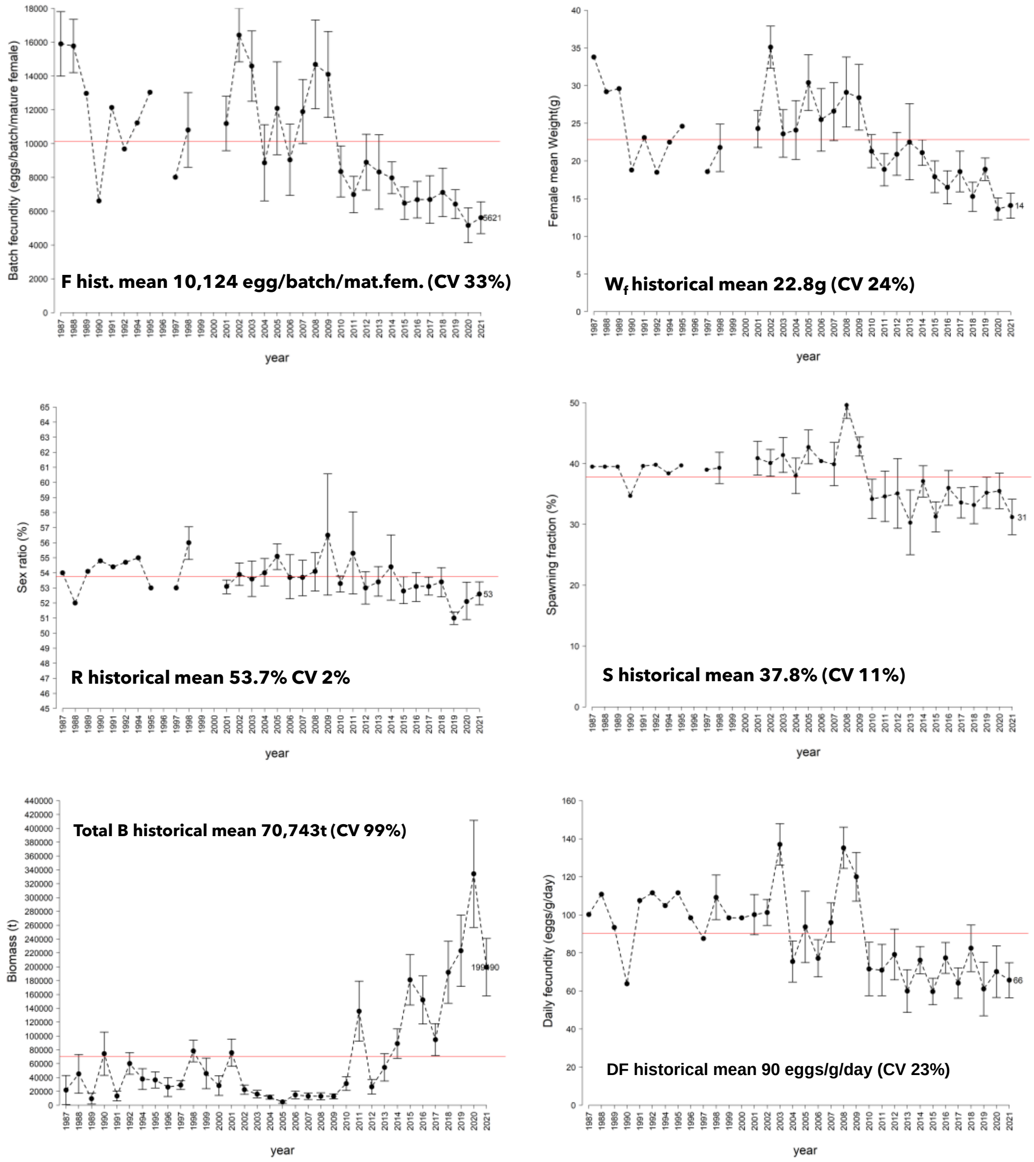


Figure 3.3.1.3.1: Bay of Biscay anchovy: historical series including 2021 estimates of the adult parameters for anchovy in the Bay of Biscay (ICES 8abcd): batch fecundity (F) (eggs/batch/mature female), female mean weight(g), sex ratio (R) (% of females), spawning fraction (S) (% of females spawning per day), daily fecundity (DF) (eggs/g/day) for the application of the DEPM and the total biomass (B)(tons). The red line is the historical mean, the value showed in bold is the historical mean and CV is de coefficient of variation over time for each parameter.

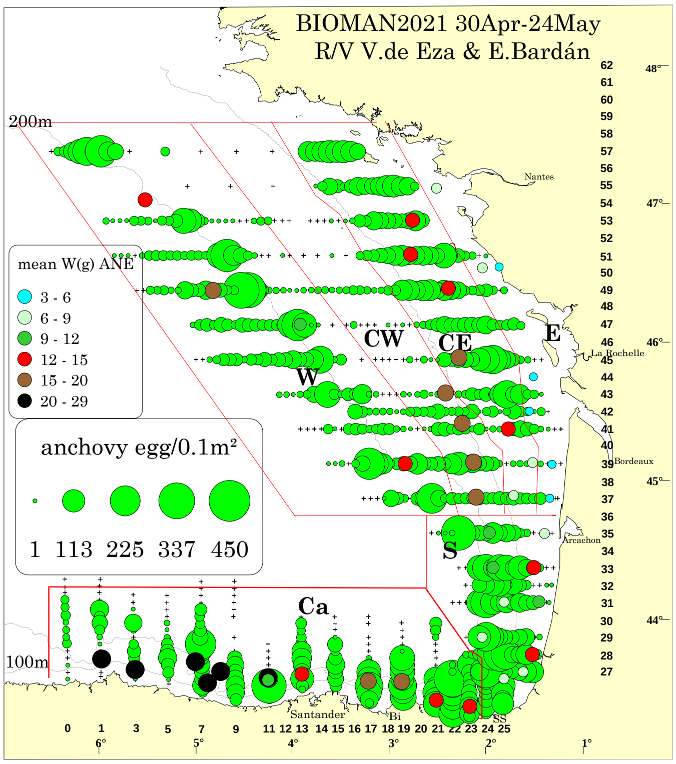


Figure 3.3.1.4.1: Bay of Biscay anchovy: 6 regions were defined to weight the adult samples to estimate anchovy numbers-at-age in 2021: Cantabric (Ca), South (S), East(E), Central East (CE), Central West (CW) and West(W). The red lines represent the border of the regions, the green bubbles the abundance of anchovy eggs (egg/0.1m²) in each station and the small colour bubbles represent the mean weight (g) of individuals within each haul.

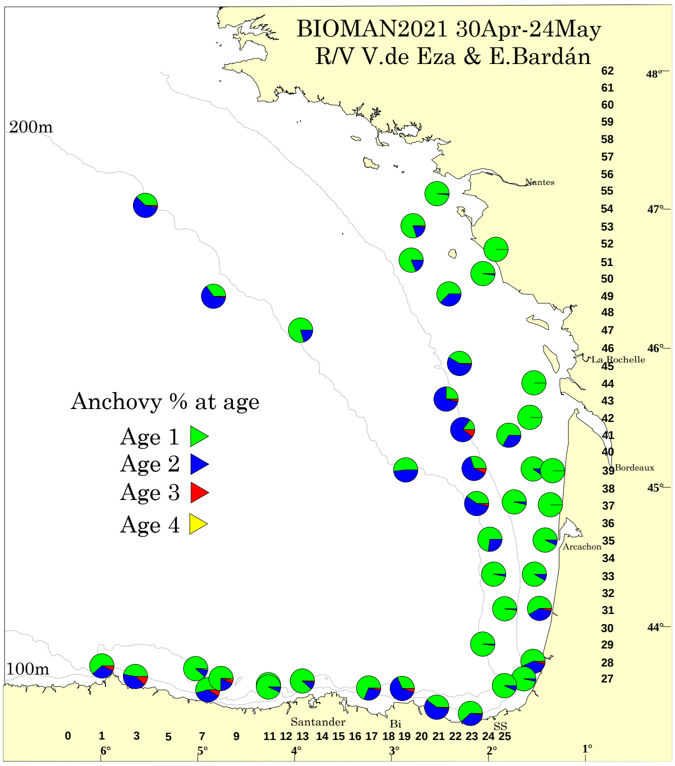


Figure 3.3.1.4.2: Bay of Biscay anchovy: Anchovy age composition by haul in BIOMAN2021.

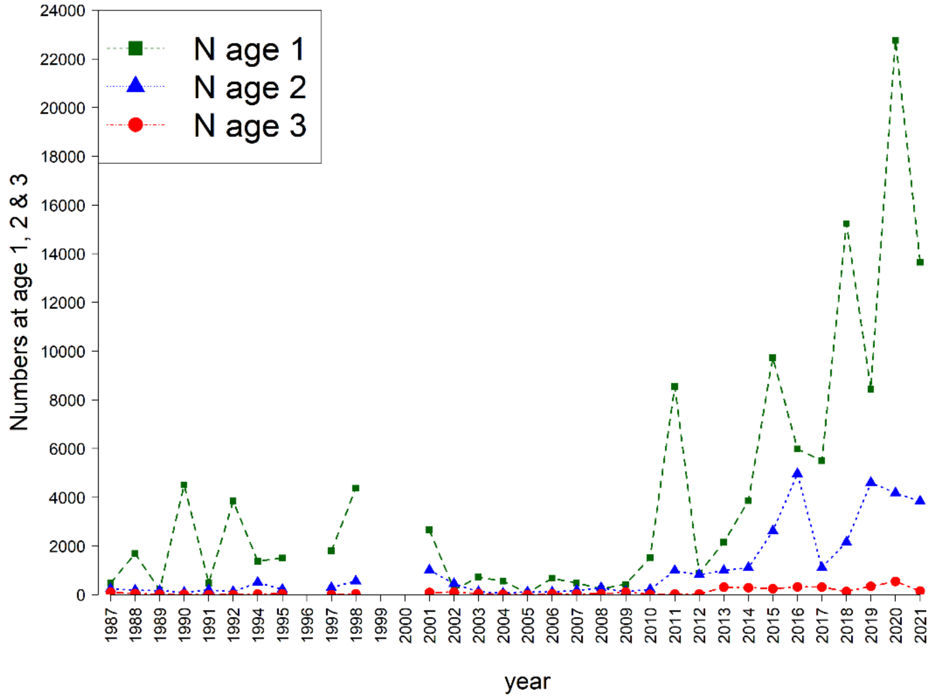


Figure 3.3.1.4.3: Bay of Biscay anchovy: Anchovy historical series of numbers-at-age from 1987 to 2021 from BIOMAN surveys.

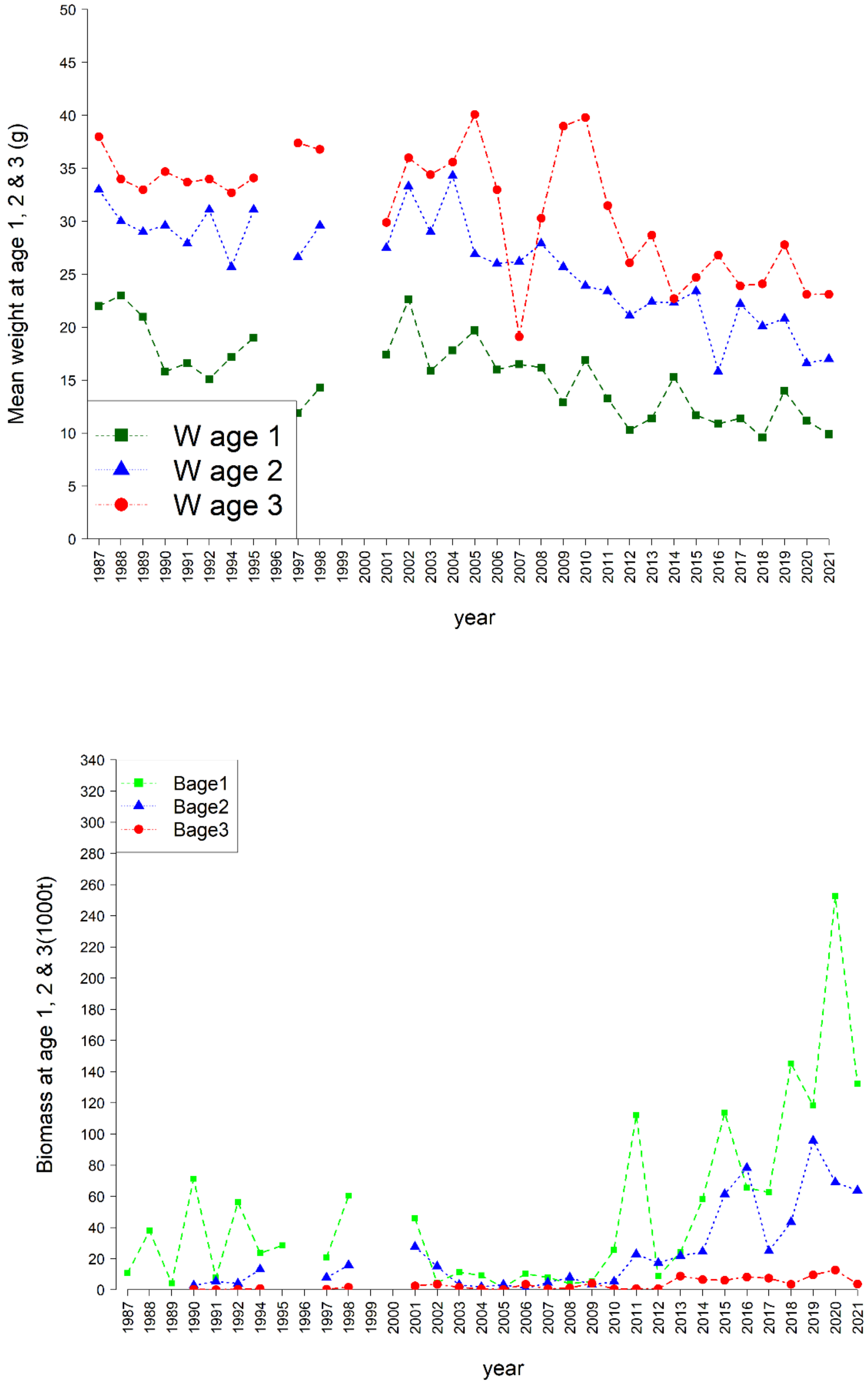


Figure 3.3.1.4.4: Bay of Biscay anchovy: Anchovy historical series (1987-2021) of mean weight at age (top) and total biomass at age (bottom).

Table 3.3.1.1.1. Bay of Biscay anchovy: Details of the DEPM survey BIOMAN 2021.

Parameters	Anchovy DEPM survey
Surveyed area	(43º19' to 47º23'N & 6º 29' to 1º14' W)
R/V	*Vizcon de de Eza & Emma Bardán*
Date	30/04 -24/05/2021
Eggs	R/V VIZCONDE DE EZA
Total egg stations	740
% st with anchovy eggs	80%
Anchovy egg average by st	360 eggs/m^2
Max. anchovy eggs in a St	3,510 eggs/m^2
Total ANE egg collected&staged	26,587 eggs
North spawning limit	47º'23'N
West spawning limit	6º29'W
Total area surveyed	111,715 Km^2
Spawning area	86,831 Km^2
CUFES stations	1,709
Adults	R/V EMMA BARDAN& Purse-seines
Pelagic trawls	50
With anchovy	42
Selected for analysis	42
Hauls from purse-seines	2
Total adult samples for analysis	44

Table 3.3.1.2.1. Bay of Biscay anchovy: 2021 estimates for daily egg production (P0) (egg/m2/day), daily mortality rates (Z) and total daily egg production (Ptot)(eggs/day) with its Standard error (S.e) and Coefficient of variation (CV).

Parameter	Value	S.e.	CV
P_0	150.11	11.50	0.0766
z	0.24	0.034	0.1419
Ptot	1.30E+13	1.0E+12	0.0766

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): sex ratio (R) (% of females), spawning fraction (S) (% of females spawning per day), batch fecundity (F) (eggs/batch/mature female), female mean weight (Wf)(g) and daily fecundity (DF) (eggs/g/day) for the application of the DEPM and total biomass (B)(tons) with their standard error (S.e.) and coefficient of variation (CV). Total egg production (P_{tot})(eggs/day) estimate is shown as well.

Parameter	estimate	S.e.	CV
P_{tot} (eggs)	1.30E+13	1.0E+12	0.0766
R'(% of females)	0.53	0.0038	0.0072
S (% fem. spawning/day)	0.31	0.0145	0.0465
F (eggs/batch/mature fem.)	5,621	470	0.0835
W_f(g)	14.08	0.84	0.0594
DF (eggs/g/day)	65.68	4.62	0.0703
B (tons)	**199,490**	20,741	0.1040

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 corresponding standard error (S.e.) and coefficient of variation (CV) from BIOMAN 2021. Biological features such as mean weight at age(g) and mean length-at-age(mm) are also given.

Parameter	estimate	S.e.	CV
BIOMASS (tons)	**199,490**	20,741	0.1040
total mean Weight (g)	11.4	0.75	0.0657
Population (millions)	17,639	2614	0.1482
Percentage at age 1	**0.77**	0.039	0.0507
Percentage at age 2	**0.22**	0.038	0.1707
Percentage at age 3+	**0.01**	0.002	0.2358
Numbers-at-age 1	13,646	2,562.7	0.1878
Numbers-at-age 2	3,839	472.3	0.1230
Numbers-at-age 3+	154	32.2	0.2095
Percent. at age 1 in mass	**0.66**	0.042	0.0642
Percent. at age 2 in mass	**0.32**	0.041	0.1278
Percent. at age 3+ in mass	**0.02**	0.004	0.2153
Biomass at age 1 (tons)	132,182	19,108	0.1446
Biomass at age 2 (tons)	63,679	7,855	0.1234
Biomass at age 3+ (tons)	3,629	817	0.2253

Biological Features	estimate	S.e.	CV
Weight at age 1 (g)	9.87	0.66	0.0672
Weight at age 2 (g)	17.05	0.64	0.0374
Weight at age 3 (g)	23.10	1.75	0.0758
Length-at-age 1 (mm)	119.1	2.41	0.0202
Length-at-age 2 (mm)	142.1	1.36	0.0096
Length-at-age 3 (mm)	153.2	4.01	0.0262

3.3.2. PELGAS spring acoustic survey 2021

All the methodology for the survey is described in detail in the stock annex - Bay of Biscay Anchovy (Subarea 8). A detailed report of the survey and results in 2021 is presented as a working document to ICES WGACEGG 2021.

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

A consort survey is routinely organised since 2007 with French commercial vessels during 18 days. This approach is identical with previous year's surveys, using the commercial vessel's hauls for echoes identification and biological parameters to complement hauls made by the R/V Thalassa. Four commercial vessels (two pairs of pelagic trawlers) participated to PELGAS21 survey. A total of 99 hauls (including not valid) were carried out during the consort survey including 53 hauls by the R/V Thalassa and 46 hauls by commercial vessels.

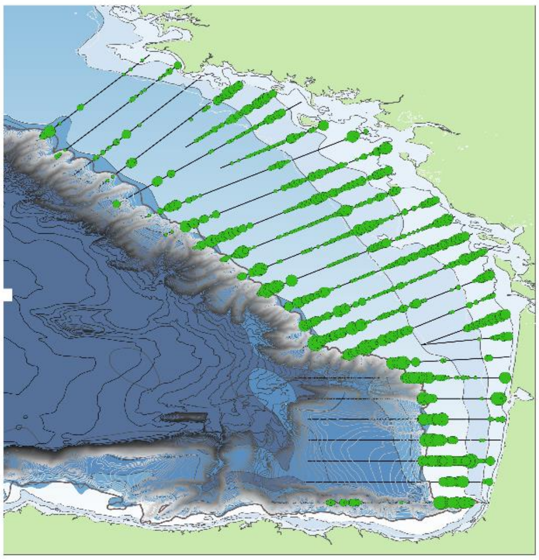


Figure 3.3.2.1. Bay of Biscay anchovy: Total abundance of anchovy per ESDU from PELGAS 2021.

Anchovy was very abundant with an abundance estimated this year at the strong maximum of the historical time-series (around 450 000 tonnes). Strong densities were observed in the Gironde area and at the shelf break with schools sometimes massive (Figure 3.3.2.1). It must be noticed that anchovy was observed on every transects from the Spanish coast until the Northwest of the Bay of Biscay.

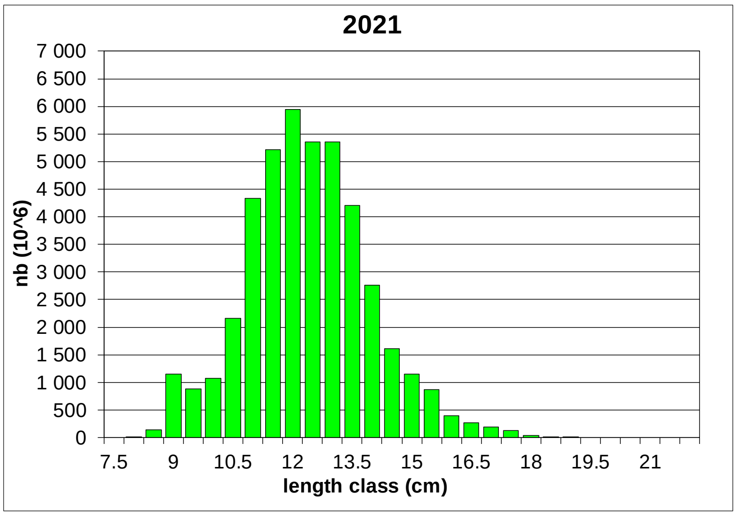


Figure 3.3.2.2. Bay of Biscay anchovy: length distribution of global anchovy as observed during PELGAS21 survey.

Globally we observe that length structure shows a classic distribution, with fish from 9 to 19 centimetres (Figure 3.3.2.2). It must be noticed that even if some individuals were small (less than 10 cm), almost all fishes were mature and in their spawning period. This observation on maturity contrasted with the 2015 observation where a large proportion of the population was not spawning at the period of the survey.

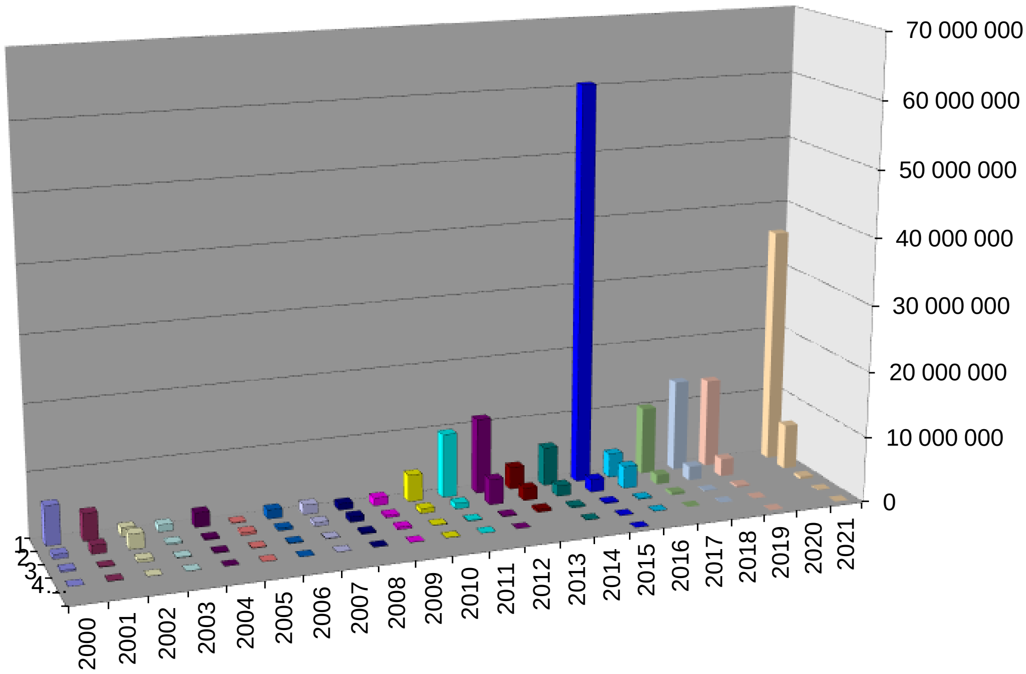


Figure 3.3.2.3. Bay of Biscay anchovy: Anchovy numbers-at-age as observed during PELGAS surveys since 2000.

Looking at the numbers-at-age since 2000, the proportion of 1 year old anchovies (83%) this year seems to be equivalent to 2011, 2012 or 2017 but in number and abundance it seems to be the best recruitment ever (Figure 3.3.2.3). 2015 was probably overestimated. The huge 2015 age class is not followed in 2016 and in 2017. Once again, it could indicate that an overestimation occurred on the recruitment in 2015. Several investigations have been done to explain, without results for the time being.

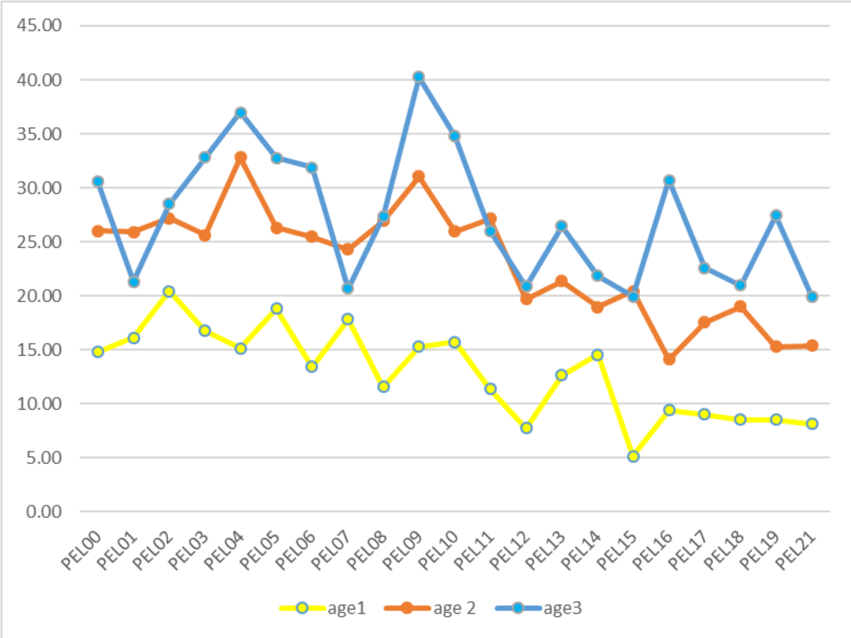


Figure 3.3.2.4. Bay of Biscay anchovy: Evolution of mean weight at age (g) of anchovy along PELGAS series.

As previous years, we observe a globally decreasing trend of the mean weight at age. This trend is almost the same for sardine in the bay of Biscay. Further investigations should be done and, if we have some hypothesis (maybe an effect of density-dependance), we do not have real explanation for the time being.

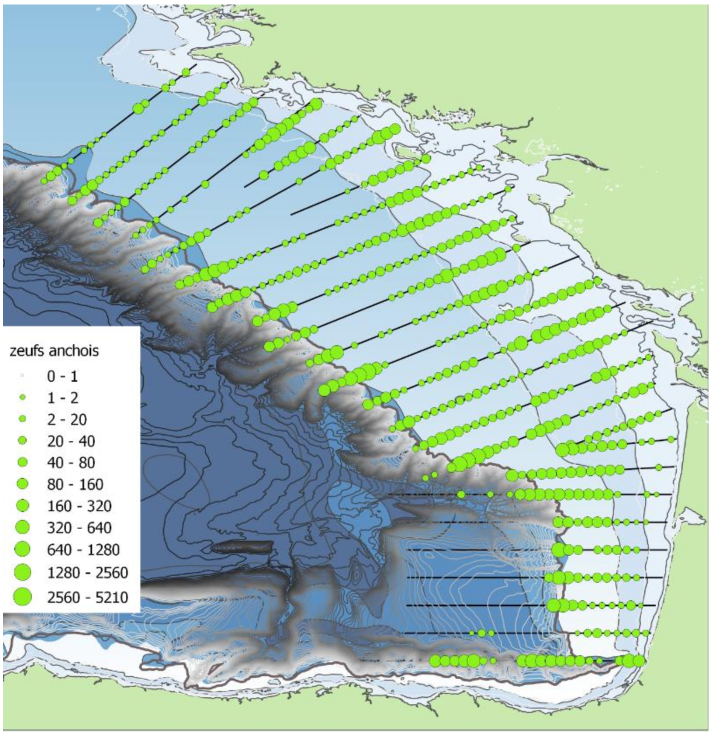


Figure 3.3.2.5. Bay of Biscay anchovy: Distribution of anchovy eggs observed with CUFES during PELGAS21.

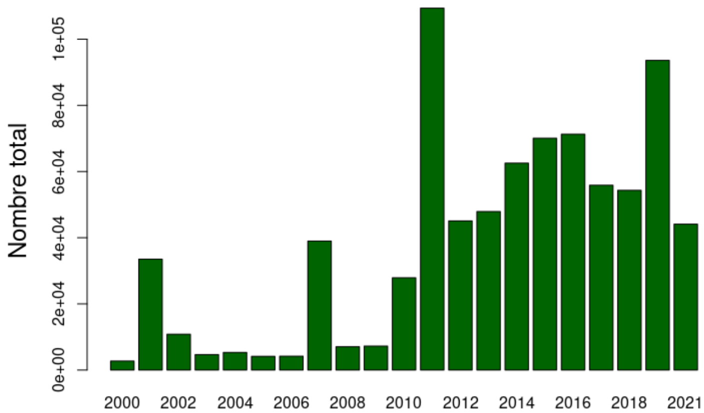


Figure 3.3.2.6. Bay of Biscay anchovy: Number of eggs observed during PELGAS surveys from 2000 to 2021.

Year 2021, as from 2011, was marked by a large quantity of collected and counted anchovy eggs (Figure 3.3.2.6), with the same magnitude over the previous values of the ongoing decade, reaching the maximum in 2011. Their spatial pattern of distribution was quite usual, with major part of the abundance South of 46°N (Figure 3.3.2.5). However, eggs are present almost everywhere in the bay of Biscay, according to the huge level of adults biomass. Eggs are particularly abundant along the coast from the Gironde until the tip of Brittany, and along the shelf break. Spawning occurred over the mid-shelf in the north, an area where eggs are observed rarely. Globally, the total number of eggs seems to be equivalent as the previous one, in 2019. But, according to the very high level of biomass, the fecundity seems (very) low. It was corroborated with the visual aspect of the gonads, showing that the spawning season was at its beginning during the survey.

3.4.3 Autumn juvenile acoustic survey 2021 (JUVENA 2021)

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 2021 were reported and discussed in WGACEGG 2021 (Boyra *et al*., 2021, WD WGACEGG2021, ICES, 2021). Therefore, in this section only a short summary is provided, highlighting some issues of relevance for this assessment input.

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 2021, 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 2021 took place between the 16th of August and 4th of October on board the chartered RV Angeles Alvariño and the RV Emma Bardán, both equipped with scientific echo sounders (Boyra *et al*., 2021; WD to WGACEGG). Following the standard transect design and acoustic methods as in previous years, the survey covered from 7º30′ W in the Cantabrian area to 47º56′ N in the French coast. A total of 92 hauls were done during the survey to identify the species detected by the acoustic equipment, 78 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 5.3 cm long, smaller than the average of the time-series.

The biomass of juveniles estimated for this year was around 208 200 tonnes (**Table 3.3.3.1**). This value represents a medium value in the time-series.

Table 3.3.3.1. Bay of Biscay anchovy. Summary of the estimates obtained in JUVENA autumn acoustic surveys from 2003 to 2021.

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
2021	26723	5.3	208 241

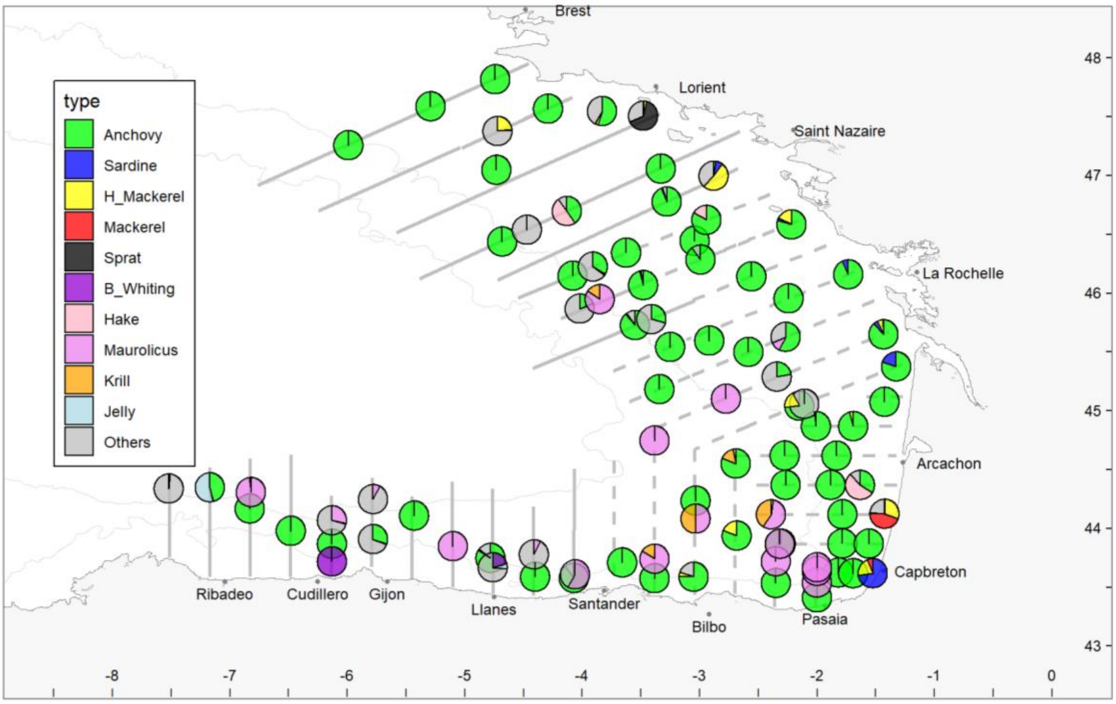


Figure 3.3.3.1. Bay of Biscay anchovy. Survey transects and species composition of the pelagic hauls in JUVENA 2021.

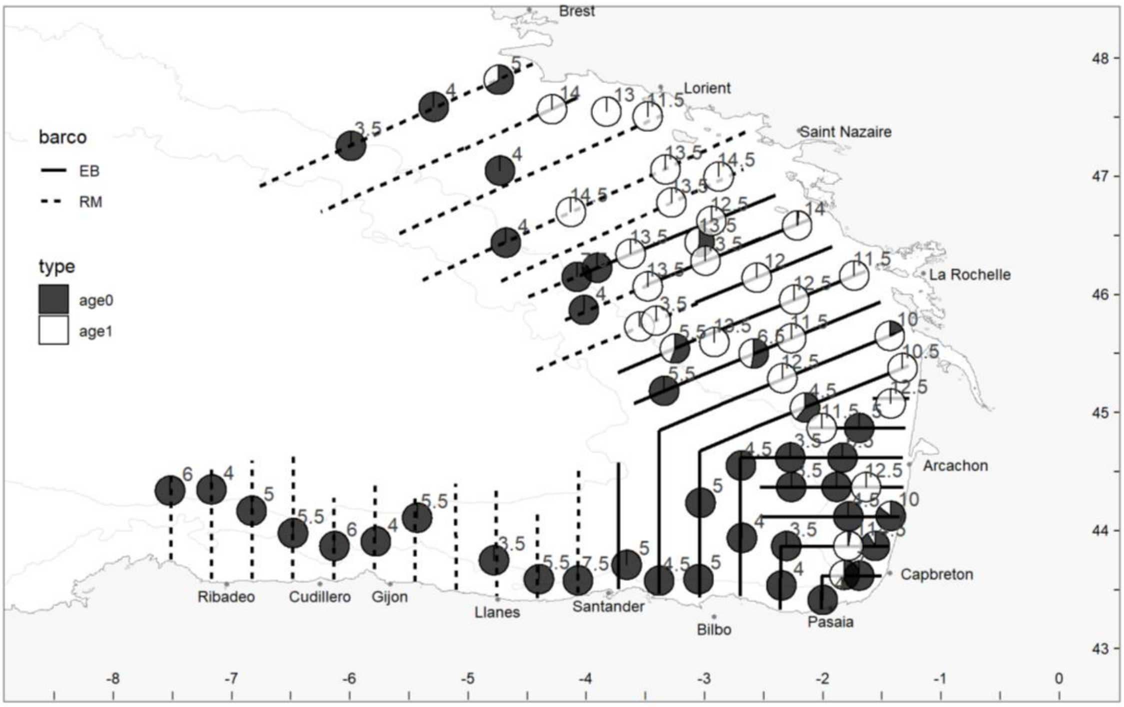
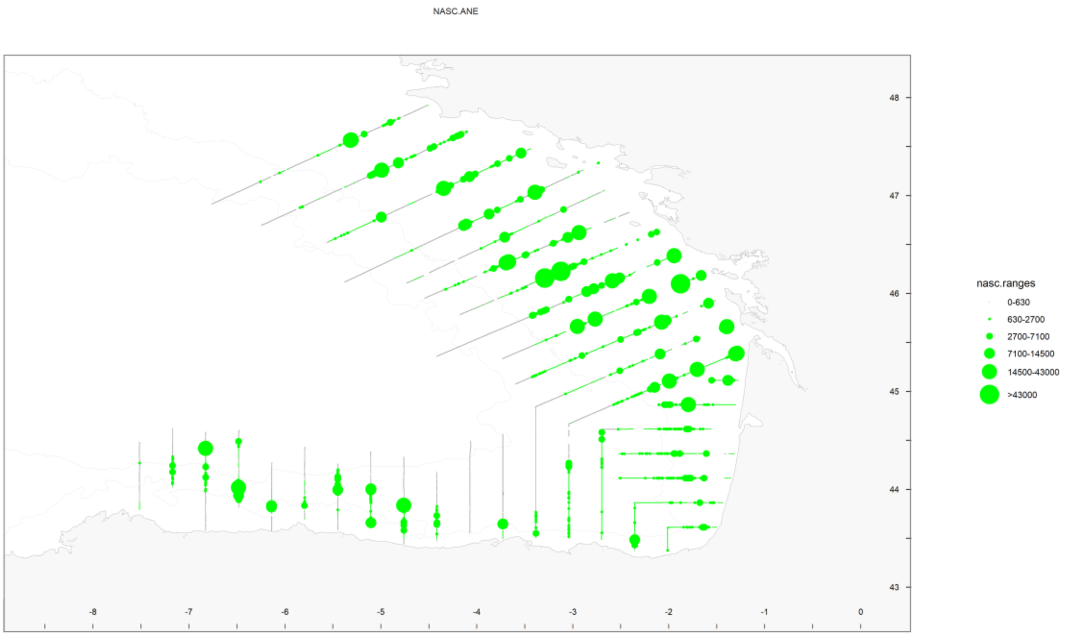


Figure 3.3.3.2. Bay of Biscay anchovy. Positive area of anchovy in JUVENA 2021. The pie charts show the percentage of juveniles (white) and adults (black) in the fishing hauls.



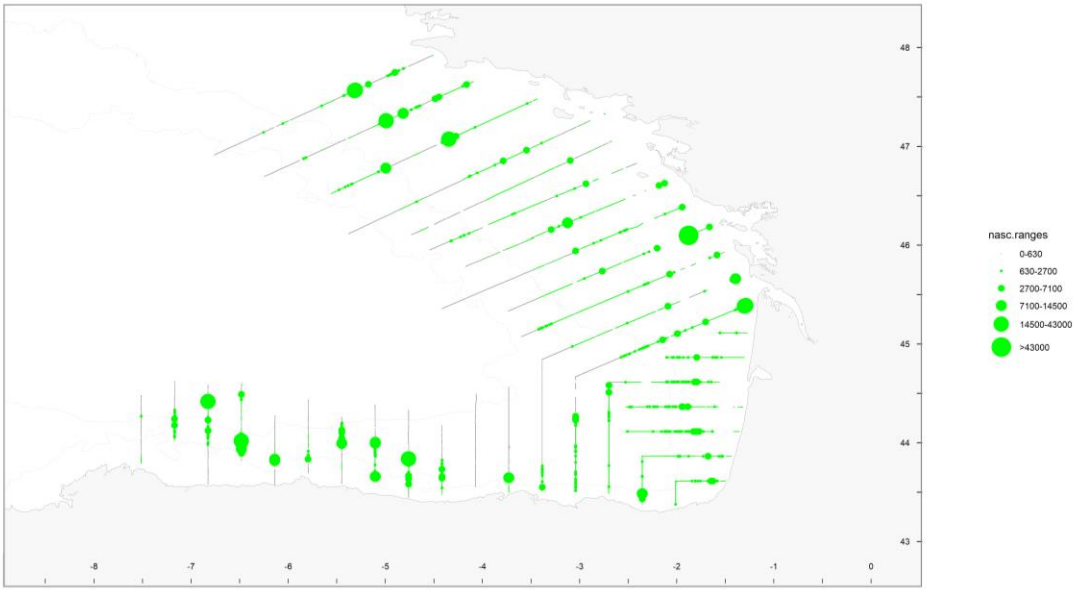


Figure 3.3.3.3. Bay of Biscay anchovy. Bubble maps representing acoustic backscattering by ESDU of 0.1 nm for total anchovy (top) and age 0 anchovy (bottom).

3.5 Biological data

3.5.1 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.

3.5.2 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.

3.6 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 2021. 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. All the research surveys (PELGAS, BIOMAN and JUVENA) were conducted in 2021. The procedure to obtain numbers-at-age and weight-at-age from the 2020 catch was different from previous years as explained in Section 3.2.3. For the rest, the assessment presented below follows the stock annex as in previous years.

3.6.1 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 2021 only for the first semester);
- growth rates by age estimated from the weights-at-age of the stock.

The historical series of spawning–stock biomass (SSB) from the DEPM and acoustic surveys are shown in Figure 3.5.1.1. The trends in biomass from both surveys are similar. From 2003 to 2018, a parallel trend but with larger biomass estimates from the acoustic surveys is apparent, except in 2016 and 2018 that the DEPM biomass estimate was larger than the acoustic biomass. In 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. In 2021, the acoustic survey provided the largest SSB estimate of the historical time-series (451 660 t) with a much higher value than the

DEPM SSB estimate for 2021 (199 490 t).The largest discrepancy between the SSB estimates from the DEPM and acoustic surveys occurred in 1991, 2000, 2002, 2012 2015 and 2021.

The agreement between both surveys is usually higher when estimating the relative age composition of the population. In 2021 the DEPM survey age 1 biomass proportion was around 0.66 and the acoustic age 1 biomass proportion was around 0.73, both 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 2021 survey index represents a medium value, slightly below the average of the temporal series and slightly below the 2020 index value.

In 2019 and 2020 due to the bad weather conditions the JUVENA survey could not cover the region to the north of 46.6ºN and the 2019 and 2020 juvenile abundance indices were considered likely underestimated. This has been confirmed in next years by the BIOMAN 2020 and 2021 and PELGAS 2021 surveys. Besides being among the largest SSB estimates of the BIOMAN and PELGAS surveys time-series, the age 1 proportion estimates were above the average indicating large recruitments.

In 2020, due to the Covid-19 disruption and to some administrative problems, length sampling for 91% of Spanish catches was not available and the age structure was based on commercial size categories from sales notes. For French catches, due to the low total landing in 2020 (138 t), length sampling was not available and age structure from Spanish catches in divisions 8.a and 8.b was used for catch-at-age calculations (see Section 3.2.3). 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 2021, the preliminary total catch was around 23 580t in the first half of the year and 4371 t in the second half. The latter was under the assumption that the November and December catches were 0 for Spain (the Spanish fishery was closed in mid-August due to quota exhaustion) and 4t for France (6.3% of the total French catch which is the average % of November and December French catches in 2010–2020). Definitive 2021 catch estimates will be provided in WGHANSA 2022. Regarding the age structure of the catches, age 1 proportion in the catches in the first semester in 2021 was 0.46, which is around 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 2021 is approximately 206 215 t, which is the highest in the time-series, and the 90% probability interval is around 134 022t and 301 183 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 2022 is around 51 817t and the 90% probability interval is between 20 165t and 135 371t. The posterior distribution of recruitment in 2022 is wide because only the JUVENA 2021 survey provides direct information about that recruitment (age 1 biomass) level. Assuming no fishing takes place in 2022, the SSB in 2022 is estimated around 152 863t with a 90% probability interval around 98 642t and 243 492t (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, and for the last two years (2020 and 2021) large negative residuals are observed for JUVENA recruitment index, which should be further investigated in next years.

The final estimates are compared with last year's November assessment (ICES, WGHANSA 2020) 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 2021 has been revised upwards significantly, being the highest recruitment value estimated by the assessment model in the historical series.. Fishing mortalities in the first semester of 2018 and 2019 aree slightly larger than in last year's assessment. As a result, biomasses in 2018 and 2019 are slightly smaller than in last year's assessment..

3.6.2 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 exceptions are recruitments in 2020 and 2021 that have been strongly revised upwards in last year's and this year's assessments.

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 in 2017 and 2019, and negative in the other years, with high absolute values for 2020 and 2021 (Figure 3.5.2.2). It ranged between -0.75 and 0.12 and the Mohn's rho was calculated at -0.28. The relative bias for SSB in the terminal year was always positive (Figure 3.5.2.2). The relative bias for SSB ranged between 0.05 and 0.27, and the Mohn's rho was 0.14. Mohn's rho for the fishing mortality by semester and annual harvest rate was -0.12, -0.17 and -0.12 respectively. The relative bias for the three time-series was negative in all the years (Figure 3.5.2.2).

3.6.3 Reliability of the assessment

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

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

The catch data for 2021 are preliminary and the definite data will be available for WGHANSA 2022. As a result, the fishing mortality estimates in 2021 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

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
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	8831	14870	9173	10350	0.424	0.332
2021	132182	199490	0.104	327454	451660	0.097	228879	10791	23580	NA	4371	NA	NA
2022	NA	NA	NA	NA	NA	NA	208241	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	0.662	0.800	0.969	Catchability of the DEPM B index
Qac	1.202	1.430	1.707	Catchability of the Acoustic B index
Qrobs	0.034	0.612	13.541	Parameter of the observation equation for the juvenile index
Krobs	0.870	1.157	1.428	Parameter of the observation equation for the juvenile index
Psidepm	2.426	4.200	7.226	Precision (inverse of variance) of the observation equation of DEPM B index
Psiac	4.405	7.903	13.637	Precision (inverse of variance) of the observation equation of Acoustic B index
psirobs	0.889	1.671	2.970	Precision (inverse of variance) of the observation equation of juvenile index
xidepm	3.376	4.041	4.790	Variance-related parameter for the observation equation of DEPM age 1 proportion
xiac	2.784	3.368	3.941	Variance-related parameter for the observation equation of Acoustic age 1 proportion
xicatch	2.322	2.664	2.998	Variance-related parameter for the observation equation of age 1 proportion in the catch
B0	16216	21035	26996	Initial biomass
mur	10.312	10.591	10.866	Median (in log scale) of the recruitment process
psir	0.743	1.145	1.669	Precision (in log scale) of the recruitment process
sage1sem1	0.392	0.460	0.541	Age 1 selectivity during the 1st semester
sage1sem2	0.855	1.035	1.245	Age 1 selectivity during the 2nd semester
G1	0.484	0.542	0.601	Intrinsic growth at age 1
G2	0.170	0.225	0.283	Intrinsic growth at age 2+
Psig	19.537	27.655	37.484	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	12038	15761	21086	15942	20730	27268	0.961	1.256	1.612	0.266	0.373	0.527	0.528	0.694	0.902
1988	25720	31012	38165	23439	28653	35991	0.819	1.056	1.322	0.302	0.407	0.541	0.400	0.503	0.615
1989	6424	9047	12821	10618	15261	21485	0.712	0.986	1.353	0.137	0.201	0.306	0.383	0.540	0.776
1990	59083	67630	78178	45780	53110	62559	1.016	1.257	1.540	0.582	0.758	0.997	0.539	0.635	0.737
1991	17572	23070	30235	22227	29562	38884	0.891	1.173	1.524	0.209	0.294	0.426	0.466	0.613	0.815
1992	68286	86937	109828	53315	71491	93042	0.917	1.222	1.653	0.274	0.395	0.593	0.400	0.520	0.698
1993	51284	65068	80391	61042	72653	87067	0.702	0.883	1.119	0.459	0.595	0.783	0.452	0.541	0.644
1994	33146	40971	50805	38592	47201	58364	0.952	1.194	1.479	0.488	0.658	0.891	0.576	0.712	0.871
1995	34303	45148	59519	28541	40047	54761	1.175	1.593	2.174	0.260	0.390	0.620	0.532	0.727	1.020
1996	40448	50483	62357	38438	46690	57572	0.995	1.274	1.632	0.548	0.745	1.018	0.571	0.704	0.856
1997	30653	39427	51237	34114	44229	57992	0.505	0.674	0.889	0.430	0.621	0.893	0.353	0.462	0.600
1998	69770	90945	118817	68387	90022	117010	0.356	0.477	0.643	0.368	0.533	0.792	0.268	0.349	0.459
1999	30537	45254	63739	50891	68069	88405	0.411	0.548	0.747	0.313	0.434	0.635	0.294	0.382	0.511
2000	74344	91152	110121	76633	92434	111165	0.587	0.731	0.924	0.307	0.403	0.539	0.332	0.399	0.481
2001	62255	73563	87436	78234	89702	104326	0.564	0.677	0.811	0.418	0.526	0.656	0.385	0.447	0.513
2002	9193	12897	17848	31628	38014	46507	0.458	0.564	0.684	0.408	0.525	0.667	0.376	0.460	0.553
2003	15560	19639	24424	22148	27177	33154	0.312	0.393	0.494	0.509	0.673	0.901	0.316	0.386	0.473
2004	24477	30203	37679	24411	30343	38576	0.686	0.882	1.126	0.467	0.646	0.901	0.420	0.533	0.663
2005	2762	4223	6219	10257	14242	19544	0.116	0.160	0.226	0.000	0.000	0.000	0.058	0.079	0.110
2006	11620	15772	21434	14476	19323	25625	0.187	0.250	0.339	0.008	0.012	0.016	0.068	0.091	0.121
2007	15163	21048	28438	21993	29095	37676	0.011	0.014	0.018	0.000	0.000	0.000	0.004	0.005	0.006
2008	6108	8900	12811	17737	23217	29863	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		
2009	6819	9766	14023	14981	19523	25264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	36246	47334	61640	36925	48023	61816	0.321	0.418	0.545	0.143	0.198	0.280	0.163	0.210	0.273
2011	88946	112283	142401	94257	117909	147524	0.236	0.303	0.387	0.052	0.070	0.095	0.098	0.123	0.154
2012	34271	45436	59752	78545	97147	120574	0.158	0.199	0.250	0.122	0.156	0.201	0.119	0.148	0.183
2013	28956	38220	50318	54213	68460	86209	0.291	0.369	0.471	0.091	0.120	0.159	0.163	0.206	0.260
2014	55794	73123	94841	67372	86353	109701	0.364	0.468	0.601	0.111	0.151	0.206	0.178	0.226	0.290
2015	88534	111902	143051	104390	129399	160140	0.346	0.436	0.554	0.127	0.169	0.223	0.176	0.218	0.271
2016	39525	52398	69410	78441	98931	124360	0.280	0.356	0.452	0.081	0.106	0.140	0.156	0.196	0.247
2017	52129	68384	88291	68798	89268	113780	0.506	0.649	0.840	0.069	0.092	0.126	0.229	0.291	0.378
2018	87474	113331	148088	97291	126427	164426	0.447	0.583	0.768	0.074	0.101	0.140	0.187	0.243	0.316
2019	52438	72651	100401	82053	112353	150355	0.365	0.491	0.667	0.067	0.094	0.134	0.179	0.239	0.327
2020	95204	136984	195019	116758	165720	230357	0.191	0.265	0.373	0.104	0.152	0.226	0.109	0.152	0.216
2021	100510	157198	235560	134023	206215	301184	0.215	0.314	0.470	0.034	0.051	0.082	0.093	0.136	0.209
2022	20165	51817	135371	98642	152864	243493	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

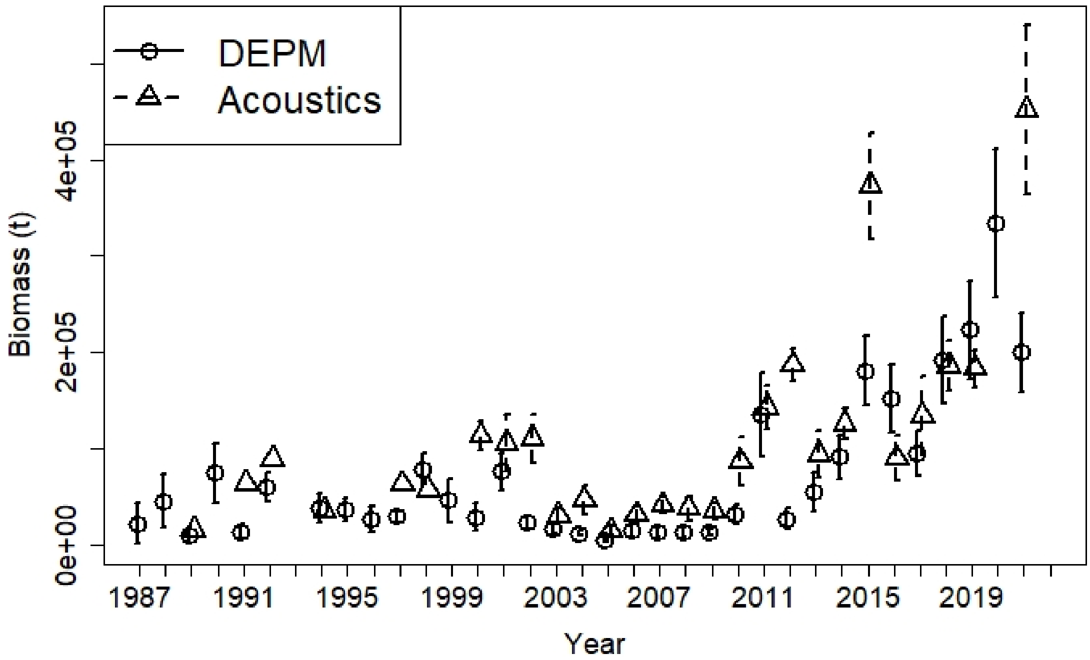


Figure 3.5.1.1. Bay of Biscay anchovy: Historical series of spawning–stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

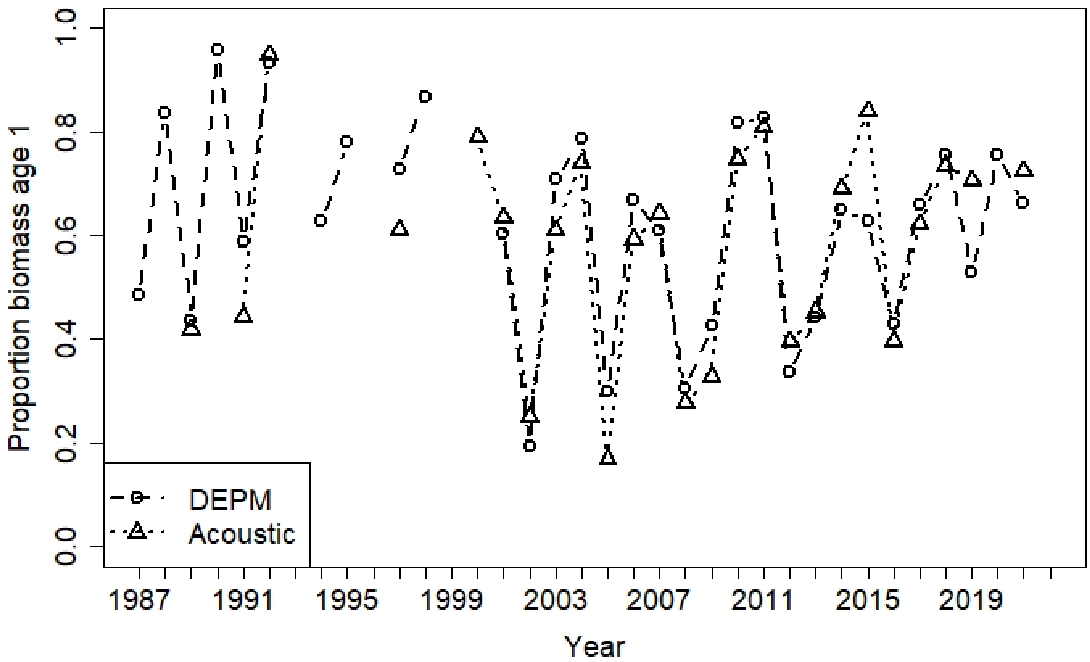


Figure 3.5.1.2. Bay of Biscay anchovy: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

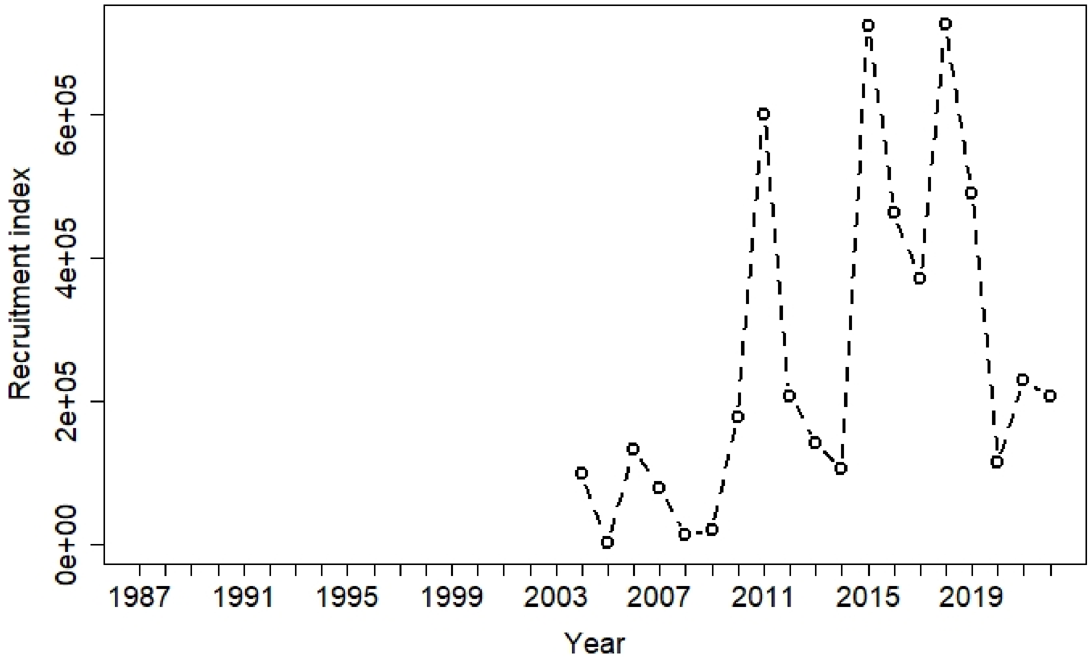


Figure 3.5.1.3. Bay of Biscay anchovy: Historical series of the juvenile abundance index from the autumn acoustic survey JUVENA that is related to recruitment (age 1) next year.

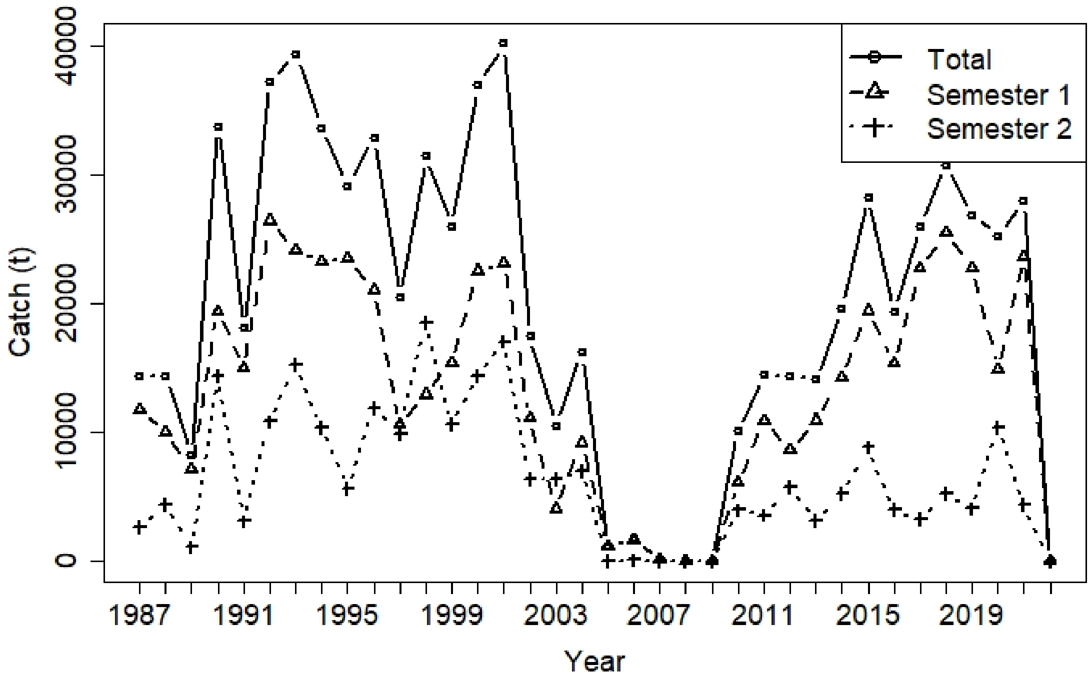


Figure 3.5.1.4. Bay of Biscay anchovy: Historical series of total catch (solid line) and catch by semesters (dashed and dotted lines for the first and second semester respectively). Note that the catch in 2020 is provisional and the catch in 2021 is set at zero.

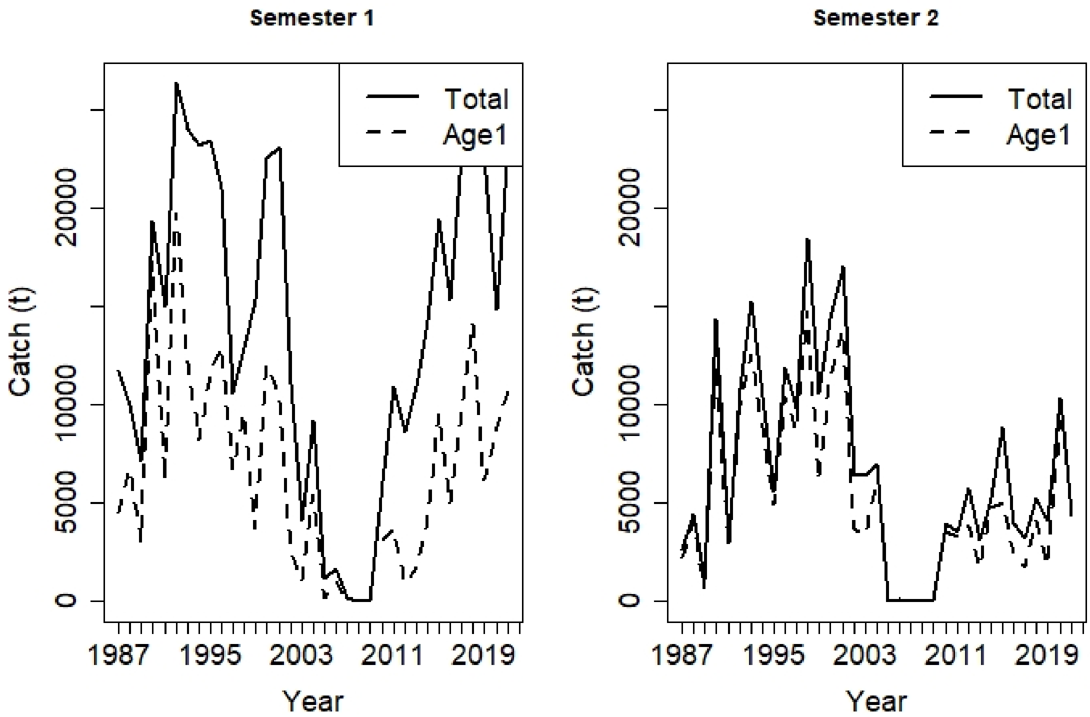


Figure 3.5.1.5. Bay of Biscay anchovy: Historical series of total (solid line) and age 1 (dashed line) catch (in tonnes). The left panel corresponds to the first semester and the right panel to the second semester. Note that the catch in 2021 is provisional.

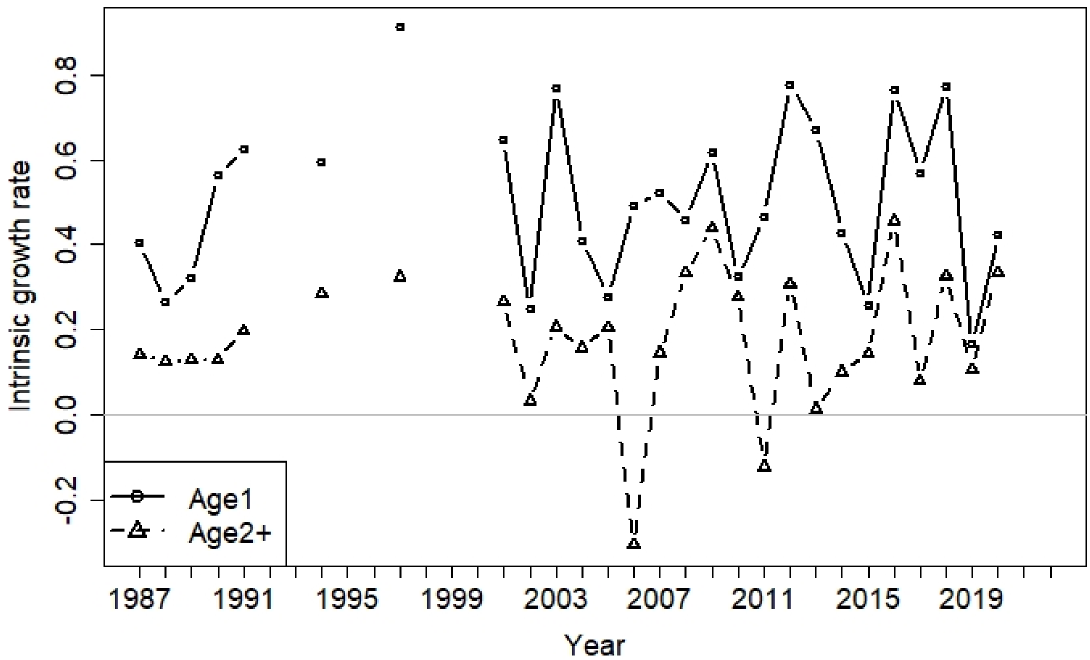


Figure 3.5.1.6. Bay of Biscay anchovy: Historical series of intrinsic growth rates by age as estimated from the mean weights-at-age of the stock.

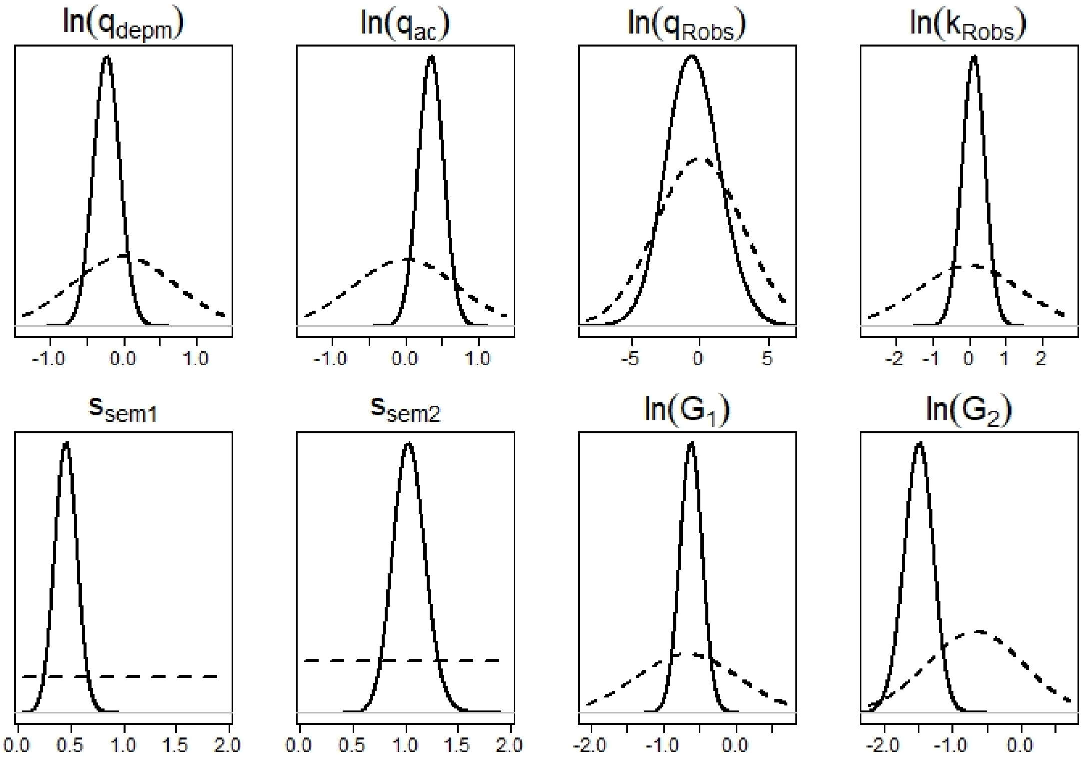
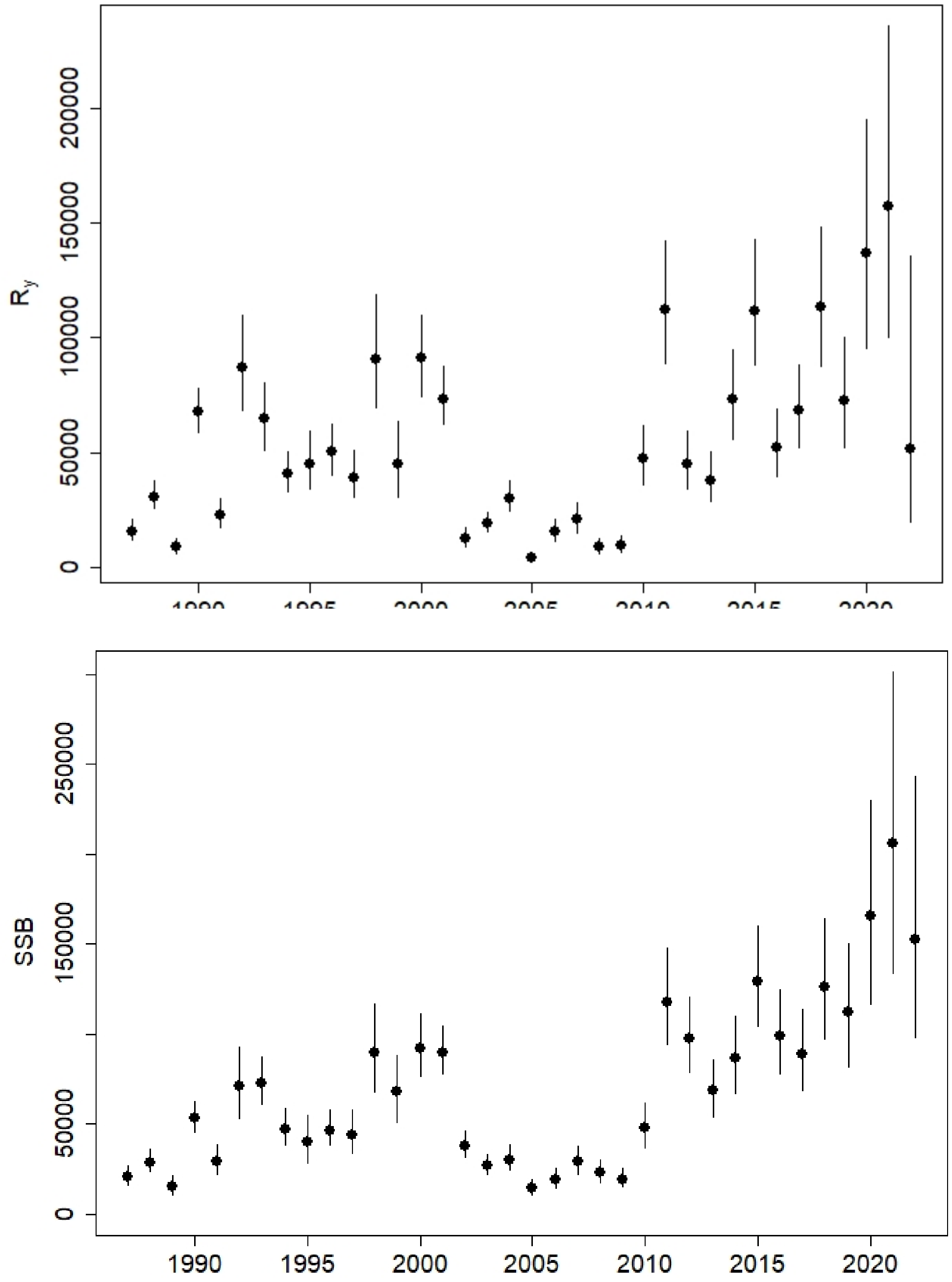


Figure 3.5.1.7. Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of CBBM.



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

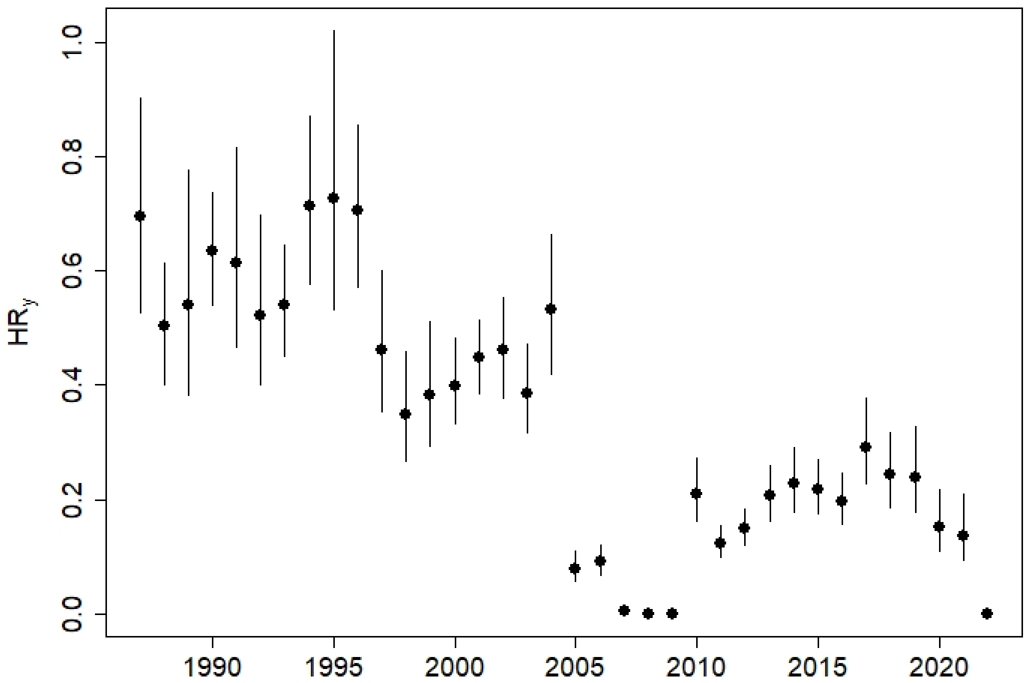


Figure 3.5.1.8. Bay of Biscay anchovy: Posterior median (bullet points) and 90% probability intervals (solid lines) for the recruitment (age 1 in mass in January), the spawning–stock biomass, the fishing mortality for the first and second semesters and the harvest rates (catch/biomass) from the CBBM. It must be taken into account that the fishing mortalities in 2022 are fixed at zero and SSB in 2022 results from no fishing in 2022.

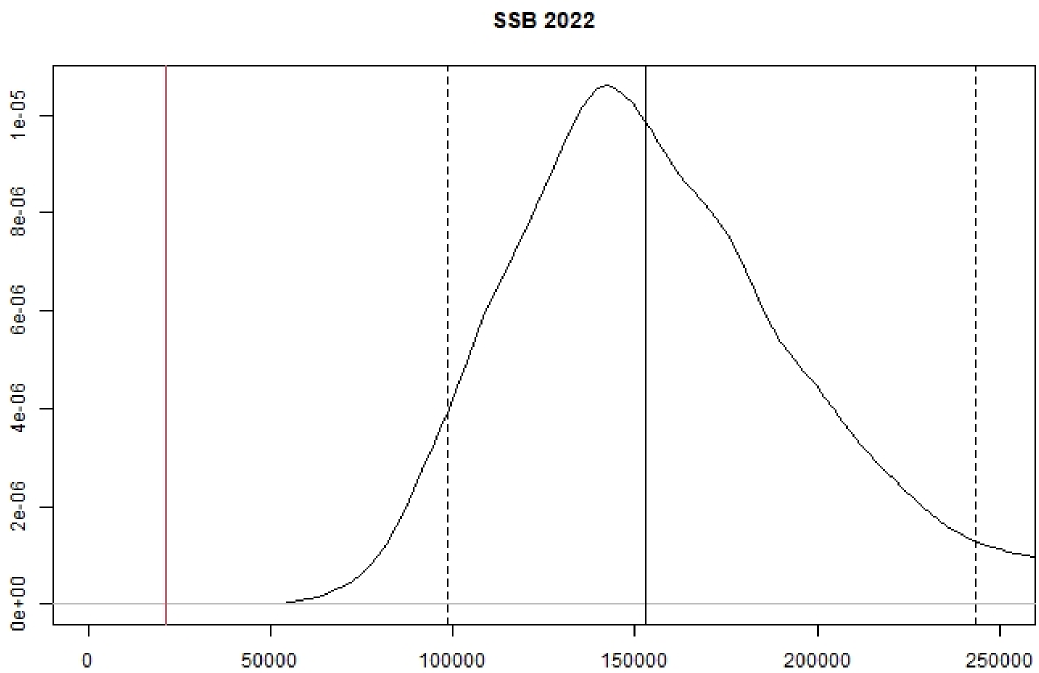


Figure 3.5.1.9. Bay of Biscay anchovy: Posterior distribution of SSB in 2022, under the assumption of no fishing during 2022. The red vertical line represents B_{lim} at 21 000 tonnes.

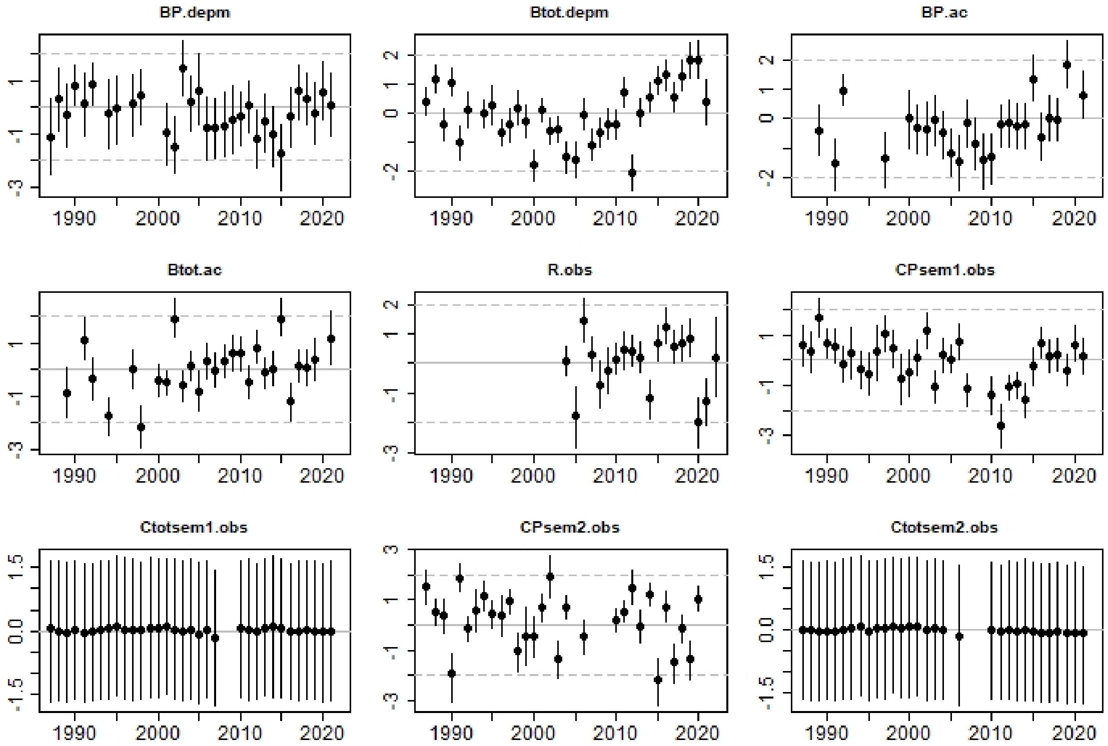
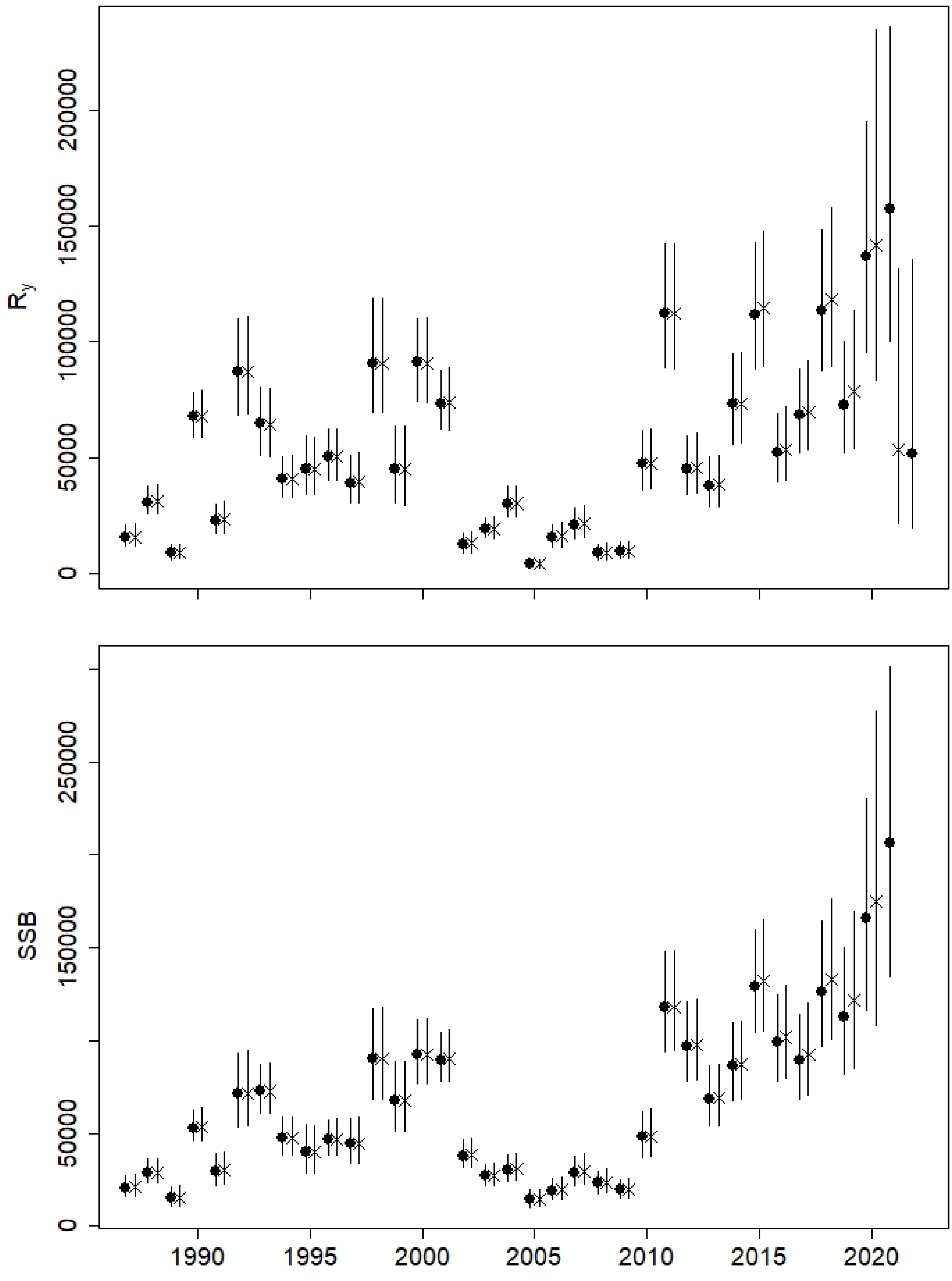
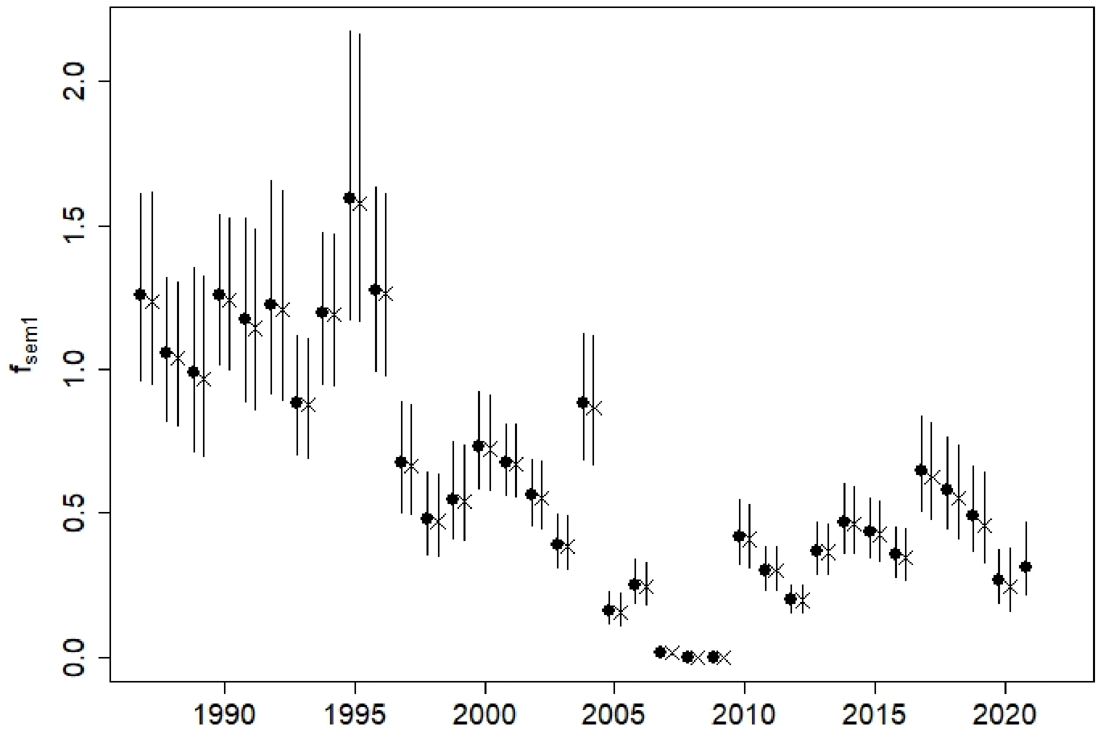
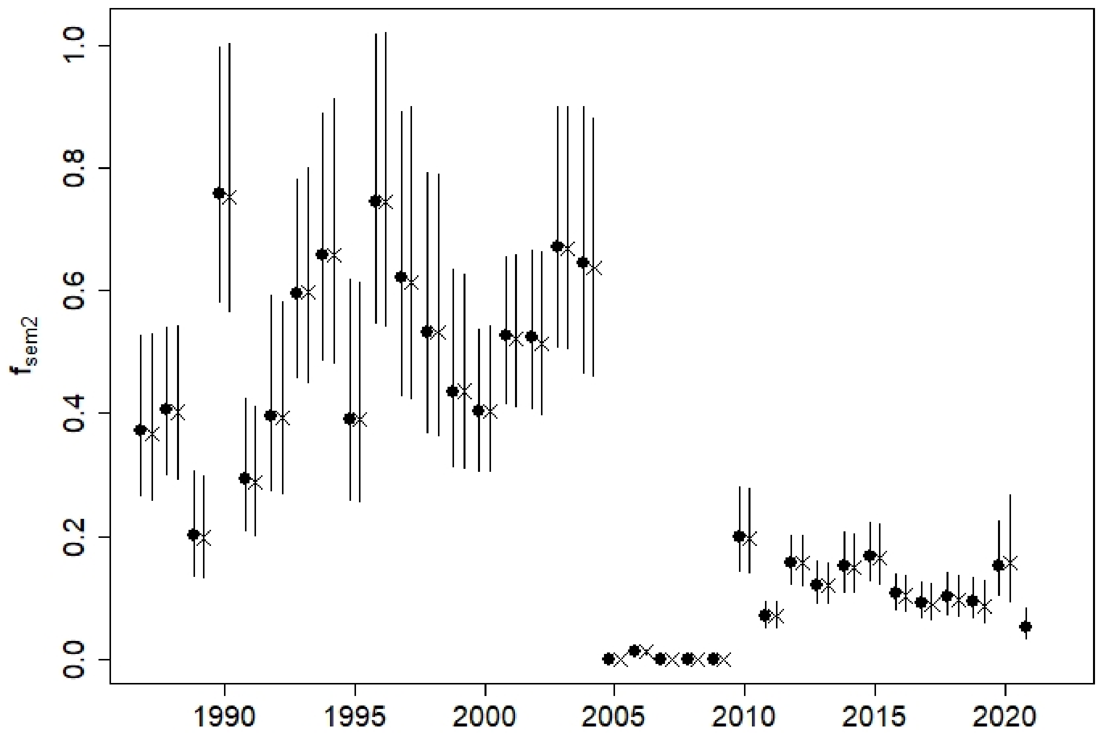


Figure 3.5.1.10. Bay of Biscay anchovy: Pearson residual medians and 90% probability intervals to the survey and catch observations used in the CBBM. From top to bottom and from left to right, residuals of the age 1 biomass proportion from the DEPM, total biomass from the DEPM, age 1 biomass proportion 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
SSB
0
50000
150000
250000
1990
1995
2000
2005
2010
2015
2020


2.0
1.5
1.0
0.5
0.0
f_{sem1}
1990
1995
2000
2005
2010
2015
2020


1.0
0.8
0.6
0.4
0.2
0.0
f_{sem2}
1990
1995
2000
2005
2010
2015
2020

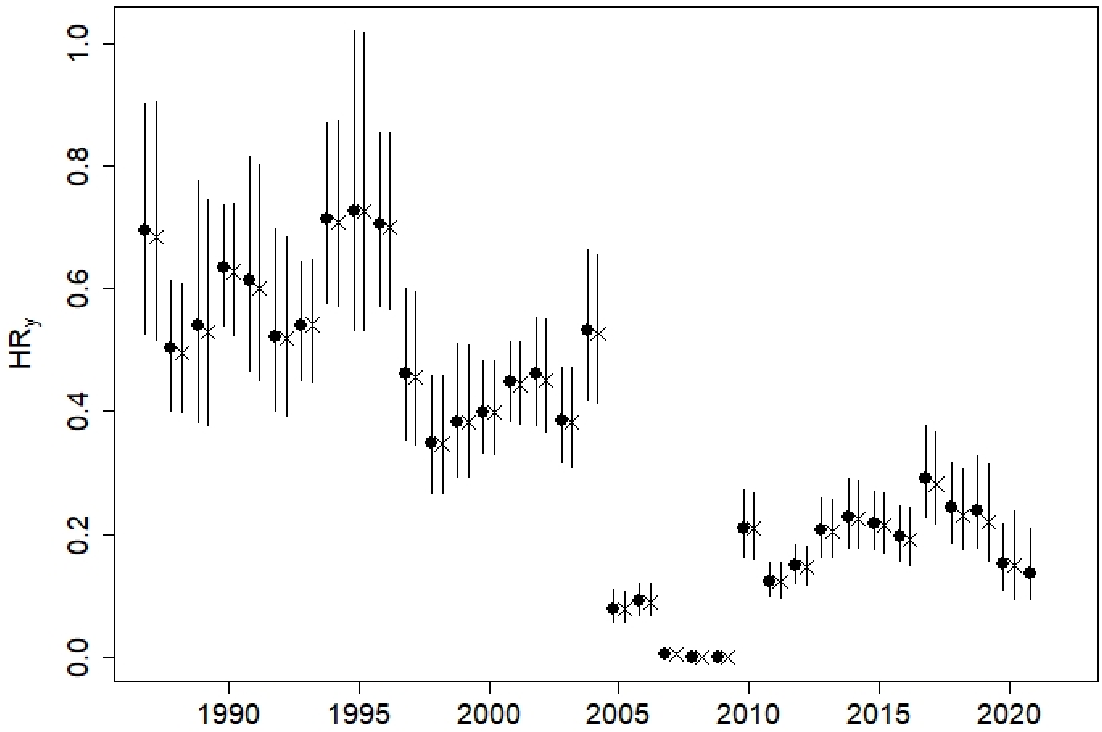
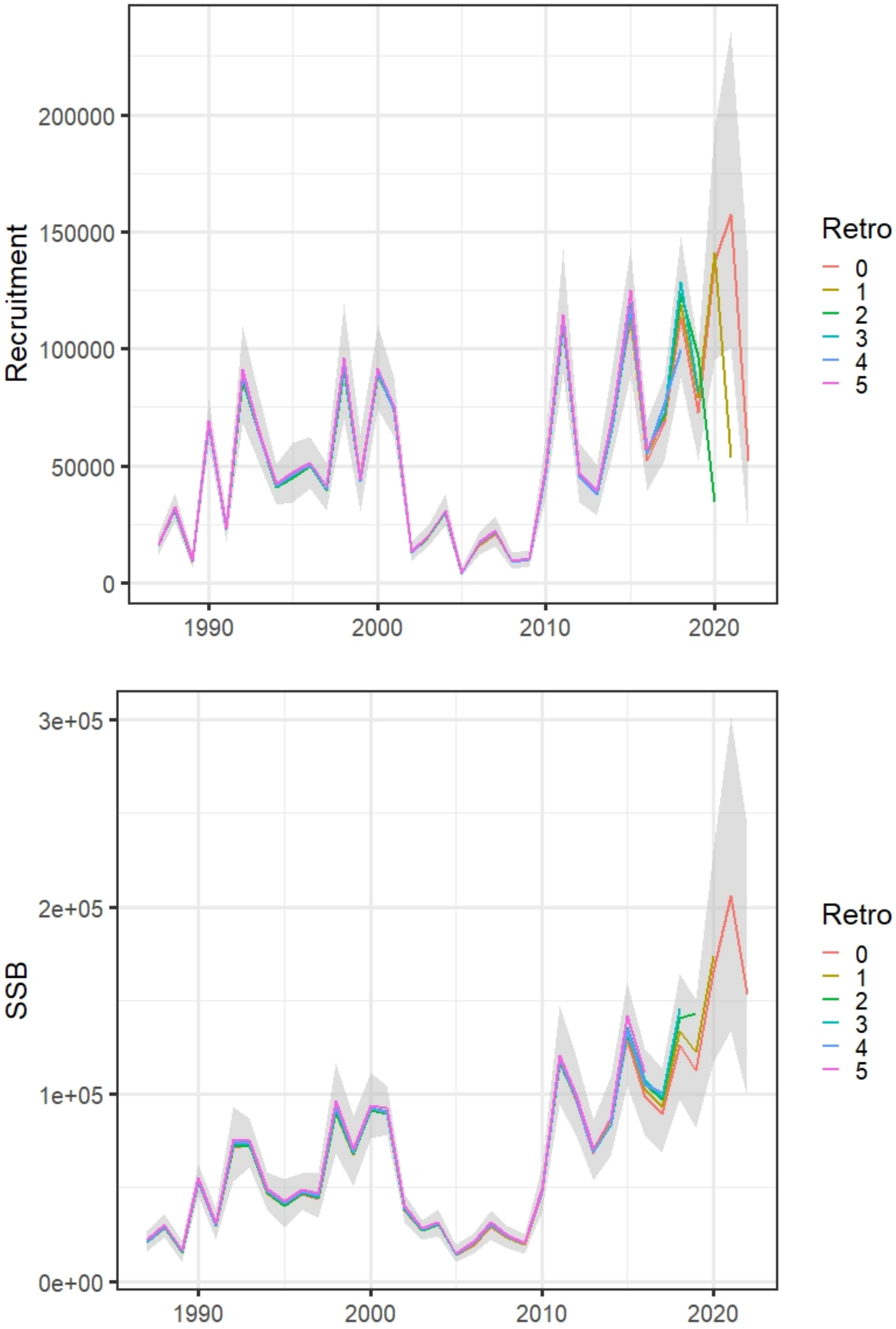
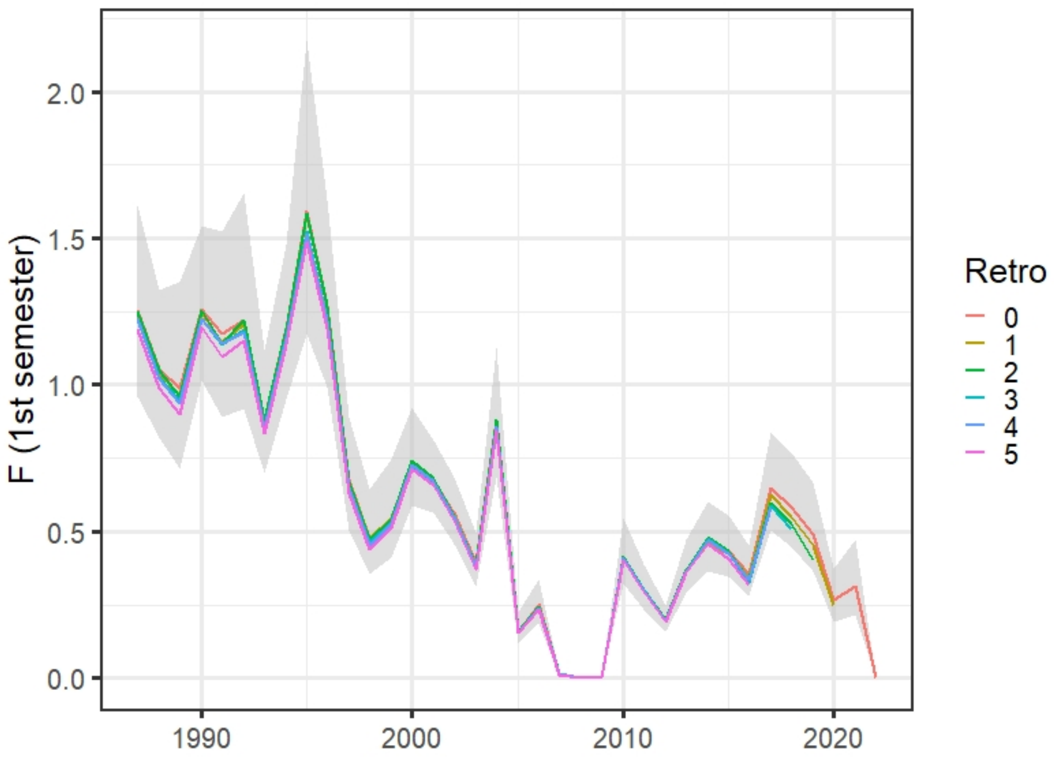
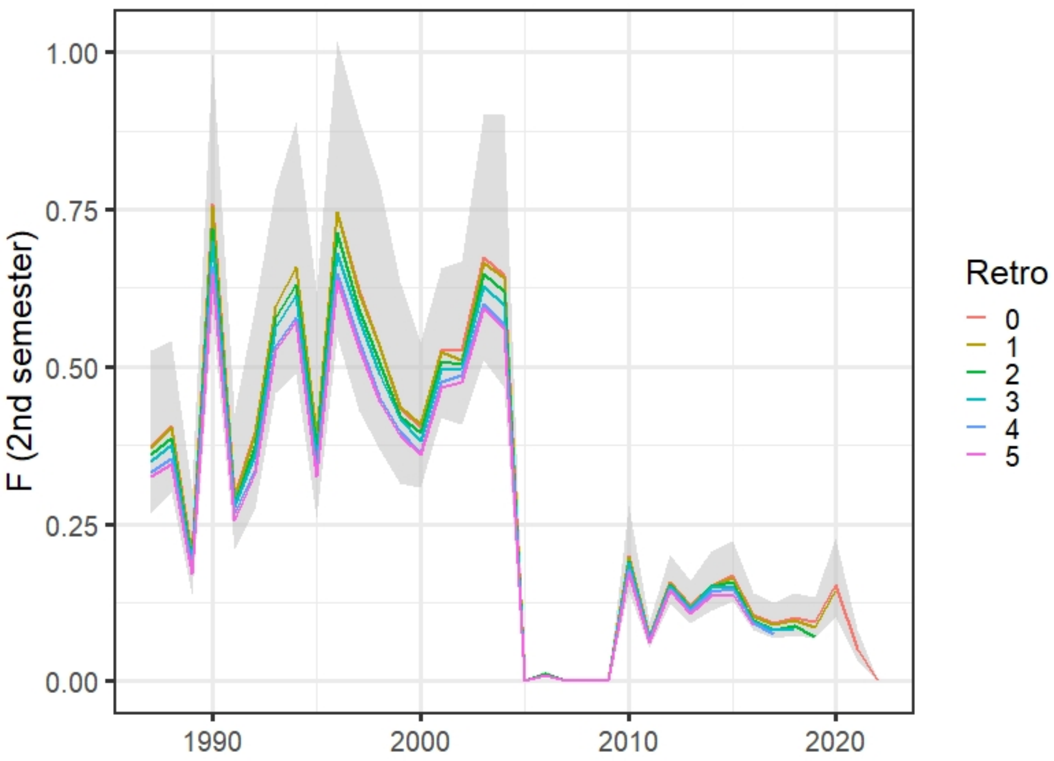


Figure 3.5.1.11. Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the spawning–stock biomass, the fishing mortality in the first and in the second semester and the harvest rate assessed in WGHANSA 2020 (cross) and in WGHANSA 2021 (bullet).


Recruitment
200000
150000
100000
50000
0
1990
2000
2010
2020
Retro
0
1
2
3
4
5
SSB
3e+05
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

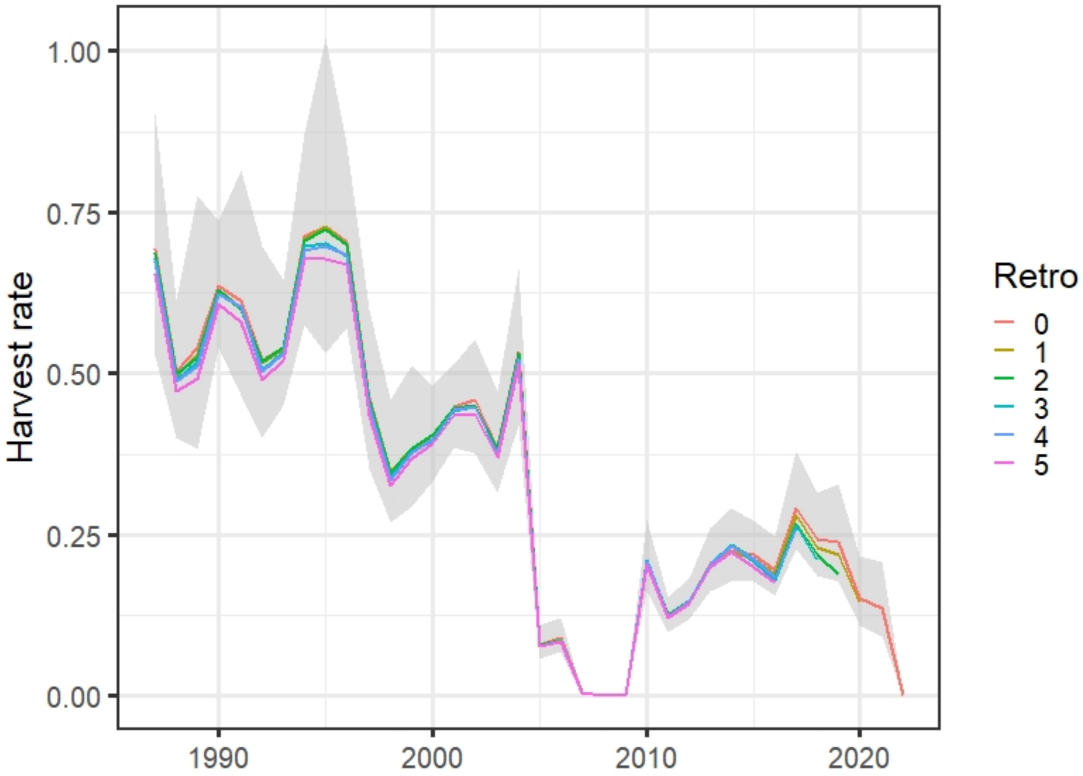
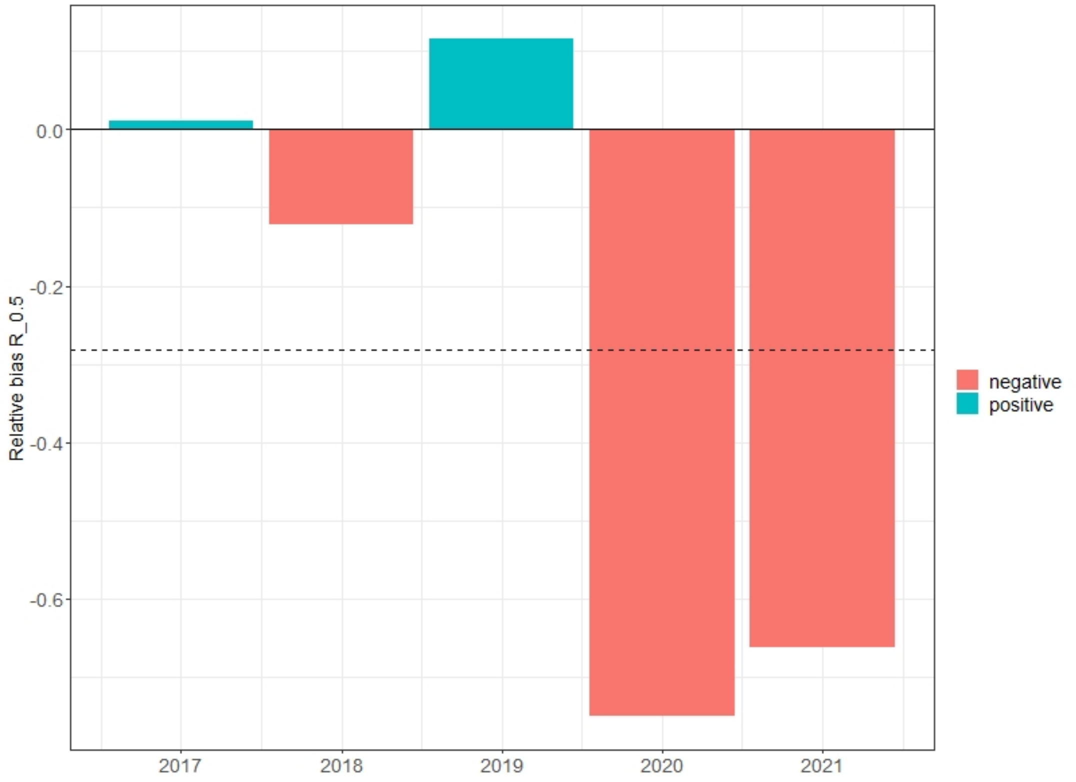
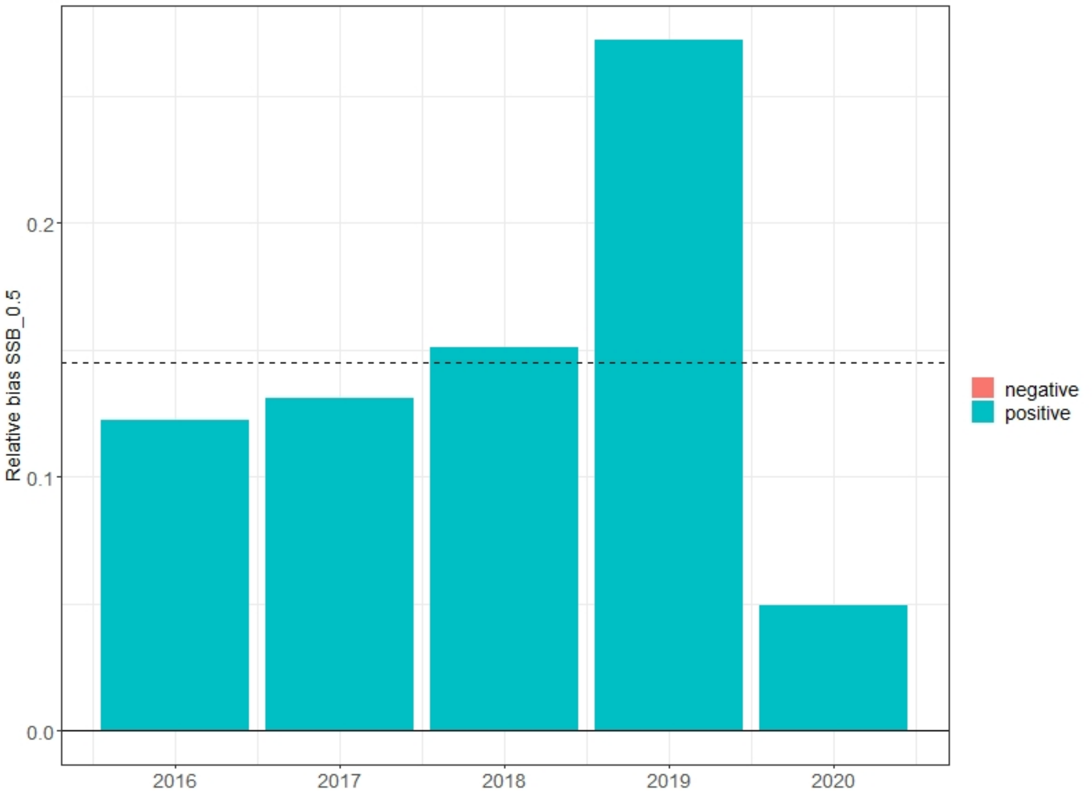
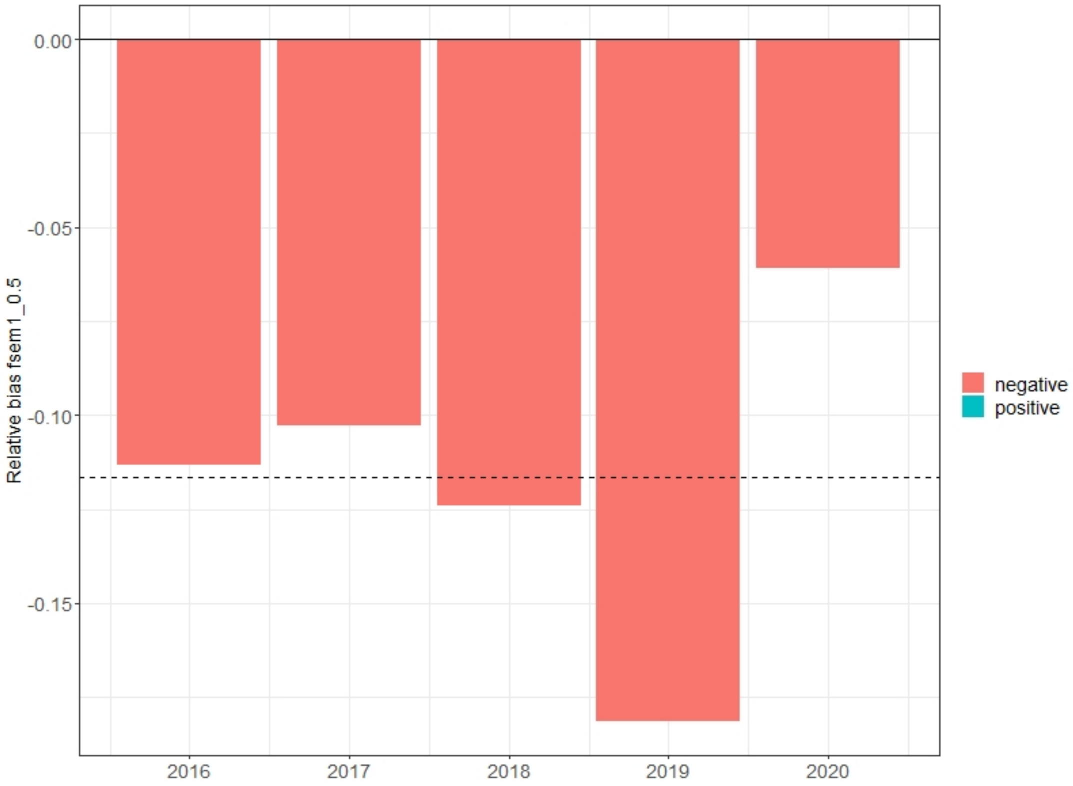
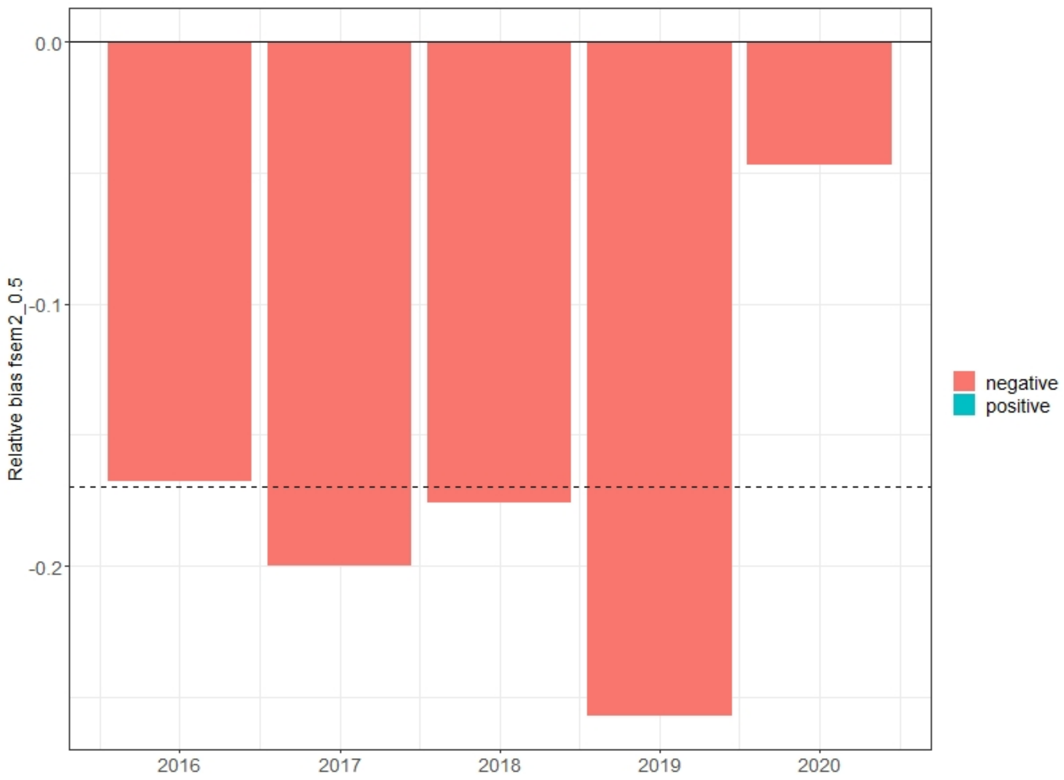


Figure 3.5.2.1. Bay of Biscay anchovy: From top to bottom retrospective pattern of recruitment (age 1 in tonnes on 1st January), SSB, fishing mortality on 1st and 2nd semesters and harvest rate. The shaded are represents the 90% probability intervals from this year's assessment.


Relative bias R_0.5
0.0
-0.2
-0.4
-0.6
2017
2018
2019
2020
2021
negative
positive


Relative bias SSB_0.5
0.2
0.1
0.0
2016
2017
2018
2019
2020
negative
positive


0.00
-0.05
-0.10
-0.15
Relative bias fsem1_0.5
2016
2017
2018
2019
2020
negative
positive


0.0
-0.1
-0.2
Relative bias fsem2_0.5
2016
2017
2018
2019
2020
negative
positive

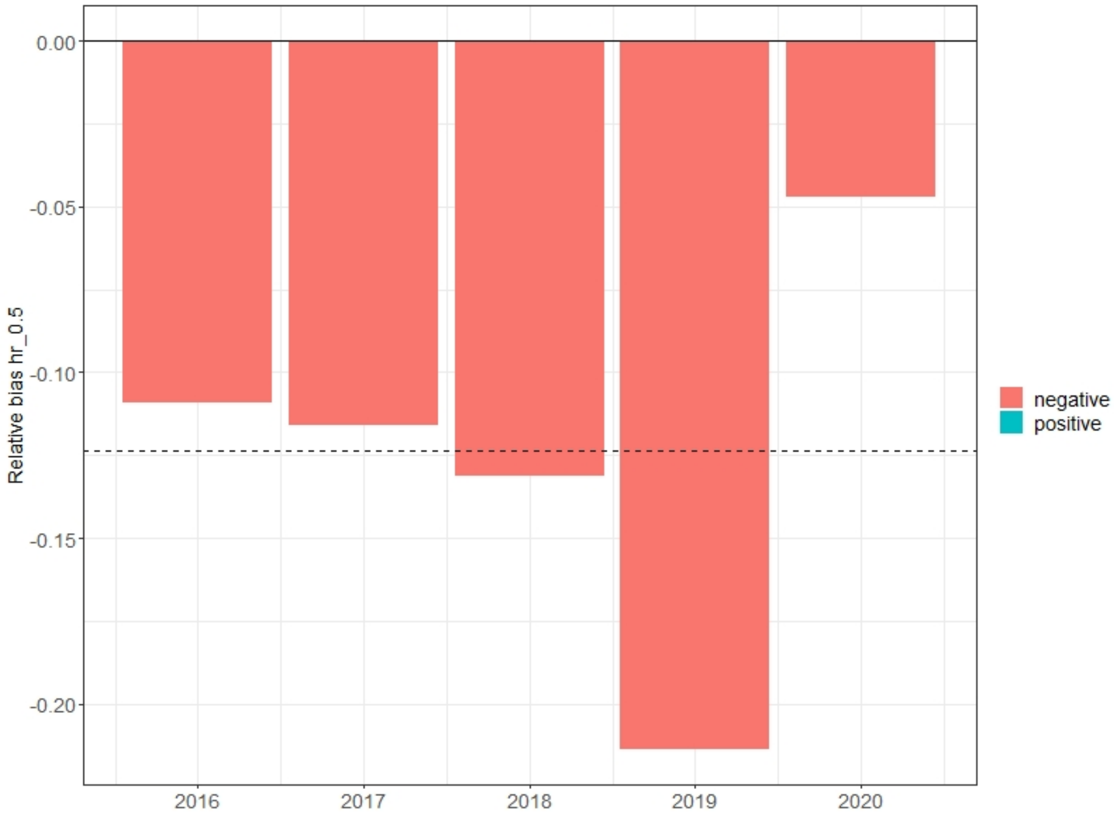


Figure 3.5.2.2. Bay of Biscay anchovy: From top to bottom relative bias of recruitment (age 1 in tonnes on 1st January), SSB, fishing mortality on 1st and 2nd semesters and harvest rate. The horizontal dashed lines represent the Mohn's rho statistic for each time-series.

3.7 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 2022 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 2022 from the assessment in November. The median recruitment (age 1 biomass on 1st January) in 2022 for the November projections is around 51 817t.

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 2022, biomass at-age 2+ at the beginning of 2022, 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 2022 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 2022 is 135 124 t (Table 3.6.3). When the projection is stochastic, the median SSB in 2022 is around 139 412 t with a 90% probability interval between 85 179 t and 230 125 t (Figure 3.6.3). The probability of SSB in 2022 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 2022, the population was projected forward for one year. Total allowable catch during 2022 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 2022 were derived for each of the catch options. For all cases, the probability of SSB in 2022 being below B_{lim} is below 0.004 (Table 3.6.1 and Figure 3.6.4) and the corresponding median SSB values in 2022 are above 103 777 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 2022 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 2021 was equal to 0.136. The same harvest rate in 2022 would lead to catches around 19 086 t and SSB around 140 812 t, with probability of SSB being below B_{lim} lower than 0.001.

The final catch options table for 2022 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. In 2020 a sensitivity analysis was carried out to test the potential influence of this assumption. In general, given the current high levels of biomass, the impact in the final catch option table was low.

Table 3.6.1. Bay of Biscay anchovy: Probability of SSB in 2022 of being below B_{lim} under different catch options for 2022 and alternative catch allocation by semesters.

P(SSB<B_{lim})			% CATCHES IN THE 1st SEMESTER 2022										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R estimated	TOTAL CATCH 2022	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		5000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		10000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		15000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		20000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		25000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		30000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		35000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		40000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		45000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		50000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		55000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018
		60000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00018
		65000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00182
		70000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.00127	0.00309

Table 3.6.2. Bay of Biscay anchovy: Median SSB in 2022 under different catch options for 2022 and alternative catch allocation by semesters.

SSB		% CATCHES IN THE 1st SEMESTER 2022										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R estimated	TOTAL CATCH 2022: 0	152864	152864	152864	152864	152864	152864	152864	152864	152864	152864	152864
	5000	152864	152528	152193	151856	151525	151193	150859	150526	150191	149855	149519
	10000	152864	152193	151525	150859	150191	149519	148846	148173	147494	146813	146132
	15000	152864	151856	150859	149855	148846	147834	146813	145791	144766	143740	142711
	20000	152864	151525	150191	148846	147494	146132	144766	143397	142024	140652	139275
	25000	152864	151193	149519	147834	146132	144424	142711	140995	139275	137548	135837
	30000	152864	150859	148846	146813	144766	142711	140652	138585	136516	134475	132423
	35000	152864	150526	148173	145791	143397	140995	138585	136177	133793	131373	128903
	40000	152864	150191	147494	144766	142024	139275	136516	133793	131021	128193	125381
	45000	152864	149855	146813	143740	140652	137548	134475	131373	128193	125029	121842
	50000	152864	149519	146132	142711	139275	135837	132423	128903	125381	121842	118268
	55000	152864	149183	145449	141680	137895	134134	130318	126438	122555	118626	114671
	60000	152864	148846	144766	140652	136516	132423	128193	123970	119701	115395	111074
	65000	152864	148510	144082	139619	135157	130670	126086	121486	116831	112156	107435
	70000	152864	148173	143397	138585	133793	128903	123970	118985	113953	108896	103777

Table 3.6.3. Bay of Biscay anchovy: Catch options for 2022 under the assumption that 60% of the catches were taken in the first semester.

		STOCHASTIC	DETERMINISTIC
Basis	Catch 2022	$P(SSB_{2022}<Blim)$	SSB_{2022}
G3 with hr=0.4	33000	<0.0001	135124
Zero catches	0	<0.0001	148521
Same deterministic harvest rate as 2022 (0.1355428)	19086	<0.0001	140813
$P(SSB_{2022}<Blim)=0.05$	174843	0.0498	72839
Other options	5000	<0.0001	146511
	10000	<0.0001	144496
	15000	<0.0001	142472
	20000	<0.0001	140441
	25000	<0.0001	138402
	30000	<0.0001	136355
	35000	<0.0001	134301
	40000	<0.0001	132237
	45000	<0.0001	130166
	50000	<0.0001	128087
	55000	<0.0001	125999
	60000	<0.0001	123902
	65000	<0.0001	121796
	70000	<0.0001	119682

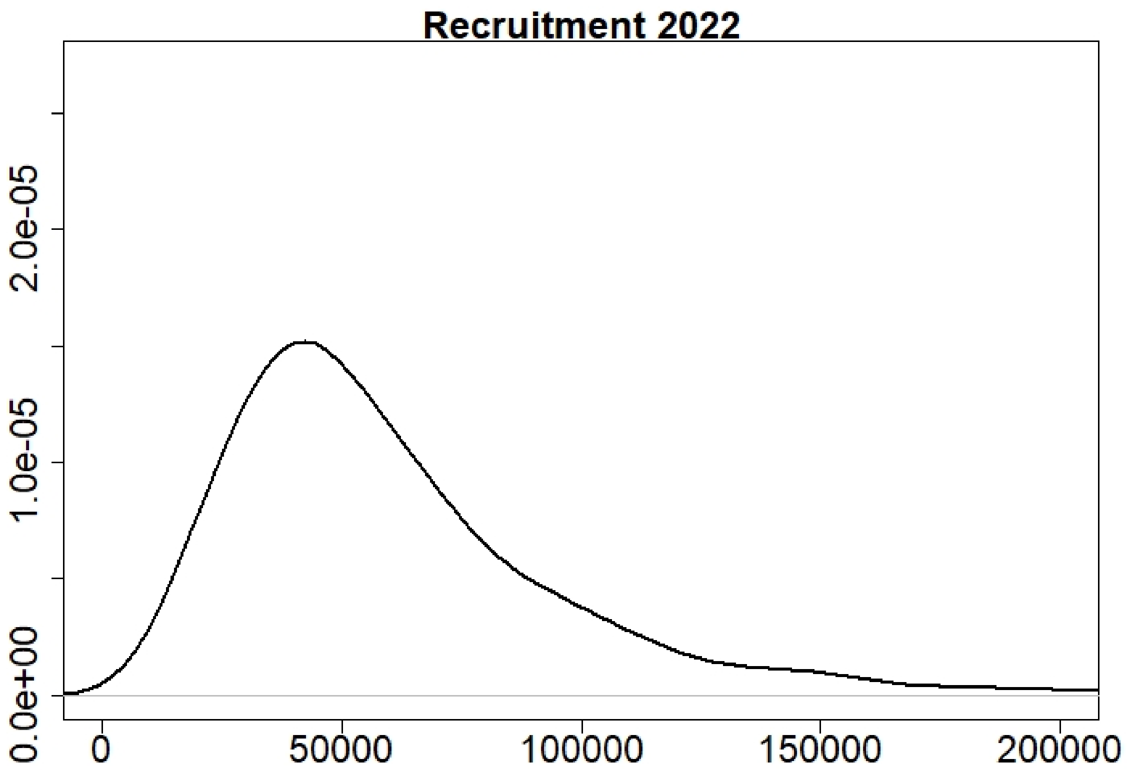


Figure 3.6.1. Bay of Biscay anchovy: Posterior distribution of recruitment (age 1 biomass at the beginning of the year) in 2022.

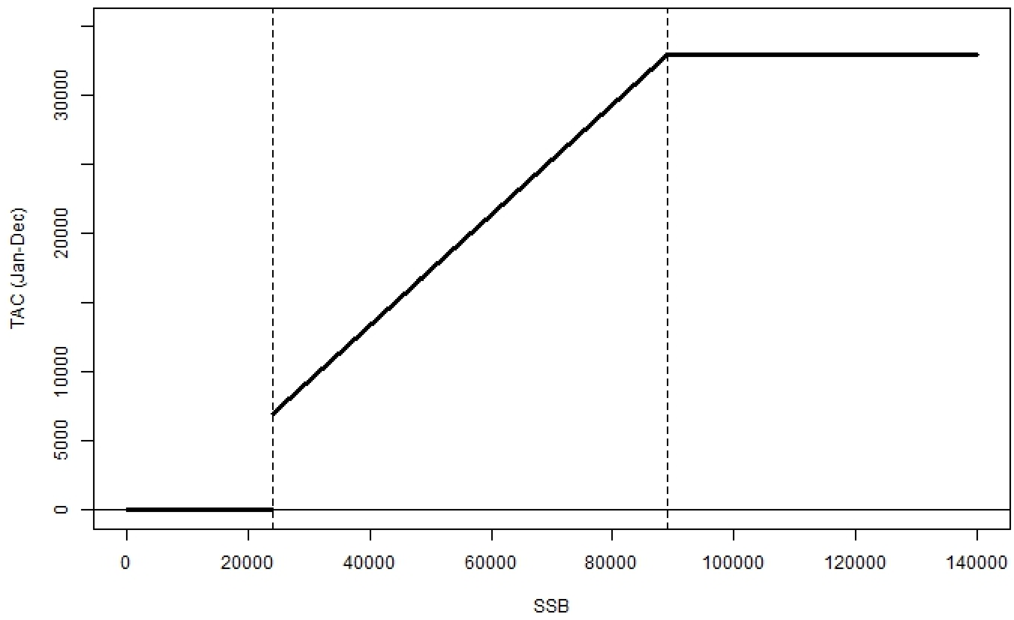


Figure 3.6.2. Bay of Biscay anchovy: Harvest control rule G3 with harvest rate of 0.4 according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

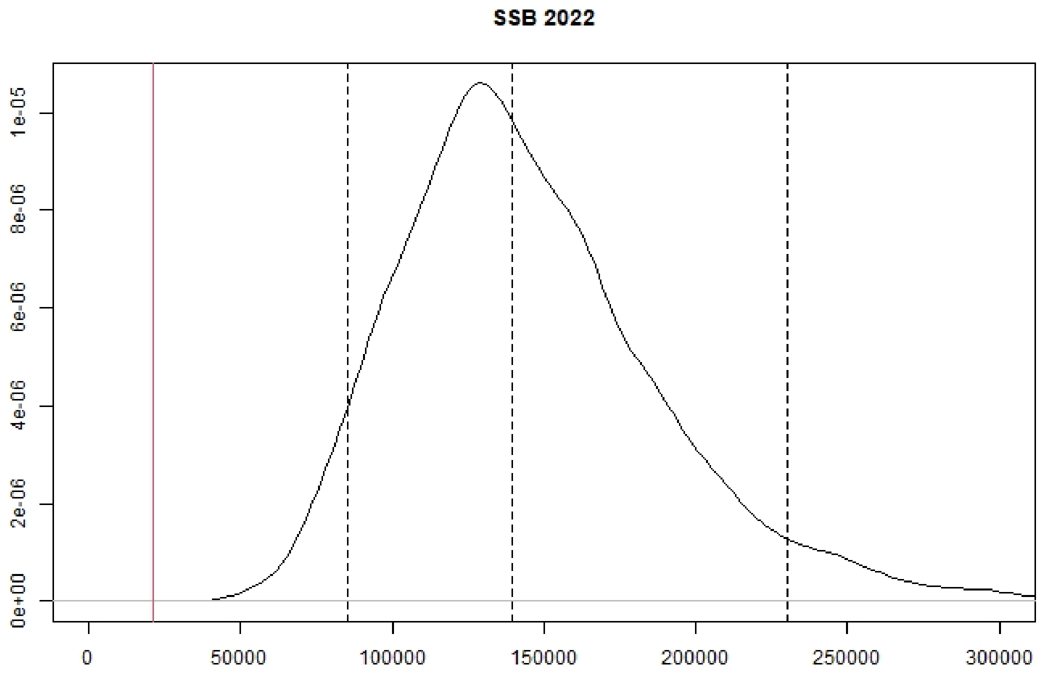
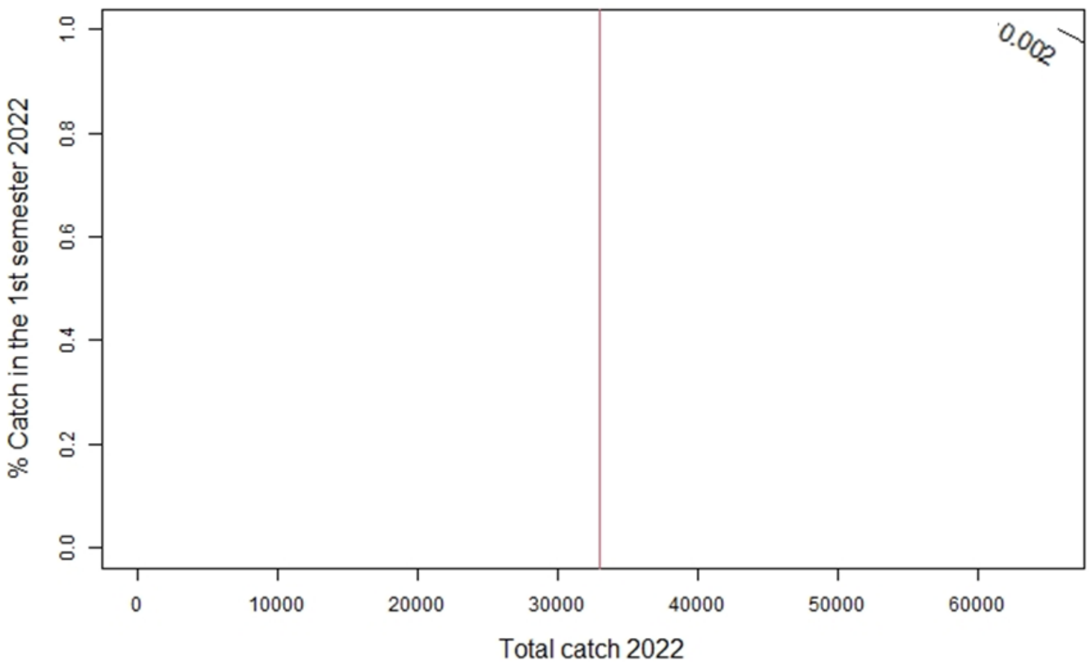


Figure 3.6.3. Bay of Biscay anchovy: Posterior distribution of SSB in 2022 if the annual catch is set according to the LTMP at 33 000 t and 60% of the catch is taken during the first semester. Vertical black dashed lines represent the 5, 50 and 95 posterior quantiles, whereas the red vertical line is B_{lim} (21 000 t).



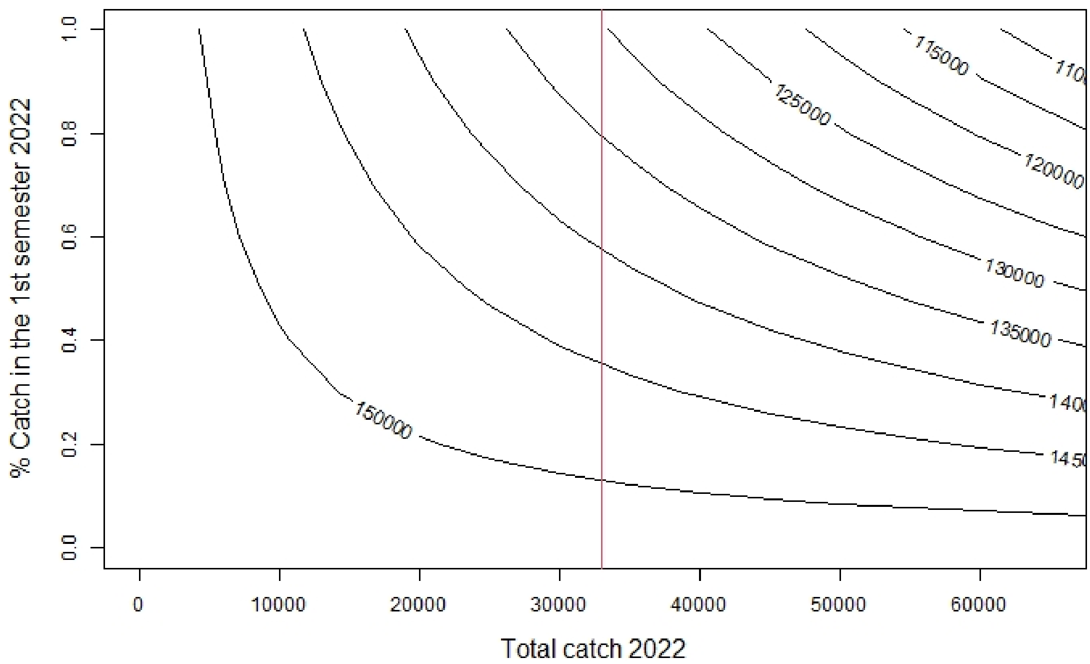


Figure 3.6.4. Bay of Biscay anchovy: Contour plots of probability of SSB in 2022 being below B_{lim} (on the top) and median SSB in 2022 (on the bottom) depending on the total catch in 2022 (x-axis) and the % of the catch in the first semester (y-axis). The vertical red line is set at 33 000 t.

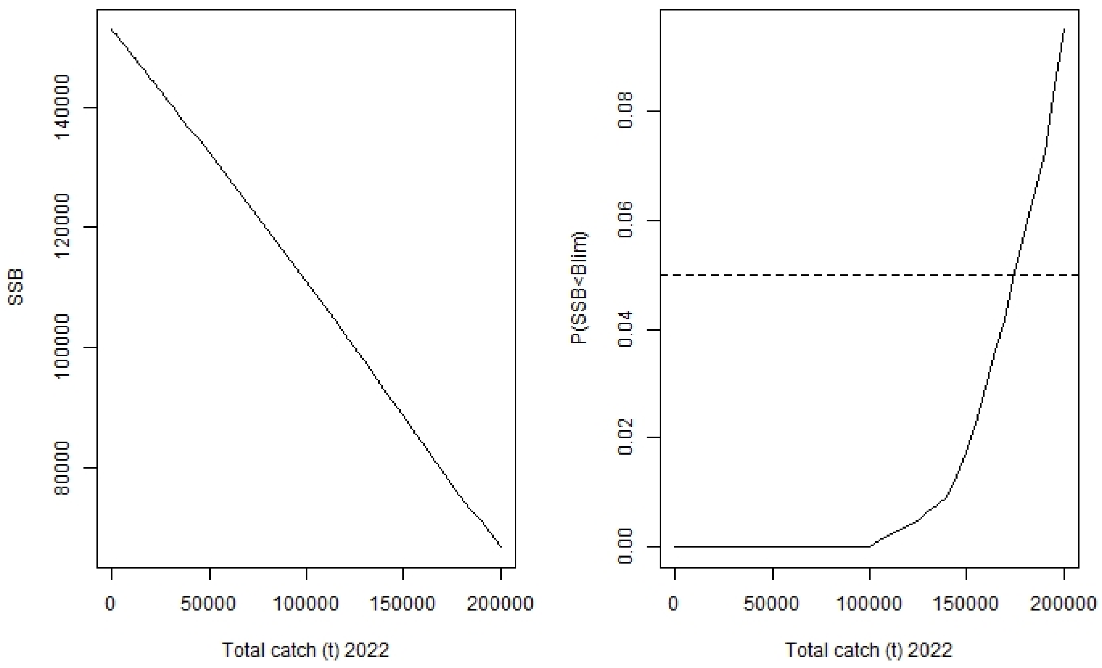


Figure 3.6.5. Bay of Biscay anchovy: SSB in 2022 (on the left) and probability of SSB in 2022 been below B_{lim} (on the right) depending on the total catch taken in 2022 when 60% of the catch is taken during the first semester.

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 provides 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 (Southwestern 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.

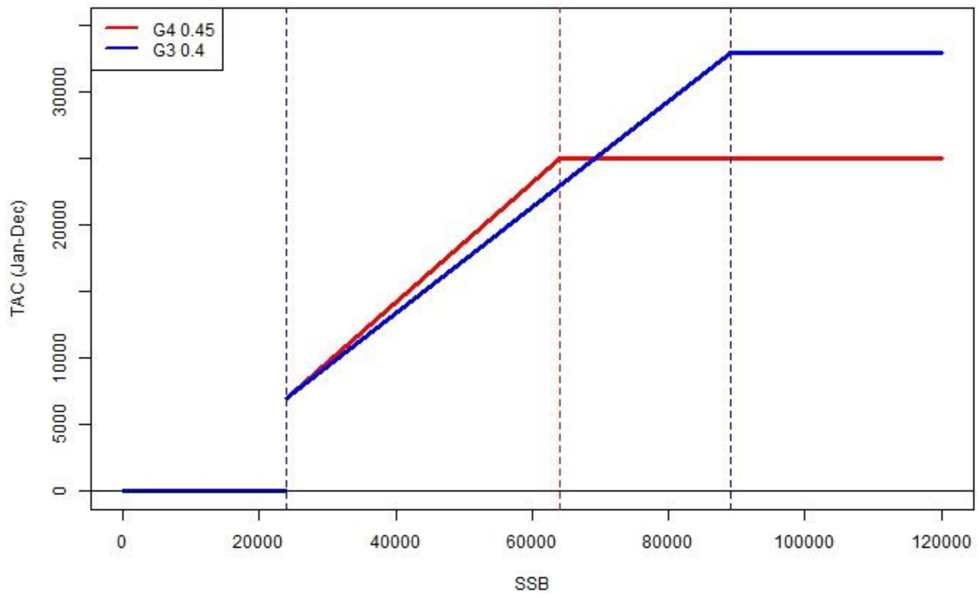


Figure 3.7.3.1. Bay of Biscay anchovy: Harvest control rules G4 with harvest rate of 0.45 (in red) and G3 with harvest rate of 0.4 (in blue) according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

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. In 2021 all the surveys (PELGAS, BIOMAN and JUVENA) were conducted.

3. **Missing or deteriorated catch data:**

The sampling programs coordinated by the IEO were suspended partially in 2020 due to administrative problems and to the Covid-19 disruption. As a result, no length frequency distributions were available for 91% of the 2020 Spanish catches.

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

Not applicable.

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

There was 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.

Numbers-at-age for the Spanish catches that were lacking the length sampling were derived from the sales notes by commercial size category. Biological samples from commercial catch collected by AZTI and from various Spanish research surveys were used to convert the commercial sizes into ages and to estimate the weight-at-age.

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, in 2020, 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. See WGHANSA ICES 2020.

The methodology to estimate catch-at-age and weight-at-age from the sales notes by size category distribution has been used previously by the working group to obtain preliminary catch-at-age estimates for the first semester of the assessment year and it is considered reliable. So, the impact on the quality of the catch-at-age and weight-at-age estimates is expected to be low.

4 Anchovy in Division 9.a

4.1 ACOM Advice Applicable to the management period July 2020–June 2021

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 consider 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 2020 to 30th June 2021 that when the precautionary approach is applied, catches from the western component should be no more than 4347 t and catches from the southern component should be no more than 11 322 t (no more than 15 669 t for the whole stock). The TAC for this same management period was agreed in 15 669 t (Portugal: 8175 t; Spain: 7494 t).

Official anchovy landings in the division in 2020 were of 12 852 t. Estimated total catches were 12 956 t. Provisional estimated catches for the current management calendar are 11 204 t (western component: 5421 t; southern component: 5784 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 summarized above 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 2020 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 2020

4.3.1 Fishing fleets

Anchovy harvesting throughout the Division 9.a was carried out in 2020 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).

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 2020 by a total of 68 vessels. From this total, 54 vessels (79%) were purse-seiners (**Table 4.3.1.1**). The Portuguese fleet targeting anchovy and operating in the Western component in 2020 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 2020, GoC anchovy fishing was practised by 66 purse-seiners, entailing an 18% increase in comparison with the number of purse-seiners targeting anchovy in 2019 (56 vessels), but still lower than 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 WGHANSA reports. The Portuguese fleet targeting anchovy and operating in the Southern component in 2020 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 2020 was estimated at 12 956 t, which represented an 18% increase on the catches landed in the previous year (11 014 t), and is still among the most recent historical maxima recorded in the last years (since 2016; **Table 4.3.2.1.1**, **Figure 4.3.2.1.1**). The above estimate is the result from adding up 12 851 t of official landings and 105 t of discards (see **Section 4.3.3**).

As usual, the anchovy fishery in 2020 was almost exclusively harvested by purse-seine fleets (98.2% 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 2014–2020.

Provisional official landings during the first semester in 2021 amounted to 1565 t (updated until 30th April for the Portuguese fishery and until 11th May for the Spanish one). Preliminary, 37% of the official landings from the Spanish fishery in 9a S in January–May (mean 2009–2020) were added to account for catches in June 2021 not yet reported. After such computations, the official landings during the first semester in 2021 were estimated in 2123 t.

Provisional catches during the current management period (July 2020–June 2021), as the result of summing up total catches from the second semester in 2020 and provisional official (estimated) landings from the first semester in 2021, amounted to 11 204 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 2020 catches by subdivision is shown in **Table 4.3.2.2.2**.

Western component

The total catch in 2020 for this stock component was estimated at 5639 t, which accounted for 9% decrease on the 2019 catch (6200 t) and represented 43.9% of the total catch in the division. This 2020 estimate is the sixth historic high since the one recorded in 1995 and is well above the historical mean (2011 t). The fractions composing this total catch in 2019 were: 5639 t of official landings and 0 t of discards.

Provisional official landings during the first semester in 2021 amounted to 55.7 t.

Provisional catches during the current management period (July 2020–June 2021) amounted to 5420 t.

The distribution of these catches by subdivision is as follows:

Subdivision 9a North

In this Spanish subdivision a total of 309 t was caught in 2020, which is lower than catch levels estimated the previous year (991 t). These catches accounted for 5.5% of the total catch estimated for the Western component and 2.4% for the whole division. Purse seiners were the main responsible for the fishery (97.5% of the total catch in the subdivision). The fishery was concentrated in the third and fourth quarters.

Provisional official landings during the first semester in 2021 amounted to 53.5 t (up to 11th May 2021). Those ones from 2020 corresponding to the current management calendar amounted to 288 t.

Subdivision 9a Central-North

This subdivision concentrated a great part of the anchovy fishery in 2020, both in relation to the whole division (41.1%) and to the Western component (94.5%): a total catch of 5327 t was estimated (with all of these catches corresponding to official landings; neither unallocated nor discarded catches were reported). These catches represented a 2.3% increase on the catches estimated the previous year (5205 t), but they still are among the successive historical maxima recorded since 2016 on. Purse-seiners practically harvested the whole fishery, mainly during the third and fourth quarters in the year.

Provisional official landings during the first semester in 2021 amounted to 1.94 t (up to end of April). Official landings during 2020 for the current management calendar were 5075 t.

Subdivision 9a Central-South

Anchovy catches from this subdivision were only 2.4 t (all of them official landings), accounting for a 39% decrease in relation to the catches in 2019 (4 t) and staying this value close to its historical minima. Such catches accounted only for 0.04% of the total catch in the Western component and 0.02% on the total catch in the division. The fishery was mainly harvested by purse-seiners, mostly during the third quarter.

Provisional official landings during the first semester in 2021 (up to end of April) in this subdivision amounted to 0.23 t. Official landings during 2020 for the current management calendar were 2.3 t.

Southern component

Subdivision 9a South

The total catch in 2020 of this stock component was estimated at 7317 t, which accounted for a 52.0% increase with respect to the 2020 catch (4814 t) and represented 56.5% of the total catch in the division. The fractions composing this total catch in 2020 were: 7212 t of official landings (Portugal: 155 t, Spain: 7058 t) and 105 t of (Spanish) discards. Discards estimates may be slightly underestimated since the above estimate only corresponds to the discards in the second semester in 2020. Covid-19 disruption and the interruption of the IEO’s at-sea sampling program during the first semester in 2020 because administrative reasons prevented from estimating discards during that semester. Nevertheless, discards in the first semester 2020 have been assumed to be negligible after checking the seasonal estimates throughout the time-series.

Almost the whole of the total catch (99.9%) was captured by the purse-seine fleet.

The fishery was concentrated during the second and third quarters in the year, mainly in the third one.

Provisional official landings during the first semester in 2021 amounted to 1512 t (4 t from the Portuguese fishery, 1508 t from the Spanish one). Preliminary; 558 t, corresponding to 37% of the Spanish official landings in January–May (mean 2009–2020), were added to the Spanish data to account for landings in June 2021 not yet reported. So, the total estimated “official” landings for the first semester in 2021 amounted to 2070 t. Official landings and total catches during 2020 in the subdivision for the current management calendar were 3611 t and 3716 t, respectively. Preliminary estimates for catches for the current management calendar (July 2020–June 2021) amounted to 5784 t.

4.3.3 Discards

See the stock annex for previously 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).

Covid-19 disruption and the interruption of the IEO’s on-shore and at-sea sampling programmes during the first semester in 2020 because administrative and budgetary reasons prevented from estimating discards during that semester in the Spanish fisheries in subdivisions 9a N and 9a S.

Average discards estimates (in t) in Subdivision 9a N for the available time-series (2014–2019) show that quarterly discards could be considered, for the time being, as negligible, almost null. The same considerations have also been applied to the discards in the Spanish fishery in 9a S. Therefore, discards in Q1 and Q2 in 2020 (not sampled) will be considered equal to 0.

Western component

Subdivision 9a North

Bearing in mind the above assumptions, no discards have been recorded during 2020 in the Subdivision 9a N. The overall annual discard ratio for the Spanish fishery in this stock component in 2019 was 0.0006 (0.06%) and may be also considered in 2020 as negligible as described above.

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.

Discards in the Spanish fishery were only sampled during the second semester in 2020. Discards were only recorded in the fourth quarter and corresponded to the bottom trawl fishery (**Table 4.3.5.1.6**). The estimated discards (105 t) represented a discard ratio for that second semester of 0.03 (2.7%) and may be considered as a relatively very low ratio.

Contents

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 experienced a strong decrease since 2017, which was coupled to a parallel decrease in catches. A relatively stable trend in effort (with some increase in 2020) has been recorded during the 2018–2020 period, which was coupled with steeply increasing catches which resulted in an increasing trend in lpue in the very recent years (from less than 1 t to at around 1.2–1.7 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 S), since the anchovy fishery in the division is traditionally concentrated there. Data from the Spanish fishery in Subdivision 9.a N 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 S (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 N and C-N 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 C-N) since 2018 to have monthly biological data of anchovy in that area that represents the bulk of catches in the western component.

Quarterly LFDs and ALKs in 2020 have not been provided for the Spanish fishery in Subdivision 9.a N because the interruption of the on-shore and at-sea sampling programmes coordinated by the IEO during most of 2020 due to administrative and budgetary problems and, in a lesser extent, to Covid-19 disruption. Biological sampling at laboratory was also seriously affected by the above reasons. These problems will be described in more detail in **Section 4.14**. Quarterly catches from 9a N were raised to the adjacent 9a CN quarterly LFDs and ALKs.

The above problems also affected to the provision of quarterly LFDs and ALKs from the Spanish fishery in Subdivision 9.a S, but in this case, the data gaps occurred only during the first semester in 2020. LFDs in the first (Q1) and second (Q2) quarters in 2018 and 2019 showed statistically significant similar between them and different from the homologous quarters in previous years. LFDs from the same quarter were then pooled for 2018 and 2019 and the resulting LFDs were raised to the corresponding quarterly catches in 2020. The *PELAGO 20* ALK was applied to both quarterly LFDs for the age structuring of catches.

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 0.04% and 3% of the Portuguese catches occurred in the 9.a Central-South and 9.a South (Algarve) subdivisions, respectively.

Catch-at-age data in 2020 have only been provided for the Portuguese fishery from Subdivision 9.a C-N. No age structure is available for 2020 Portuguese anchovy catches in subdivisions 9.a C-S and 9 a. S (Algarve), related to the low catches observed in those areas.

4.3.5.1 Length distributions

Western component

Subdivision 9.a North

No length or age composition is available from the Spanish fishery in this subdivision, hence the raising and further pooling processes applied in order to obtain overall LFDs by quarters were done using the data from purse-seine fishery in the Portuguese Subdivision 9.a C-N. Quarterly and annual size composition of anchovy catches for the purse-seine and for the whole fishery in the Subdivision 9.a North in 2020 are shown in **Tables 4.3.5.1.1** and **4.3.5.1.2**. Size range in catches from the whole fishery varied between 10.5 and 18.5 cm size classes (mode at 16.5 cm size class), with an annual mean size and weight in catches being estimated at 16.1 cm and 28.6 g, respectively.

Subdivision 9.a Central-North

The available size compositions of 2020 anchovy catches from the Subdivision 9.a Central-North are shown in **Tables 4.3.5.1.3** and **4.3.5.1.4**. 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 >97% 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 16.5 cm size class), with an annual mean size and weight in catches being estimated at 16.2 cm and 28.9 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 2020 by métier/fraction and for the whole fishery are shown in **Tables 4.3.5.1.5** to **4.3.5.1.7**. Size range of the exploited stock (landings plus discards) in the whole fishery varied between 6.5 and 17.0 cm size classes, with the modal class at 12.0 cm size class. Anchovy mean length and weight in the Spanish 2020 annual catch (12.0 cm and 11.5 g) were somewhat higher than in previous years but 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

No estimate from this subdivision in 2020 has been provided to this WG for the reasons explained above. Therefore, the raising and further pooling processes applied in order to obtain overall ALKs by quarters were done using the data from purse-seine fishery in the Portuguese Subdivision 9.a C-N. Estimates from the fishery in this subdivision in 2020 are shown in **Table 4.3.5.2.1**. These estimates are shown together with the age structure 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 2020 was of 9.8 million fish, composed by ages 1, 2 and 3 anchovies, with age- 1 and 2 olds accounting for 57% and 41% of the total catch, respectively.

Subdivision 9.a Central-North

Estimates from the fishery in this subdivision in 2020 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 2020 was of 164 million fish, composed by 1, 2 and 3-year old anchovies, which accounted for 41%, 42%, and 15% of the total catch, respectively.

Subdivision 9.a Central-South

No estimate from this subdivision in 2020 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 2020. Total catches in the Spanish fishery in 2020 were estimated at 599 million fish, which accounted for a 35% increase in relation to the 446 million caught during the previous year. Such an increase was mainly caused by 20%, 41% and 63% increases of ages 0, 1 and 2 respectively. Age 1 group is still the dominant age group (62% of the total catch in numbers). Age group 3 anchovies were present but incidentally 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 data series 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

No estimate from this subdivision in 2020 has been provided to this WG for the reasons explained above. Therefore, the raising and further pooling processes applied in order to obtain overall ALKs by quarters were done using the data from purse-seine fishery in the Portuguese Subdivision 9.a C-N. The resulting estimates for the fishery in 2020 are shown in **Tables 4.3.6.1** and **4.3.6.2**. Anchovy mean length and weight in the catches were 16.1 cm and 28.4 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 2020, 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 2020 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 north-western Portugal were 16.2 cm and 28.9 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 above problems also affected to the provision of quarterly LFDs and ALKs from the Spanish fishery in Subdivision 9.a S, but in this case, the data gaps occurred only during the first semester in 2020. LFDs in the first (Q1) and second (Q2) quarters in 2018 and 2019 showed statistically significant similar between them and different from the homologous quarters in previous years. LFDs from the same quarter were then pooled for 2018 and 2019 and the resulting LFDs were raised to the corresponding quarterly catches in 2020. The *PELAGO 20* ALK was applied to both quarterly LFDs for the age structuring of catches.

The problems with the length and age sampling from the Spanish fishery in 2020 and the raising procedures followed to fill the gaps has been described in the introductory text of this **Section 3.5**. The 2020 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 2020 annual catches were estimated at 12.0 cm and 11.5 g respectively, values close to those recorded 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) and Massé *et al*. (2018).

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 has been conducted in summer 2020

The next survey will be conducted in July 2023.

BOCADEVA 0720

BOCADEVA 0720 DEPM survey was carried out on board RV *Ramón Margalef* (IEO) between 9th and 17th July 2020 surveying the Spanish and Portuguese waters of the Gulf of Cadiz between the 20 and 200 m isobaths. PairoVET plankton samples, which were obtained from a grid of 21 parallel and 8 nm interspaced transects perpendicular to the coast, were utilised for the delimitation of the spawning area, and the estimation of egg densities required for the estimate of the daily egg production. The fishing hauls providing samples for the estimation of adult parameters (sex ratio, female mean weight, batch fecundity and spawning fraction) were carried out during the *ECOCADIZ 2020-07* acoustic-trawl survey, a survey which was conducted two weeks after than the egg survey. A summary of the survey's results is given by Ramos *et al*. (Presentation, 2020).

A total of 162 PairoVET stations were carried out, with 86 stations (53%) showing presence of anchovy eggs (positive stations), which yielded a total of 2916 anchovy eggs, with total and maximum egg densities estimated at 33 874 and 6162 eggs/m^2, respectively. Anchovy eggs showed a patchy distribution along the surveyed area and they were mainly located between Bay of Cadiz and Guadiana river mouth, showing the highest egg densities in the outer shelf waters in front of Doñana coast (**Figure 4.4.1.1**). The total spawning area (*A*+) was estimated at 10 058 km^2, the highest estimate in the time-series, evidencing a noticeable increase in relation to the previous surveys. Daily (P_0, 523 eggs/m^2/day) and total egg production (P_{total}, 5.26 eggs x10^{12}/day) estimates also rose up to their respective historical maxima (**Figure 4.4.1.2**). Adult parameters estimated so far did not show significant differences with the more recent estimates. The values of the mean estimates and their associated variances for the egg and adult parameters, and the SSB estimates are summarized in **Table 4.4.1.1**. Given that the spawning fraction estimate (*S*) is not yet available (the histological analysis is still in progress) and the constancy of the point estimates throughout the time-series, a provisional SSB estimate has been derived by using the time-series average of *S*. The resulting provisional SSB estimate, 81 466 t (CV=0.43), is the time-series historical record, evidencing a huge increase in relation to the previous estimates (**Figure 4.4.1.3**). The magnitude of this estimate contrasts not only with previous DEPM-based SSB estimates within its series, but also with the anchovy biomass estimates provided by the acoustic-trawl surveys surveying the Gulf of Cadiz in 2020 (between 36 and 50 kt depending on the survey; see sections below). Causes for such differences should be analysed in more detail within the frame of ICES WGACEGG once all the adult parameters are estimated.

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 **Figures 4.4.1.2** and **4.4.1.3**.

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. Survey methodologies deployed by the respective national Institutes (IPMA and IEO) are also thoroughly described in Massé *et al*. (2018) and Doray *et al.* (2021).

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 2020 and 2021 WGHANSA meetings.

PELACUS **series**

PELACUS 0321

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 subsurface 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) or in fish accessibility, catchability or selectivity (trawl) were detected, and therefore similar performance for both vessels was assumed.

PELACUS 0321 was conducted between 28th March and 18th April 2021 on board the RV *Miguel Oliver*. Sampling grid this year was based on acoustic transects separated 10 nm, between 20 and 1000 m depth, and with random start in each of the geographical strata, which correspond to the ICES subareas. Two control areas started this year to be surveyed in Central Cantabrian Sea to monitor mesopelagic fish. Anchovy schools (and eggs) were present in all the prospected area, although 90% of the total biomass (and 93% in number) were found in the inner Bay of Biscay. **Figure 4.4.2.1** shows the species contribution (% in number) in each of the valid hauls performed in 9.a N. A total of 6.6 t anchovies were caught in the whole surveyed area, corresponding to 455 485 specimens, of those 3057 were measured (56 kg of fish). Sardine, with a presence in 63% of the fishing hauls accounted for the 38% of the total catch in number (**Table 4.4.2.1**). Anchovy was caught in 56% of the trawl hauls, and represented 45.9% of total catch number. On overall mean length in the catch was 15.92 cm. **Figure 4.4.2.2** shows the distribution area and density derived from the NASC values attributed to this fish species in the subdivision 9.a N. In the same way, egg density, as collected by CUFES, was scarce, but matching well with the distribution obtained from acoustic.

A total of 6075 t, corresponding to 358 million fish were estimated in the Subdivision 9.a N, corresponding to the second highest value of the *PELACUS* time-series (**Table 4.4.2.2**). The bulk of the biomass belonged to age group 1 (75% in biomass, 82% in number). **Figure 4.4.2.3** shows the estimated abundance and biomass by length class, while in **Figure 4.4.2.4** the estimates are shown by age group. **Figure 4.4.2.5** shows the time-series (1996–2021) of anchovy biomass estimates from *PELACUS* in area 9.a N.

PELAGO series

PELAGO 21

The *PELAGO 20* survey was conducted this year between 3rd and 21st March on board RV *Miguel Oliver*. Seventy-one (71) transects were acoustically sampled between Caminha and Cape Trafalgar. A total of 38 pelagic trawl hauls were carried out by the research vessel, 26 additional hauls were done by two purse-seiners. The distribution and species composition of all of these hauls are shown in **Figure 4.4.2.6**.

Regarding the mapping of acoustic energy, anchovy was found in both extremes of the distribution area (9.a CN and 9.a S (CAD)), with only few fish in both 9.a CS and 9.a S (ALG) (**Figure 4.4.2.7)**.

Anchovy acoustic estimates for the whole surveyed area were 5082 million fish and 73 673 t.

In 9.a Central-North were estimated a total of 3069 million fish and 53 513 t, an estimate which represents the second highest peak of abundance and the first of biomass of the time-series. The estimated population in this subdivision ranged between 9.5 and 18.5 cm size classes, with a main mode at 14.5 cm size class (**Figure 4.4.2.8**). The assessed population abundance from this subdivision was structured by Age-1, Age-2, Age-3 and Age-4 fish, with the Age-1 being the dominant age (58%), followed by Age-2 fish (34%), Age-3 (7%) and Age-4 (0.2%) fish (**Figure 4.4.2.9**).

Anchovy population in 9a Central-South was supported by 519 million fish and 6095 t, showing a size range between 11.0 and 19.5 size classes, with a 14.5 cm modal size, and with a predominance of Age 1 individuals (78%), followed by Age 3 (17%), Age 3 (5%) and Age 4 (0.1%) (**Figures 4.4.2.8** and **4.4.2.9**).

In the Subdivision 9.a South, with values of 5639 million fish and 49 787 t (**Table 4.4.2.3**), the Spanish waters concentrated most of the population. In 9a South-Algarve were estimated a total of 89 million fish and 1798 t (**Figure 4.4.2.8**). 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 4.4.2.9**).

In 9a South-Cadiz were estimated a total of 5550 million fish and 47 998 t (**Figure 4.4.2.8**). 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 4.4.2.9**).

Table 4.4.2.3 and **Figure 4.4.2.10** 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. In 2021, anchovy had a 14% increase in abundance (19% in biomass), representing the highest biomass of the historical series. Anchovy in 9.a Central-South had low abundances in the past and had a 3 order of magnitude increased in number and biomass. Biomass levels in the Subdivision 9.a South, after experiencing an increasing trend started in 2018 decreased 72% in number and 74% in biomass since last year (**Figure 4.4.2.10**).

Figure 4.4.2.11 shows the age structure of the population estimates in the western component. Age 1 anchovies constitute the bulk of the population in spring (61%), followed by age 2 (32%), 3 (7%) and Age 4 was present in very low numbers. Strong incoming recruitments seem to be inferred in 2020, 2019, 2018 and 2019, although 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 4.4.2.5** and **Figure 4.4.2.12** 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 Southern component 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. Conversely, the 2020 year class shows again a low strength.

ECOCADIZ series

ECOCADIZ 2020-07

The *ECOCADIZ 2020-07* survey was conducted by IEO between 01st and 14th August 2020 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 26 valid fishing hauls (between 36–191 m depth) were carried out for echotrace ground-truthing purposes. Four additional night trawls were conducted to collect anchovy hydrated females (DEPM-adult *ad hoc* sampling) (**Figure 4.4.2.13**). CUFES sampling was not used in the survey since it was used in the previous *BOCADEVA 0720* anchovy DEPM survey. A census of top predator species was also carried out along the sampled acoustic transects. A total of 158 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 characterize the surveyed area. A detailed description of the *ECOCADIZ 2020-07* survey methods and results are given in Ramos *et al*. (WD 2021a).

Chub mackerel (*Scomber colias*) was the most frequent captured species in the fishing hauls, followed by mackerel (*S. scombrus*), anchovy, horse mackerel (*Trachurus trachurus*), bogue (*Boops boops*), sardine, blue jack mackerel (*T. picturatus*) and Mediterranean horse mackerel (*T. mediterraneus*). Round sardinella (*Sardinella aurita*), longspine snipefish (*Macrorhamphosus scolopax*), Atlantic pomfret (*Brama brama*) and transparent goby (*Aphia minuta*) showed a very low occurrence, whereas the occurrence of boarfish (*Capros aper*) and pearlside (*Maurolicus muelleri*) was incidental. Chub mackerel, anchovy and sardine showed the highest yields in these hauls (**Figure 4.4.2.13**).

The estimate of total NASC allocated to the "pelagic fish species assemblage" has shown a slight decrease in relation to the historical records in 2018 and 2019, mainly caused by the regional decrease in Spanish waters. However, both total and regional estimates are still above their respective historical averages. Such estimates are the result of the relatively high acoustic contributions of anchovy, sardine (both mainly in Spanish waters), and chub mackerel (in Portuguese waters).

Anchovy (35% of the total NASC attributed to fish) was widely distributed in the surveyed area, showing the highest densities between Cape Santa Maria and Bay of Cadiz. The *PELAGO 20* spring survey not recorded the species to the west of Cape Santa Maria (**Figure 4.4.2.13**).

Overall acoustic estimates in summer 2020 were 5153 million fish and 44 877 tonnes. By geographical strata, the Spanish waters yielded 91% (4714 million) and 83% (37 114 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 439 million and 7773 t. The current biomass estimate (44 877 t) becomes in the second historical maximum within the time-series (historical maximum in 2019: 57 700 t; **Table 4.4.2.4**, **Figure 4.4.2.14**). The *PELAGO 20* spring Portuguese survey previously estimated for this same area 49 787 t and 5639 million (Portuguese waters: 1789 t, 89 million; Spanish waters: 47 998 t, 5550 million). The *PELAGO 20* recorded increased biomass population levels in relation to those recorded the last year (29 876 t).

The size class range of the assessed anchovy population in summer 2020 varied between the 7.0 and 18.0 cm size classes, with two modal classes, the main mode at 11.5 cm and a secondary mode at 9.5 cm. The size composition of anchovy throughout the surveyed area confirms the usual pattern exhibited by the species during the survey 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 (**Figures 4.4.2.13** and **4.4.2.14**).

The population was composed by fish not older than two years. As it has been happening in the last years, during the 2020 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 74% and 57% of the total estimated abundance and biomass, respectively. Age 1 fish represented 26% and 41% of the total abundance and biomass (**Figure 4.4.2.15**).

Table 4.4.2.5 shows the time-series of population estimates at-age in the southern component estimated by *PELAGO* and *ECOCADIZ* surveys (see also **Figure 4.4.2.12**).

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 but the trend is so far not consistent with spring survey series.

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 previous to *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 0920

IBERAS 0920 was carried out on board RV *Miguel Oliver* from 9th to 30th September 2020. Further details are shown in Carrera *et al*. (2020). 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 85 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**). 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 backscattering acoustic energy from marine organisms was measured continuously during daylight except in the northern area, where some tracks were steamed at night.

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 3616 echotraces with a total NASC (sA) of 796 880 m^2 nmi^{-2}. On tracks, they were 3469 fish schools and NASC values were 608 124 m^2 nmi^{-2}, which was much higher than that recorded in 2019 (430 069). Fish schools occurred more or less in the same areas as recorded in 2019, with some of them (e.g. Ria de Muros or north Figueira da Foz) having an important contribution to the total backscattering. It should be noticed the amount of sardine found north Nazaré. Schools were denser than in the 2019 survey, with some schools with mean sV higher than -18 dB, and, although the number was also lower, the backscattering energy was higher than in 2019. Bathymetric distribution of schools was significantly different from that recorded in 2019, when the mode was located at 47.5 m, whereas during the 2020 survey was found at 27.5 m. The weighting average (weighting factor, sA) shifted from 37.53 (c.v. 0.38) to 32.35 (c.v. 0.36).

A total of 40 pelagic hauls were done as shown in **Figure 4.4.3.1**. This year, sardine accounted more than 50% of the total catch in weight, and was present in 83% of the hauls. On the contrary, anchovy only occurred in 17% of the hauls, with a small contribution in the total catch (0.5%).

Anchovy was found in 9.a N in the outer part of the surveyed area (e.g. close to the slope), while in 2019 it was absent from this area (**Figure 4.4.3.2**). It occurred in epipelagic schools, rather dense. This is the first time this near slope aggregation is recorded. Whether this behaviour is similar to that observed in the Bay of Biscay, where anchovy pre-recruits mainly occur offshore and then are approaching to the coast, once the size of the of fish is increasing, to finally recruit to the area located on the continental self, should be studied. However, given the complementarity between sardine and anchovy recruitment areas, it seems difficult to cover both during IBERAS given the duration of the survey.

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). Anchovy biomass in autumn 2020 was also low ($5*10^3$). However, while almost no recruits were assessed last year, this year recruits accounted for 98% of the total number of individuals (**Table 4.4.3.2**; **Figures 4.4.3.3** and **4.4.3.4**).

ECOCADIZ-RECLUTAS survey series

ECOCADIZ-RECLUTAS 2020-10

ECOCADIZ-RECLUTAS 2020-10 survey was conducted by IEO between 2nd and 21st October 2020 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 178 $CTDO_2$ 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 2021b).

The 21 foreseen acoustic transects were sampled. A total of 22 valid fishing hauls were carried out for echotrace ground-truthing purposes. From the pelagic fish species set, chub mackerel, anchovy, mackerel and sardine were the most frequent captured species in the fishing hauls, followed by bogue, horse mackerel, Mediterranean horse mackerel and blue jack mackerel. Boarfish, longspine snipefish and pearlside showed an incidental occurrence in the hauls performed in the surveyed area. Sardine, anchovy, chub mackerel and mackerel showed the highest yields (**Figure 4.4.3.5**).

Total and regional estimates of total NASC allocated to the "pelagic fish species assemblage" in this survey become the historical records in their time-series. Such estimates are the result of the relatively high acoustic contributions of sardine (both in Portuguese and Spanish waters), anchovy (in Spanish waters), and chub mackerel (in Portuguese waters). Sardine accounted for 57% of this total back-scattered energy, followed by anchovy (20%) and chub mackerel (14%), and the remaining species with relative contributions of acoustic energies lower than 4%.

GoC anchovy was widely distributed in the surveyed area, although higher densities were recorded between east of Cape Santa Maria and Bay of Cadiz (**Figure 4.4.3.5**). GoC anchovy acoustic estimates in autumn 2020 were of 3197 million fish and 36 070 tones (**Table 4.4.3.3**; **Figure 4.4.3.6**), entailing 42% and 25% decreases in abundance and biomass, respectively, in relation to the last year's estimates (5518 million, 48 398 t). Notwithstanding the above, the current overall estimates are either close (abundance) or above (biomass) the time-series average (i.e. 3270 million; 23 538 t). By geographical strata, the Spanish waters yielded 95% (3051 million) and 91% (32 780 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 145 million and 3290 t (**Table 4.4.3.3**; **Figure 4.4.3.6**).

The size class range of the assessed anchovy population in autumn 2020 varied between the 7.5 and 17.5 cm size classes, with two modal classes, the main mode at 9.5 cm and a secondary mode at 13.5 cm. The size composition of anchovy throughout the surveyed area confirms the usual pattern exhibited by the species during the survey 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 4.4.3.3**; **Figure 4.4.3.6**).

The population was composed by fish not older than three years. Age 0 fish accounted for 75% (2385 million) and 58% (21 060 t) of the total estimated abundance and biomass, respectively (**Table 4.4.3.3**; **Figure 4.4.3.7**). Spanish waters concentrated the bulk (99%) of this juvenile fraction. The estimates of age-0 fish experienced a similar decreasing trend than the one showed by the whole population in relation to the historical peak recorded the year before, but with values close to the time-series average. Age 1 fish represented 24% and 40% of the total abundance and biomass.

The time-series of survey estimates is shown in **Figure 4.4.3.8**. **Figure 4.4.3.9** 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.

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 (2020), as follows:

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

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, 2018a), 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 X (ICES, 2020a).

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.

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 2021 are described in Rincón *et al*. (WD 2021).

There are two model issues that were found this year regarding last year implementation. The first is that it was noticed that there was a length distribution data for *PELAGO* in year 2000 that was not part of the *PELAGO* survey time-series; it was data from another survey performed during that year in November. The second is that due to random optimization, the model results differ slightly on each trial. This was supposed to be solved by setting a seed number on the optimization algorithm, but a bug on the software does not allow to do it.

For this year, it was decided to remove the length distribution data on year 2000 from the *PELAGO* survey and to make different trials of the model and choose the more consistent with the models used for previous advices and with less likelihood score (better goodness of fit).

In addition, due to lack of information of length distributions and Age–length keys for commercial catches in the first and second quarter of 2020, for this year the length distribution was approximated using the joint distribution of 2018 and 2019 and the Age–length key used was the one for the *PELAGO 2020* survey.

4.6.2.1.1 Data input

Data input for optimization routines is summarized in **Table 4.6.2.1.1.1**. It corresponds to all the information of the fishery available until the end of June of 2021, together with data from *ECOCADIZ* and *PELAGO* survey series up to 2020 and 2021, respectively.

Catches (landings +discards, discards from 2014 onwards) from Spain and Portugal are assumed to be removed from the population by only one fleet from 1989 to the second quarter of 2021. For the first two quarters of year 2021, provisional catches estimations of Spanish (until May 18th) purse-seine fleet were used and catches for June were estimated as the 37% of January to May catches based on historical records from 2009 to 2020.

4.6.2.1.2 Model fit

A summary of the goodness of fit of model estimations compared with data is shown in **Figures 4.6.2.1.2.1**, **4.6.2.1.2.2**, **4.6.2.1.2.3** (length distributions), **4.6.2.1.2.5**, **4.6.2.1.2.6** and **4.6.2.1.2.7** (age distributions). These figures show that length and age frequency distributions of catches and surveys match reasonably well with available data. Goodness of fit for length distribution of catches (**Figure 4.6.2.1.2.1**) is better in the last 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 year 2013 for the *ECOCADIZ* survey (**Figure 4.6.2.1.2.2**) and for most of the years for *PELAGO* survey; in this survey series the length distribution fit is better for years 2000, 2005, 2008, 2017–2020 (**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 years 2014, 2017 and 2020 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 benchmark model implementation.

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

4.6.2.1.3 Model estimates

Parameter estimates after optimization are presented in **Table 4.6.2.1.3.1**, while **Figure 4.6.2.1.3.1** presents model annual estimates for abundance (removing Age-0 individuals to be accurate with the time of the assessment), recruitment, fishing mortality and catches at the end of the second quarter of each year. **Figure 4.6.2.1.3.2** shows annual estimates for biomass of individuals of Age-1+ at the end of the second quarter of each year. Due to some inconsistencies in the maturity ogives not noticed during WKPELA 2018, we assume that all individuals with Age 1 or older (B_{1+}) are mature, *i.e.* these biomass estimates result equivalent to spawning stock biomass estimates. The SSB estimates used for 2021 advice are those corresponding to years 2019, 2020 and 2021, with values of 4426, 5891 and 3276 t, respectively (**Figure 4.6.2.1.3.2**). Detailed model outputs are available at https://github.com/ices-taf/2021_ane.27.9a_assessment/tree/main/results, where each file corresponds to the following description:

- sidat: model fit to the survey indices.
- suitability: model estimated fleet suitability.
- Stock–recruitment: model estimated recruitment.
- res.by.year: results by year.
- catchdist.fleets: data compared with model output for the length and age–length distributions.
- stock.full: modelled abundance and mean weight by year, step, length and stock.
- stock.std: modelled abundance, mean weight, number by age consumed by the fleet, stock and year.
- stock.prey: consumption of the fleet by length, year and step.
- fleet.info: information on catches, harvest rate and harvestable biomass by fleet, year and step.
- params: parameter values used for the fit.

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 1483.48 t (corresponding to a relative B_{lim} equal to 0.316) and a B_{pa} of 2433 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 obtained this year.

4.8.2 Southern component

The SSB has been fluctuating without a trend over the time-series showing a decrease in the last year which is consistent with the trend on recruitment and survey biomass estimates, and with an increase of F. Time-series for recruitment and F are 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 2021 (65 683 t) and the average of the two preceding values of 2019 and 2020 (30 327 t), and the Advised Catch (July 2020 to June 2021, 4347 t). The index is estimated to have increased by 116% and thus the 80% uncertainty cap was 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 (3276 t) and the average of the two preceding values (5158.5 t), multiplied by the recent advised catches for 2020 (July 2020 to June 2021, 11 322 t). Following the guidelines presented in ICES (2020) an uncertainty cap of 80% was not applied. The index ratio is estimated to have decreased 37%, i.e. less than 80% and thus the uncertainty cap was not applied. Stock size has been above B_{pa} for the last years and without any trend. The advice rule with an uncertainty cap of 80% is considered precautionary and as such the precautionary buffer was not considered (ICES, 2020a). 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

At 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 X (ICES, 2020a), 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. The WG considers that the current Rule (1over2 with 80% UCap) cannot accommodate to the highly fluctuating biomass. For this reason, work is being carried out in the framework of WKDLSSLS to evaluate a new method to provide advice for this stock.

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.

A comparison with last year estimated time-series and also a sensitivity analysis regarding the assumption made for length and age-length distributions of the commercial catches in first and second quarters of 2020 (length distribution for those quarters was approximated using the joint distribution of 2018 and 2019 and the Age–length key used was the one for the *PELAGO 2020* survey) was performed and it is presented in **Figure 4.11.1.** This figure shows the annual model estimates for relative SSB of individuals with more than one year of age, relative fishing mortality, recruitment and catches (in tons) in the current model implementation (green line) compared with the one used for last year assessment (blue line) and another implementation without data for age–length key and length distribution for catches in first and second quarters of 2020 (pink line). It was observed that the estimated relative biomass for the last three years is higher when assuming the join length distribution of 2018 and 2019 together with the Age–length key of *PELAGO 2020* survey for first and second quarters of 2020, than assuming no data available for those quarters. Nevertheless, the estimates for those years are lower than the last year estimated relative biomass time-series.

During the meeting the group acknowledges that the estimated relative SSB time-series for this year (green line) had changed in comparison with the SSB time-series estimated last year (blue line). Even when the trend was the same, the estimates for 2020 and 2019 were lower. The discrepancy regarding 2020 estimate, was considered as expected considering that information for year 2020, in the assessment of 2020, was preliminary. However, for 2019, the estimates showed a big difference (being reduced to approximately 30% of the level in the past assessment in WGHANSA 2020).

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 2020 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 advice 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.

4.13 Ecosystem considerations

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

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

For this year assessment there were some deviations for the southern component of the stock but for the western component there were only deviations that were previously considered in the 2020 assessment. Those deviations in 2020 were related to missing survey data associated to *PELACUS* survey, details which were provided at ICES 2020b (WGHANSA 2020 report).

1. Stock: Anchovy 9.a southern and western components.
2. Missing or deteriorated survey data: NO
3. Missing or deteriorated catch data: The sampling programs coordinated by the Spanish Institute of Oceanography-IEO (on-shore, observers at-sea and biological sampling) were suspended partially in 2020 due to administrative problems and to the Covid-19 disruption. This affected all stocks. Anchovy discards in the Spanish fisheries in 9.a N (Western component) and 9.a S (Southern component) were not sampled in first semester in 2020.
4. Missing or deteriorated commercial *LPUE*/*CPUE* data: NO
5. Missing or deteriorated biological data: Missing length distributions (LFD) and age–length keys (ALK) for commercial catches during the whole year in 2020 for the Spanish fishery in the western component (9.a N) and for the first (Q1) and second (Q2) quarters in 2020 for the Spanish fishery in the southern component (9.a S). No missing data for the Portuguese fishery in the western component of the stock.
6. Brief description of methods explored to remedy the challenge: For the western component: 2020 quarterly LFDs and ALKs from the adjacent 9.a C-N were propagated to the quarterly Spanish landings from the 9.a N (without data), because their relative similarity and

geographical closeness. Anchovy discards from the Spanish fishery in 9.a N during Q3 and Q4 in 2020 were sampled and estimated as null. After checking the time-series of quarterly estimates was also assumed that discards during the first semester in 2020 are null. For the southern component: discards from the Spanish fishery in 9.a S during Q3 and Q4 were sampled and estimated. Time-series of quarterly discards estimates was also checked. It was also assumed that discards during the first semester in 2020 were negligible and they also might be considered as null. Quarterly LFDs from the Spanish fishery of the last five years were analysed; small differences for LFDs in the missing quarters suggest that the same quarter distribution from one of the previous years could be used instead. Statistical differences between those LFDs were tested. Regarding Age–length key, using *PELAGO 2020* key applied to catches was preferred because it was performed at the end of the 2020 first quarter; the age–length structure of the population estimated by this survey is the only data available for the age–length relationship on those missing periods. Length distribution of *PELAGO 2020* was not considered because of differences in the selectivity between the survey and the purse-seine fleet.

7. Suggested solution to the challenge, including reason for this selecting this solution: For the southern component: the join LFD of 2018 and 2019 for both missing quarters (Q1 and Q2) were chosen. The Kolmogorov-Smirnov test indicated that there is not enough evidence to say they are different LFDs ($p>0.05$ comparing the Q1 2018 and Q1 2019 LFDs, and $p>0.05$ comparing the Q2 2018 and Q2 2019 LFDs), and Fisher test indicated that year is related to length bins for both quarters ($p<0.05$). The tests results suggest both samples come from the same distribution, thus including both would provide a better representation of it. The Age–length key of *PELAGO 2020* was used for catches in those quarters considering that the survey was performed at the end of the first quarter, and that it is the only data sample available providing an estimation of the age–length structure of the population at that time.
8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? For the southern component: A sensitivity analysis to the assumption made regarding the missing length distributions and age–length keys was carried out and the resulting trend of both model implementations (with and without the assumption, see green and pink lines, respectively, in **Figure 4.11.1**) was similar, nevertheless the ratio between the last SSB value and the average of the two preceding values in the implementation considering the assumption is approximately a 30% higher than the ratio resulting from the other implementation.

4.15 References

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Table 4.3.1.1. Anchovy in Division 9.a. Composition of the Spanish fleets operating in Southern Galician waters (Western component, subdivision 9.a North) and in the Gulf of Cadiz (Southern component, Subdivision 9.a-South) targeting anchovy in 2020. 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						
2020	Vessels targeting anchovy					
	Engine (HP)					
Length (m)	0–50	51–100	101–200	201–500	>500	Total
≤10	8	1				9
11–15	5	12	6			23
16–20			5	4		9
>20			2	22	3	27
Total	13	13	13	26	3	68
Subdivision 9.a South						
2020	Vessels targeting anchovy					
	Engine (HP)					
Length (m)	0–50	51–100	101–200	201–500	>500	Total
≤10						
11–15	2	5	2	1		10
16–20		6	26	9		41
>20			3	11	1	15
Total	2	11	31	21	1	66

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 2020. 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						
2020	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						
2020	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						
2020	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. Discards estimates for the Spanish fishery are not available for the first semester 2020 because Covid-19 disruption and interruption of the IEO's observers at-sea sampling program. (*) Provisional official landings data for the 2021 first semester updated until 30th April (9a.CN, 9a.CS, 9a.S-ALG) –11th 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
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	309	5327	2	5639	155	7163	7317	12956
2021*	54	2	0	56	2	2066	2068	2124

Table 4.3.2.2.1. Anchovy in Division 9.a. Catches (t) by gear and subdivision in 1989–2020. 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. Discards estimates for the Spanish fishery are not available for the first semester 2020 because Covid-19 disruption and interruption of the IEO's observers at-sea sampling programme. Landings by gear in subdivisions 9.a C-N to S (PT) are not available by subdivision until 2009.

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

Subarea	Gear	2001	2002	2003	2004	2005	2006	2007	2008	2009
9.a N	Artisanal	0	0	4	1	0	0	0	1	0.1
	Purse-seine	27	21	19	2	4	15	4	4	18
9.a C-N to 9.a S (PT)	Demersal Trawl	16	13	7	5	7	27	14	9	4
	P. seine polyvalent	32	13	184	197	57	24	376	141	38
	Purse-seine	806	888	287	455	62	57	484	185	30
	Not different. By gear	-	-	-	-	-	-	-	-	-
9.a S (ES)	Demersal Trawl	36	23	14	6	0.2	0.4	0.3	0.1	0.02
	Purse-seine	8180	7847	4754	5177	4385	4367	5575	3168	2922

Subarea	Gear	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
9.a N	Demersal trawl	0	0	0	0	0	0.2	0	7	0.6	0.6	0
	Artisanal	4	0	1	6	0	21	6	6	0.4	0.1	0.1
	Purse-seine	175	541	37	63	581	152	217	1057	991	990	309
9.a C-N	Demersal Trawl	5	4	1	0.5	2	3	2	2	0,3	0.2	2
	P. seine polyvalent	45	1116	177	17	9	150	294	332	403	34	122
	Purse-seine	50	2119	342	175	668	2381	6613	8521	7468	5170	5203
9.a C-S	Demersal Trawl	1	1	0.4	1	3	2	1	0.2	1	0.02	0.02
	P. seine polyvalent	0	0.1	17	4	1	0.4	4	13	14	1	2
	Purse-seine	1	0.4	202	127	18	8	5	157	355	4	0
9.a S (PT)	Demersal Trawl	8	13	16	2	5	1	3	6	1	0	0.1
	P. seine polyvalent	4	33	0.1	2	0.04	0.02	0.04	0	0	0	1
	Purse-seine	17	33	41	63	113	1	16	20	65	113	153
9.a S (ES)	Demersal Trawl	0	0	2	0	99	33	118	204	90	209	105
	Artisanal	0	0	0	0	0	0.1	0.1	0.01	0	0	0
	Purse-seine	2901	6216	4752	5172	8835	6845	6463	4381	4343	4492	7058

Table 4.3.2.2.2. Anchovy in Division 9.a. Quarterly anchovy catches (t) by subdivision in 2020.

SUBDIVISION/ COMPONENT	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2020)	
	C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
9.a North	14	4,7	7	2,3	261	84,5	26	8,5	309	2,4
9.a Central North	253	4,7	0,01	0,0002	2629	49,3	2446	45,9	5327	41,1
9.a Central South	0	0,0	0,1	5,5	2	94,5	0	0,0	2	0,02
Western Comp.	267	4,7	7	0,1	2893	51,3	2472	43,8	5639	43,5
9.a South (PT)	2	1,0	67	43,5	74	47,6	12,2	7,9	155	1,2
9.a South (ES)	1285	17,9	2247	31,4	2530	35,3	1101	15,4	7163	55,3
Southern Comp.	1286	17,6	2315	31,6	2603	35,6	1113	15,2	7317	56,5
TOTAL	1554	12,0	2322	17,9	5496	42,4	3585	27,7	12956	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 (1988–2020). Increasing colour intensities denote increasing problems in sampling coverage of fishing effort.

Year	Landings	Effort	LPUE
1988	4263	4546	0,933
1989	5330	5726	0,920
1990	5726	6188	0,916
1991	5697	7641	0,737
1992	2995	5602	0,539
1993	1629	3008	0,476
1994	2883	3626	0,711
1995	495	1666	0,160
1996	1556	5568	0,224
1997	4376	4342	0,928
1998	7824	4949	1,476
1999	4594	6002	0,765
2000	2078	5902	0,352
2001	8180	6739	1,214
2002	7847	7543	1,040
2003	4754	6417	0,741
2004	5177	7095	0,729
2005	4386	5611	0,782
2006	4367	7224	0,605
2007	5575	6863	0,812
2008	3168	4540	0,698
2009	2922	4657	0,628
2010	2901	4345	0,668
2011	6196	6190	1,001
2012	4754	4739	1,003
2013	5172	6268	0,825
2014	6340	6365	0,996
2015	6701	5030	1,332
2016	6424	6016	1,068
2017	3636	3360	1,075
2018	4342	3515	1,207
2019	4490	3405	1,280
2020	7058	4063	1,685

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–frequency distributions ('000) of anchovy landings in 2020. Quarterly LFDs were not available. They have been estimated by raising landings from this métier to the respective quarterly LFDs from the métier PS_SPF_0_0_0 from subdivision 9.a C-N.

2020	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	31	15	0	0	46
11	31	15	0	0	46
11.5	31	15	0	0	46
12	31	15	0	0	46
12.5	31	15	0	0	46
13	31	15	0	0	46
13.5	31	15	61	0	106
14	62	30	543	24	658
14.5	68	33	301	0	403
15	68	33	1011	100	1213
15.5	68	33	1483	128	1713
16	38	18	1465	128	1649
16.5	38	18	1467	128	1651
17	38	18	1170	128	1354
17.5	38	18	0	104	160
18	38	18	465	52	573

2020 Length (cm)	Q1 9.a N	Q2 9.a N	Q3 9.a N	Q4 9.a N	TOTAL 9.a N
18.5	7	3	0	0	10
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	680	326	7988	794	9785
Catch (T)	14467	6979	261078	26839	309363
L avg (cm)	14.8	14.8	16.1	16.6	16.0
W avg (g)	21.0	21.0	20.0	31.2	28.6

Table 4.3.5.1.2. 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 2020. Discards in first semester were not estimated but assumed as null. Discards in second semester were sampled but they also were null, hence landings equal to catches.

2020	**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	31	15	0	0	46
11	31	15	0	0	46
11.5	31	15	0	0	46
12	31	15	0	0	46
12.5	31	15	0	0	46
13	31	15	0	0	46
13.5	31	15	61	0	107
14	62	30	543	24	659
14.5	69	33	301	0	403
15	69	33	1011	100	1213
15.5	69	33	1484	128	1714
16	38	18	1465	128	1649
16.5	38	18	1467	128	1651
17	38	18	1170	128	1354
17.5	38	18	0	104	160
18	38	18	465	52	573
18.5	7	3	0	0	10
19	0	0	0	0	0

2020 Length (cm)	Q1 9.a N	Q2 9.a N	Q3 9.a N	Q4 9.a N	TOTAL 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	678	327	7968	794	9767
Catch (T)	14.5	7.0	261.5	26.5	309.4
L avg (cm)	14.8	14.8	16.2	16.6	16.1
W avg (g)	21.0	21.0	29.1	31.2	28.6

Table 4.3.5.1.3. 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 2020. Discards are null; hence landings correspond to catches.

2020	**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	537	0	0	0	0.1
11	537	0	0	0	1
11.5	537	0	0	0	2
12	537	0	0	0	4
12.5	537	0	0	0	5
13	537	0	0	0	16
13.5	537	0	611	0	17
14	0	0	5469	2189	20
14.5	0	0	3040	0	23
15	0	0	10170	9130	24
15.5	0	0	14870	11691	22
16	0	0	14870	11691	22
16.5	0	0	14870	11691	22
17	0	0	11831	11691	22
17.5	0	0	0	9501	11
18	0	0	4701	4751	9
18.5	0	0	0	0	0.4
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	11818	0	80431	72334	164584
Catch (T)	253	0	2628	2446	5170
L avg (cm)	14.8	-	16.2	16.6	16.2
W avg (g)	21.0	-	29.0	31.2	28.9

Table 4.3.5.1.4. 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 2020. 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.

2020	**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	537	0	0	0	537
11	537	0	0	0	537
11.5	537	0	0	0	537
12	537	0	0	0	537
12.5	537	0	0	0	537
13	537	0	0	0	537
13.5	537	0	611	0	1148
14	1074	0	5469	2190	8733
14.5	1194	0	3040	0	4234
15	1194	0	10170	9130	20494
15.5	1194	0	14870	11691	27755
16	657	0	14870	11691	27218
16.5	657	0	14870	11691	27218
17	657	0	11831	11691	24179
17.5	657	0	0	9501	10158
18	657	0	4701	4751	10109
18.5	118	0	0	0	118

2020 Length (cm)	Q1 9.a CN	Q2 9.a CN	Q3 9.a CN	Q4 9.a CN	TOTAL 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	11818	0	80431	72334	164583
Catch (T)	253	0,01	2629	2446	5327
L avg (cm)	14.8	-	16.2	16.6	16.2
W avg (g)	21.0	-	29.0	31.2	28.9

Table 4.3.5.1.5. 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 2020. Discards in the first semester were not estimated but assumed as null. Discards in second semester were sampled but they also were null; hence landings equal to catches. Length–frequency distributions from Q1 and Q2 landings were not available but they have been estimated by raising Q1 and Q2 landings to the respective quarterly LFDs resulting after pooling 2018 and 2019 LFDs from such quarters.

2020	**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	296	0	296
8	18	48	244	0	310
8.5	439	842	2608	215	4104
9	2197	3204	2428	945	8774
9.5	2486	6186	6216	2736	17624
10	8971	11004	6640	4444	31059
10.5	12657	18459	12566	9305	52987
11	16462	28644	23860	10684	79650
11.5	19371	32715	35720	16732	104538
12	16489	33258	44309	11587	105643
12.5	8300	25010	25382	11176	69868
13	3079	12921	21306	6691	43997
13.5	3321	7850	13725	2750	27646
14	1343	4506	12917	2685	21451
14.5	733	2187	3977	2169	9066
15	308	600	2978	1154	5040
15.5	354	612	1204	1444	3614
16	124	200	59	759	1142
16.5	177	285	0	444	906
17	88	143	0	69	300
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	96917	188674	216434	85985	588010
Catch (T)	1285	2247	2530	996	7058
L avg (cm)	11.7	11.9	12.2	12.1	12.0
W avg (g)	10.6	12.0	11.7	11.6	11.5

Table 4.3.5.1.6. 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 2020. Discards in the first semester were not estimated but assumed as null. Discards in second semester were sampled and estimated.

2020	**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	n.a	n.a	0	0	0
4.5	n.a	n.a	0	0	0
5	n.a	n.a	0	0	0
5,5	n.a	n.a	0	0	0
6	n.a	n.a	0	0	0
6.5	n.a	n.a	0	1	1
7	n.a	n.a	0	0	0
7.5	n.a	n.a	0	48	48
8	n.a	n.a	0	162	162
8.5	n.a	n.a	0	279	279
9	n.a	n.a	0	743	743
9.5	n.a	n.a	0	979	979
10	n.a	n.a	0	1419	1419
10.5	n.a	n.a	0	1254	1254
11	n.a	n.a	0	1076	1076
11.5	n.a	n.a	0	1438	1438
12	n.a	n.a	0	1119	1119
12.5	n.a	n.a	0	1540	1540
13	n.a	n.a	0	543	543
13.5	n.a	n.a	0	443	443
14	n.a	n.a	0	258	258
14.5	n.a	n.a	0	81	81
15	n.a	n.a	0	0	0
15.5	n.a	n.a	0	0	0
16	n.a	n.a	0	0	0
16.5	n.a	n.a	0	0	0
17	n.a	n.a	0	0	0

2020 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	n.a	n.a	0	0	0
18	n.a	n.a	0	0	0
18.5	n.a	n.a	0	0	0
19	n.a	n.a	0	0	0
19.5	n.a	n.a	0	0	0
20	n.a	n.a	0	0	0
20.5	n.a	n.a	0	0	0
Total N	n.a	n.a	0	0	0
Catch (T)	n.a	n.a	0	105	105
L avg (cm)	n.a	n.a	-	11.3	11.3
W avg (g)	n.a	n.a	-	9.3	9.3

Table 4.3.5.1.7. 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 2020.

2020	**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	0	0	0	0
5	0	0	0	0	0
5,5	0	0	0	0	0
6	0	0	0	0	0
6.5	0	0	0	1	1
7	0	0	0	0	0
7.5	0	0	296	48	344
8	18	48	244	162	472
8.5	439	842	2608	493	4382
9	2197	3204	2428	1688	9517
9.5	2486	6186	6216	3715	18603
10	8971	11004	6640	5863	32478
10.5	12657	18459	12566	10559	54241
11	16462	28644	23860	11760	80726
11.5	19371	32715	35720	18170	105976
12	16489	33258	44309	12706	106762
12.5	8300	25010	25382	12716	71408
13	3079	12921	21306	7234	44540
13.5	3321	7850	13725	3193	28089
14	1343	4506	12917	2943	21709
14.5	733	2187	3977	2250	9147
15	308	600	2978	1154	5040
15.5	354	612	1204	1444	3614
16	124	200	59	759	1142
16.5	177	285	0	444	906
17	88	143	0	69	300

2020 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	96917	188672	216434	97370	599393
Catch (T)	1285	2247	2530	1101	7163
L avg (cm)	11.7	11.9	12.2	12.0	12.0
W avg (g)	10.6	12.0	11.7	11.3	11.5

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.

2020	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 2015–2020).

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
2020	0	4091	4170	1526

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 2020 on a quarterly (Q), half-year (HY) and annual basis.

2020	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	6375	3.7	47030	30416	6379	75462	63623
	2	2555	1.4	33401	41917	2556	77304	75187
	3	2888	1.6	0	0	2890	0	25780
	Total (n)	11818	6.9	80431	72334	11825	152766	164590
	Catch (t)	253	0.01	2629	2446	253	5077	5330
	SOP	249	146	2342	2259	240	4595	4757
	VAR.%	101.5	96.4	112.3	108.2	105.7	110.5	112.1

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 2020 on a quarterly (Q), half-year (HY) and annual basis. No ALKs for Q1 and Q2. Catches from Q1 and Q2 have been structured by applying to both quarters the ALK from the *PELAGO 20* survey.

2020	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	118851	77374	0	196225	196225
	1	88982	169934	95961	18697	258916	114658	373573
	2	7514	17802	1621	1299	25316	2921	28237
	3	422	936	0	0	1357	0	1357
	Total (n)	96917	188672	216434	97370	285589	313803	599393
	Catch (t)	1285	2247	2530	1101	3532	3631	7163
	SOP	1031	2255	2530	1101	3286	3631	6918
	VAR.%	124.6	99.6	100.0	99.9	107.5	100.0	103.5

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 (1995–2020).

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
2020	196225	373573	28237	1357

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 2020 on a quarterly (Q), half-year (HY) and annual basis.

2020	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	-	-	-	-	-	-	-
	1	13.5	15.8	16.2	13.5	16.0	15.8	13.5
	2	15.4	16.7	16.9	15.4	16.8	16.6	15.4
	3	17.1	-	-	17.1	-	16.3	17.1
	Total	14.8	16.2	16.6	14.8	16.4	16.2	14.8

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 2020 on a quarterly (Q), half-year (HY) and annual basis.

2020	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	-	-	-	-	-	-	-
	1	0.016	0.016	0.027	0.029	0.016	0.028	0.016
	2	0.023	0.023	0.032	0.033	0.022	0.032	0.023
	3	0.031	0.031	-	-	0.029	-	0.031
	Total	0.021	0.021	0.029	0.031	0.020	0.030	0.021

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 2020 on a quarterly (Q), half-year (HY) and annual basis.

2020	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	-	-	-	-	-	-	-
	1	13.5	-	15.8	16.2	13.5	16.0	13.5
	2	15.4	-	16.7	16.9	15.4	16.8	15.4
	3	17.1	-	-	-	17.1	-	17.1
	Total	14.8	-	16.2	16.6	14.8	16.4	14.8

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 2020 on a quarterly (Q), half-year (HY) and annual basis.

2020	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	-	-	-	-	-	-	-
	1	0.016	-	-	-	0.020	0.028	0.027
	2	0.023	-	0.027	0.029	0.020	0.032	0.031
	3	0.031	-	0.032	0.033	0.030	-	0.029
	Total	0.021	-	-	-	0.020	0.030	0.029

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.

2020	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	-	-	11,6	11,6	-	11,6	11,6
	1	11,5	11,7	13,0	13,7	11,7	13,1	12,1
	2	13,2	13,3	14,7	13,1	13,3	14,0	13,3
	3	15,6	15,3	-	-	15,4	-	15,4
	Total	11,7	11,9	12,2	12,0	11,8	12,2	12,0

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.

2020	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	-	-	0,010	0,010	-	0,010	0,010
	1	0,010	0,011	0,014	0,018	0,011	0,015	0,012
	2	0,016	0,017	0,021	0,016	0,017	0,019	0,017
	3	0,027	0,027	-	-	0,027	-	0,027
	Total	0,011	0,012	0,012	0,011	0,012	0,012	0,012

Table 4.4.1. Acoustic and DEPM surveys providing direct estimates for anchovy in Division 9.a. (1): 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										
2000				Nov								
2001		Mar		Nov								
2002		Mar										
2003		Feb		(Nov)								
2004			(Jun)					Jun				
2005			Apr	(Nov)							Jun	
2006			Apr	(Nov)				Jun				
2007			Apr	Nov					Jul			

Method	Acoustics										DEPM	
2008	Apr		Apr	(Nov)							Jun	
2009	Apr		Apr					Jun	(Jul)(1)	(Oct)		
2010	Apr		Apr						(Jul)			
2011	Apr		Apr									Jul
2012	Apr									Nov		
2013	Mar		Apr		(Nov)				Aug			
2014	Mar		Apr		(Nov)				Jul	Oct		Jul
2015	Mar		Apr		Dec				Jul	Oct		
2016	Mar		Apr		Dec				Jul	Oct		
2017	Mar		Apr		Dec				Jul	Oct		Jul
2018	Mar		Apr				Nov		Jul	Oct		
2019	Mar		Apr			Sep			Jul	Oct		
2020	No survey (Covid-19 disruption)	Mar				Sep			Aug	Oct		Jul
2021	Apr	Mar										

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. (1): time-series average

Year	2005	2008	2011	2014	2017	2020
P0 (eggs/m^2/day)	50.8 / 224.5	184 / 348	276	314	146	523
Z (day^{-1}) (CV)	-0.039	-1,43	-0.29	-0.33	-0,16	-1.11
P_{total} (eggs/day) (x10^{12})	1,13	2,11	1,87	1,95	0,74	5,26
Surveyed area (km^2)	11982	13029	13107	14595	15556	16223
Positive area (km^2)	6139	6863	6770	6214	5080	10058
Female Weight (g)	25.2 / 16.7	23,7	15,2	18,2	16,2	16,6
Batch Fecundity	13820/ 11160	13778	7486	7502	7507	8212
Sex Ratio	0.53 / 0.54	0,53	0,53	0,54	0,53	0,54
Spawning Fraction	0.26 / 0.21	0,218	0,276	0,276	0,243	0,241 (1)
Spawning Biomass (tons)	14673	31527	32757	31569	12392	81466

Table 4.4.2.1. Anchovy in Division 9.a. *PELACUS* survey series (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8.c). Summary of the fishing stations performed during *PELACUS 0321*.

	TOTAL CAP (Kg)	No ind.	No Fishing st	Sample weight (kg)	Measured fish	Mean length	%PRES	% Catch_W	% Catch_No
WHB	278	944	8	278	944	20.35	18.18	0.88	0.10
MAC	10280	27058	20	832	2199	37.35	45.45	32.69	2.73
MAC-S	613	6596	19	134	1351	23.80	43.18	1.95	0.66
HKE	21	204	18	21	206	24.02	40.91	0.07	0.02
HOM	411	3872	10	86	771	23.73	22.73	1.31	0.39
HOM_S	498	24428	7	18	841	14	15.91	1.58	2.46
PIL	11443	377261	28	217	4501	17.91	63.64	36.39	38.03
PIL_S	315	17622	3	8	427	14	6.82	1.00	1.78
MAV	109	70821	5	1	388	5	11.36	0.35	7.14
BOG	312	2611	16	94	715	23.81	36.36	0.99	0.26
VMA	224	843	19	167	601	25.87	43.18	0.71	0.08
VMA_S	52	796	5	28	427	20	11.36	0.17	0.08
BOC	220	3522	2	21	367	14.15	4.55	0.70	0.35
SEAB	20	68	9	20	68	27.09	20.45	0.06	0.01
ANE	6652	455485	25	56	3057	13.84	56.82	21.15	45.91
Total	**31449**	**992131**	**44**	**1981**	**16863**				

Table 4.4.2.2. Anchovy in Division 9.a. *PELACUS* survey series (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8.c). Historical series of acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes) in Subdivision 9.a North.

Survey	Estimate	9.a North
April 2008	N	10
	B	306
April 2009	N	0.7
	B	26
April 2010	N	0.03
	B	90
April 2011	N	73
	B	1650
April 2012	N	1
	B	45
March 2013	N	-
	B	-
March 2014	N	-
	B	-
March 2015	N	-
	B	-
March 2016	N	8
	B	205
March 2017	N	124
	B	3566
March 2018	N	771
	B	10660
March 2019	N	7
	B	192
March 2020	N	No survey (Covid-19 disruption)
	B	
April 2021	N	358
	B	6075

Table 4.4.2.3. Anchovy in Division 9.a. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
Mar. 99	N	22	15	*	37	2079	2079	2116
	B	190	406	*	596	24763	24763	25359
Mar. 00	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Mar. 01	N	25	13	285	324	2415	2700	2738
	B	281	87	2561	2929	22352	24913	25281
Mar. 02	N	22	156	92	270	3731 **	3823 **	4001 **
	B	472	1070	1706	3248	19629 **	21335 **	22877 **
Feb. 03	N	0	14	*	14	2314	2314	2328
	B	0	112	*	112	24565	24565	24677
Mar. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 05	N	-	59	-	59	1306	1306	1364
	B	-	1062	-	1062	14041	14041	15103
Apr. 06	N	-	-	319	319	1928	2246	2246
	B	-	-	4490	4490	19592	24082	24082
Apr. 07	N	0	103	284	387	2860	3144	3247
	B	0	1945	4607	6552	33413	38020	39965
Apr.08	N	69	252	213	534	1819	2032	2353
	B	3000	2505	4661	10166	29501	34162	39667
Apr.09	N	127	0****	159	286	1910	2069	2196
	B	2089	0****	3759	5848	20986	24745	26834
Apr. 10	N	0	62	0	62	963	963	1026
	B	0	1188	0	1188	7395	7395	8583
Apr. 11	N	1558	0	0	1558	0	0	1558
	B	27050	0	0	27050	0	0	27050
Apr. 12	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-

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

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

******Possible underestimation: although no echo-traces attributable to the species were detected in this area, however, the loss of pelagic gear samplers prevented from confirming directly this.**

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

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
Apr. 13	N	251	0	263	514	634	897	1148
	B	3955	0	5044	8999	7656	12700	16655
Apr. 14	N	130	0	26	156	2216	2241	2371
	B	1947	0	509	2456	28408	28917	30864
Apr. 15	N	645	0	158	802	3531	3689	4334
	B	8237	0	2156	10393	30944	33100	41337
Apr. 16	N	3198	0	0	3198	9811	9811	13009
	B	38302	0	0	38302	65345	65345	103647
May 17	N	1015	0	137	1152	1718	1855	2870
	B	15481	0	1208	16689	12589	13797	29278
Apr. 18	N	4845	0	300	5145	1857	2157	7001
	B	54437	0	4328	58765	19145	23473	77910
Apr. 19	N	229	7	0	236	3398	3398	3634
	B	3814	123	0	3937	29876	29876	33813
Apr. 20	N	3152	0.3	89	3242	5550	5639	8791
	B	50282	9	1789	52080	47998	49787	100078
Mar. 21	N	3069	519	9	3597	1485	1485	5082
	B	53513	6095	107	59715	13958	13958	73673

Table 4.4.2.4. Anchovy in Division 9.a. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision 9.a South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

Survey	Estimate	Portugal	Spain	TOTAL
		S(A)	S(C)	S(Total)
Jun. 04***	N	125	1109	1235
	B	2474	15703	18177
Jun. 05	N	-	-	-
	B	-	-	-
Jun. 06	N	363	2801	3163
	B	6477	30043	36521
Jul. 07	N	558	1232	1790
	B	11639	17243	28882
Jul. 08	N	-	-	-
	B	-	-	-
Jul. 09	N	35	1102	1137
	B	1075	20506	21580
Jul. 10	N	?	954+	954 +
	B	?	12339 +	12339 +
Jul. 11	N	-	-	-
	B	-	-	-
Jul. 12	N	-	-	-
	B	-	-	-
Aug. 13	N	50	558	609
	B	1315	7172	8487
Jul. 14	N	184	1778	1962
	B	4440	24779	29219
Jul. 15	N	168	2506	2674
	B	2137	19168	21305
Jul. 16	N	346	3341	3686
	B	5250	29051	34301
Jul. 17	N	151	1354	1504

Survey	Estimate	Portugal S(A)	Spain S(C)	TOTAL S(Total)
	B	2666	9563	12229
Jul. 18	N	224	2839	3063
	B	4224	30683	34908
Jul. 19	N	80	5405	5485
	B	1561	56139	57670
Aug. 20	N	439	4714	5153
	B	7773	37114	44887

*****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 4.4.2.5. 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
2021	0	9449	3902	715	0	14065

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
2021	0	67,2	27,7	5,1	0	100

Table 4.4.2.5. 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
2020	3792	1326	35	0	0	5153

ECOCADIZ	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Year	Age 0	Age 1	Age 2	Age 3	Age 4	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
2020	73,6	25,7	0,7	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)	-	-	-	-	-	-

Survey	Estimate	Portugal				Spain	S (Total)	TOTAL
		C-N	C-S	S (PT)	Total	S (ES)		
	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)
Sep. 20	N	0 (570)	12 (1)	0 (0.7)	583 (560)	583 (572)
	B	0 (4879)	289 (20)	0 (8)	5176 (4669)	5176 (4907)

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 S (PT)	Spain S (ES)	TOTAL 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)
Oct. 20	N	145 (30)	3051 (2355)	3197 (2385)
	B	3290 (512)	32779 (20547)	36070 (21060)

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

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

Year	Age 0	Age 1	Age 2	Age 3
1995	7,0	10,7	22,6	
1996	1,1	6,3	20,0	
1997	2,6	11,1	20,9	
1998	2,6	7,4	20,4	
1999	3,2	12,8	20,0	
2000	3,1	10,0	23,8	
2001	6,2	13,3	31,8	
2002	3,3	10,5	26,3	
2003	6,0	10,6	26,8	
2004	6,6	12,0	21,9	
2005	4,9	9,2	22,6	
2006	3,6	8,2	21,0	
2007	5,4	9,4	20,4	
2008	7,2	14,9	21,8	23,1
2009	4,1	12,2	20,3	24,2
2010	6,9	11,3	19,1	23,0
2011	8,2	10,3	22,7	
2012	8,3	14,3	22,5	
2013	6,4	11,9	21,8	
2014	6,6	10,9	19,0	
2015	7,7	10,5	20,7	
2016	8,7	12,9	18,2	
2017	6,7	9,1	19,9	
2018	10,2	12,4	18,6	
2019	10.0	11.9	20.0	
2020	9.6	12.3	17.4	26.6

Table 4.6.2.1.1.1. Anchovy in Division 9.a. Southern component. Overview of the data used in the assessment model for optimization routines (maximization of likelihood function). Due to lack of information of length distributions and Age–length keys for commercial catches in the first and second quarter of 2020, the length distribution was approximated using the joint distribution of 2018 and 2019 and the Age–length key used was the one for the PELAGO 2020 survey.

Data source	Type	Time span
Commercial landings	Length distribution	All quarters, 1989–2020
	Age–length key	All quarters, 1989–2020
ECOCADIZ acoustic survey	Biomass survey indexes	Second quarter 2004, 2006 third quarter 2007, 2009, 2010, 2013–2020
	Length distribution	Second quarter 2004, 2006 third quarter 2007, 2009, 2010, 2013–2020
	Age–length key	Second quarter 2004, 2006 third quarter 2007, 2009, 2010, 2013–2020
PELAGO acoustic survey	Biomass survey indexes	First quarter 1999, 2001–2003 second quarter 2005–2010 and 2013–2021
	Length distribution	First quarter 1999, 2001–2003 second quarter 2005–2010, 2013–2021
	Age–length key	second quarter 2014–2021

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_∞=28.7556 cm
k	Annual growth rate, k =0.0740307
β	Beta-binomial parameter, β = 3809
ν_a	Age factor, $\nu_{0=}$ 51000, ν_1 = 37700, ν_2 =37700, ν_3 = 4.88e − 07
μ	Recruitment mean length, μ = 9.89cm
σ_t	Recruitment length standard deviation by quarter, σ_2 = 3.33598, σ_3 = 1.69371, σ_4 = 3.82192
$l_{50,T}$	Length with a 50% probability of predation during period T, seine: $l_{50,1}$= 10.6cm, $l_{50,2}$ = 10.7 cm, *ECOCADIZ* survey: l_{50}= 12.7 cm, *PELAGO* survey: l_{50}= 14.2 cm
α_T	Shape of selectivity function, purse-seine: α_1 = 0.393, α_2 = 0. 945, *ECOCADIZ* survey: α_3 = 1.52, *PELAGO* survey: α_3 = 0.484

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.

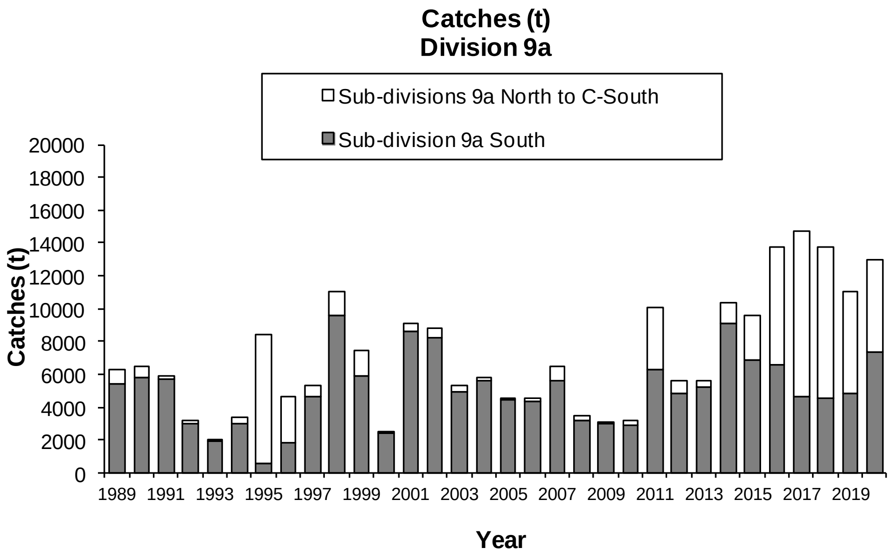


Figure 4.3.2.1.1. Anchovy in Division 9.a. Recent series of anchovy catches in Division 9.a (ICES estimates for 1989–2020, the period with data for all the subdivisions, all metiers are considered). Subdivisions are pooled in order to differentiate the anchovy fishery harvested throughout the Atlantic 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).

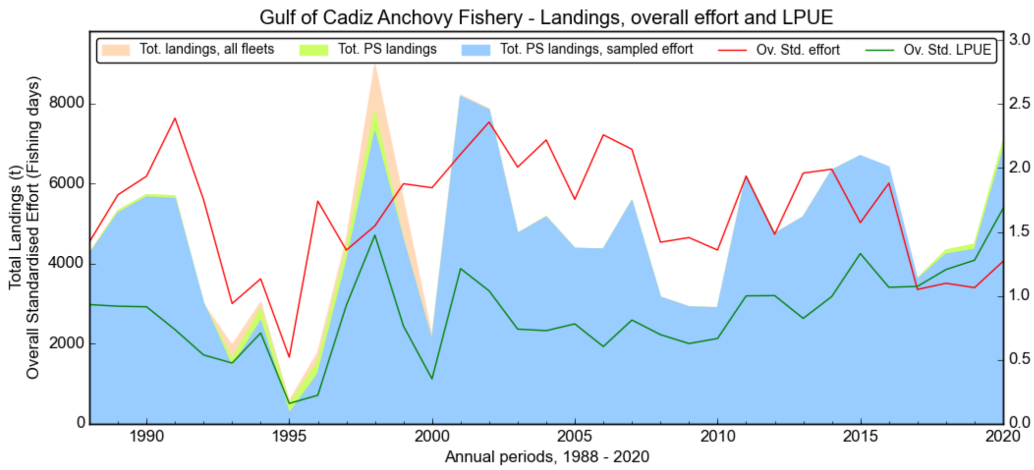


Figure 4.3.4.1. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. Spanish purse-seine fishery (métier PS_SPF_0_0_0). Trends in Gulf of Cadiz anchovy annual landings, and purse-seine fleets' standardised overall effort and lpue (1988–2020).

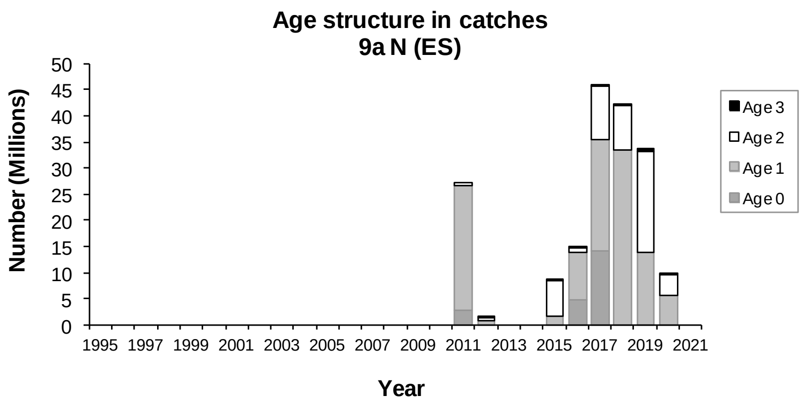


Figure 4.3.5.2.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish fishery (all métiers). Age composition in Spanish catches of SW Galician anchovy (available data provided to the WG). Although discards are still considered as negligible (hence landings are assumed as equal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

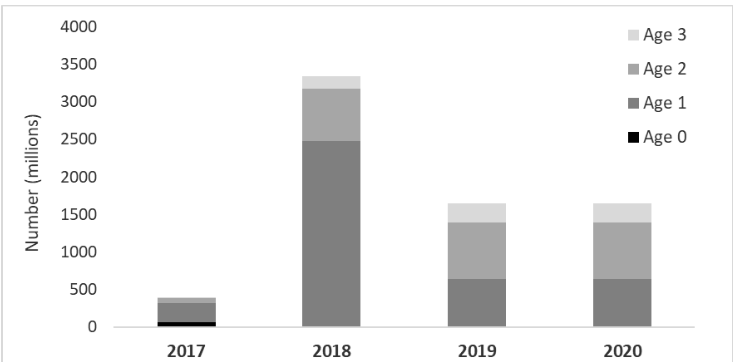


Figure 4.3.5.2.2. Anchovy in Division 9.a. Western component. Subdivision 9.a Central-North. Portuguese fishery (all métiers). Age composition in Portuguese anchovy catches (available data provided to the WG). Discards are negligible (hence landings are assumed as equal to catches).

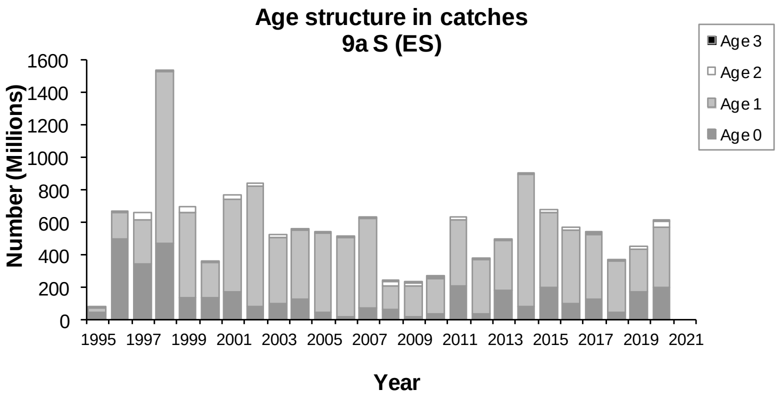
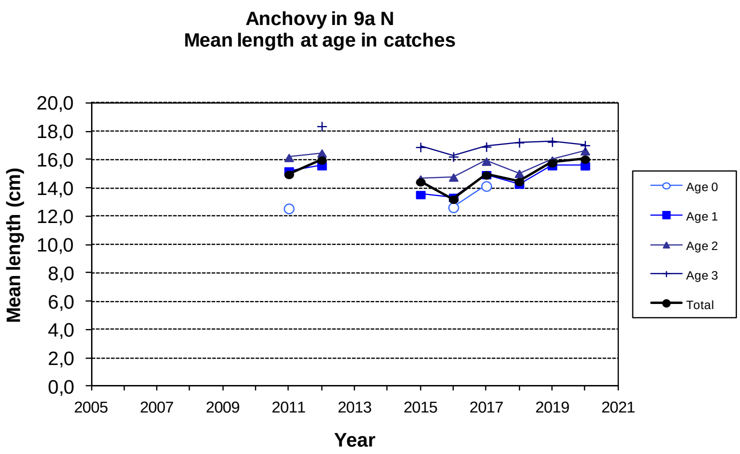


Figure 4.3.5.2.3. Anchovy in Division 9.a. Southern component. Subdivision 9.a-South. Spanish fishery (all métiers). Age composition in Spanish catches of Gulf of Cadiz anchovy (1995–2020). Discards are considered either very low or even negligible in this fishery, but since 2014 on estimates include the available discarded catches (see Section 4.3.3).



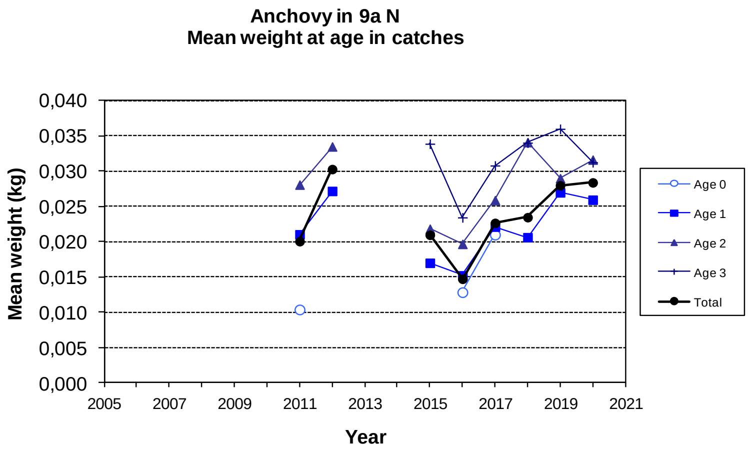


Figure 4.3.6.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Western Galicia anchovy (2011–2020).

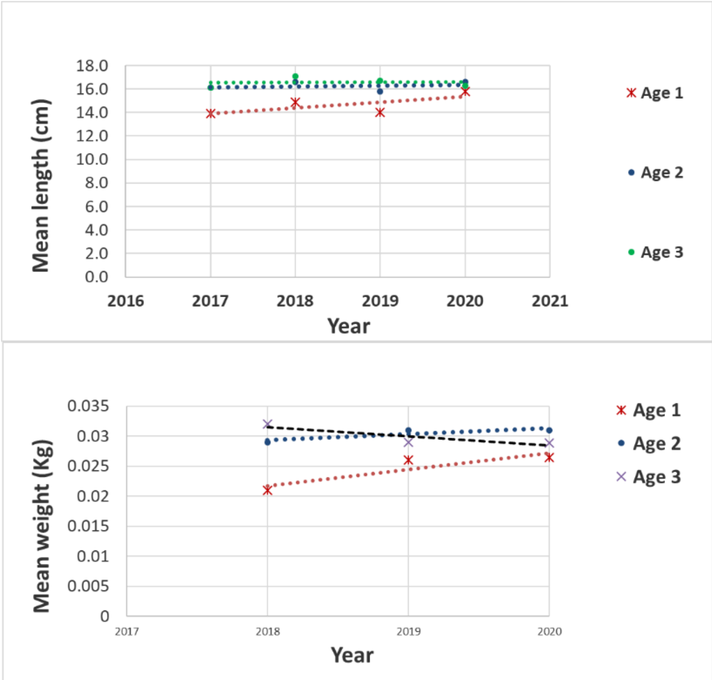
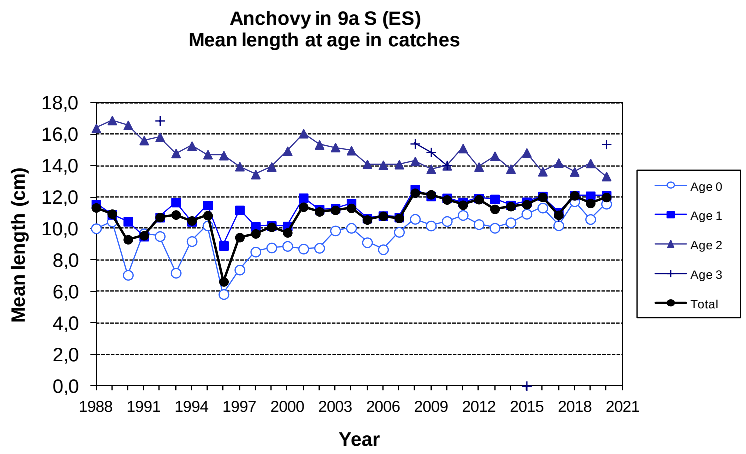


Figure 4.3.6.2. Anchovy in Division 9.a. Western component. Subdivision 9.a Central North. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Portuguese catches of northwestern Portugal anchovy (2017 to 2020).



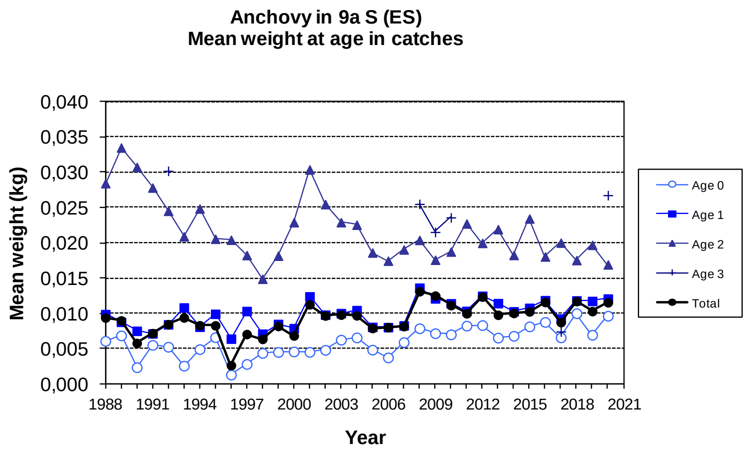


Figure 4.3.6.3. Anchovy in Division 9.a. Southern component. Subdivision 9.a-South. Spanish fishery (all métiers). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Gulf of Cadiz anchovy (1988–2020).

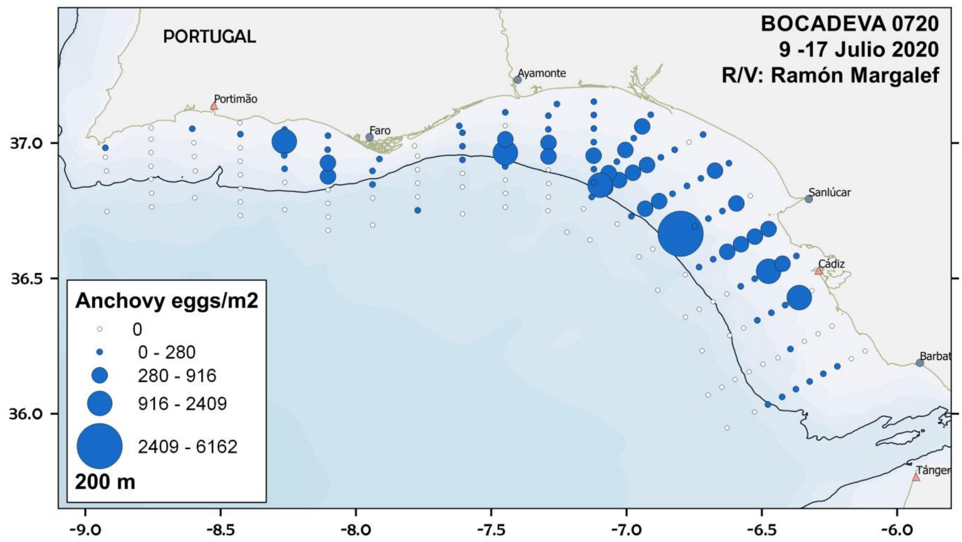


Figure 4.4.1.1. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *BOCADEVA* survey series (summer Spanish DEPM survey in Subdivision 9.a South). *BOCADEVA 0720* survey. Mapping of anchovy eggs density (eggs/m^2) sampled by PairoVET.

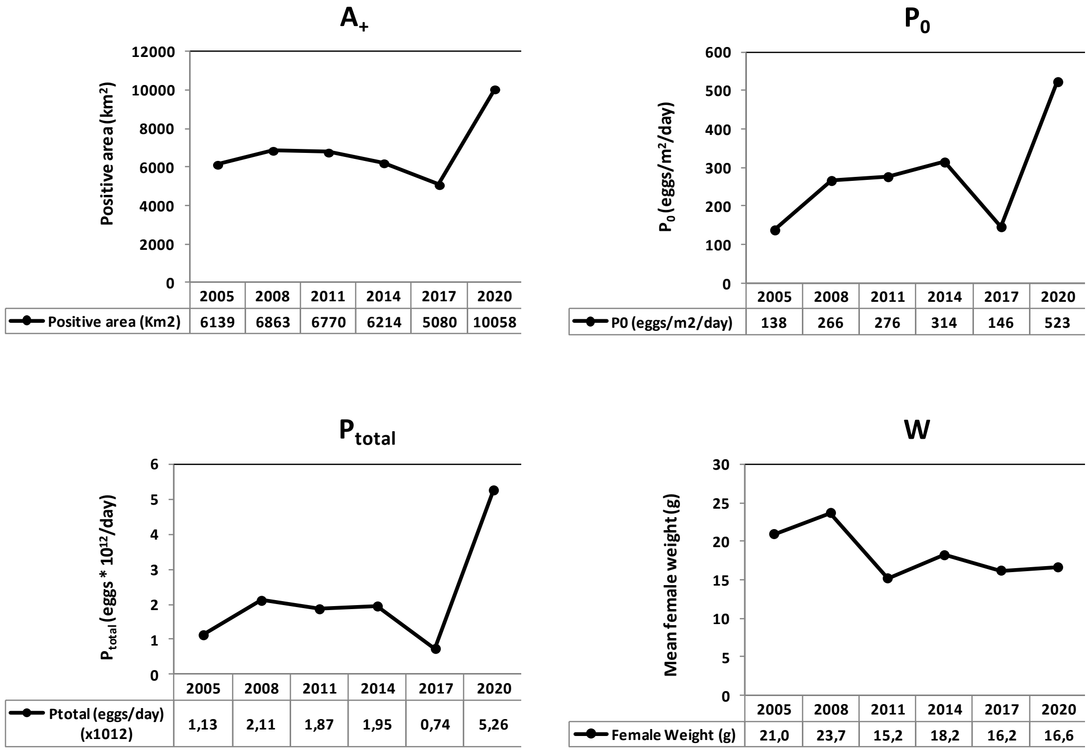


Figure 4.4.1.2. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *BOCADEVA* survey series (summer Spanish DEPM survey in Subdivision 9.a South). Time-series of eggs and adult parameters estimates. A+ (positive area, in km^2), P_0 (daily egg production, in eggs/m^2/day), P_{total} (total egg production, in eggs 10^{12}/day), W (mean female weight, in g).

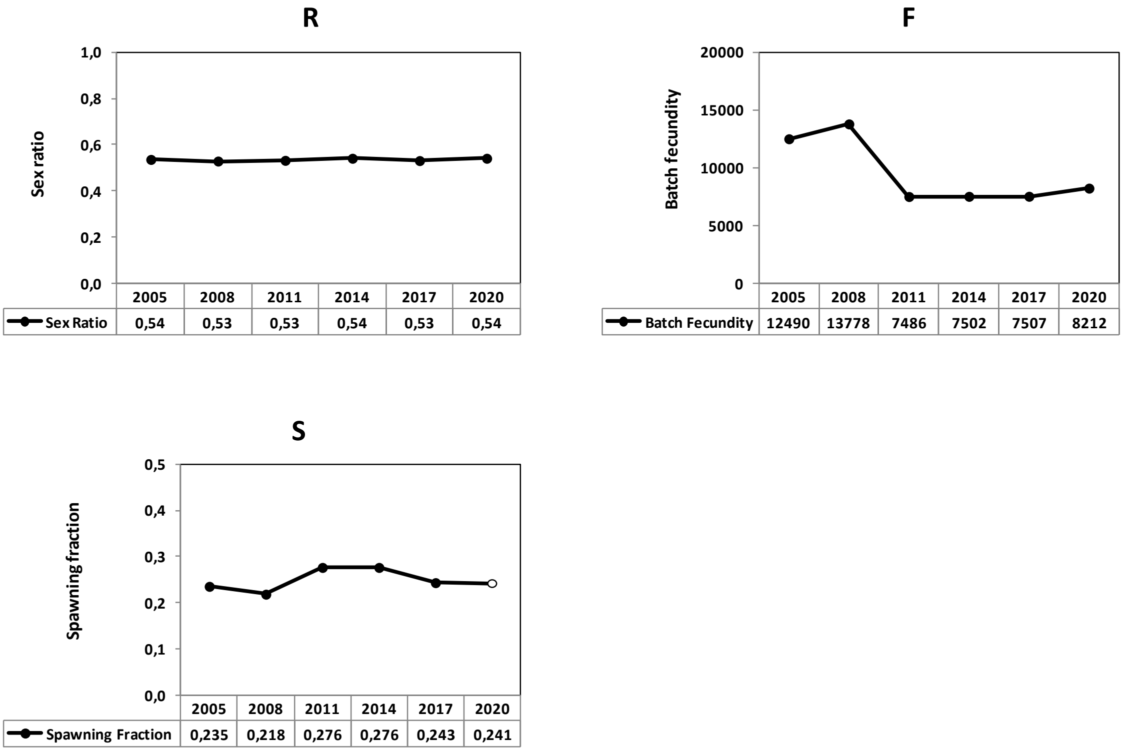


Figure 4.4.1.2. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *BOCADEVA* survey series (summer Spanish DEPM survey in Subdivision 9.a South). Time-series of eggs and adult parameters estimates. Cont'd. R (sex ratio), F (individual batch fecundity), S (spawning fraction; the 2020 estimate is provisionally computed as the time-series average value).

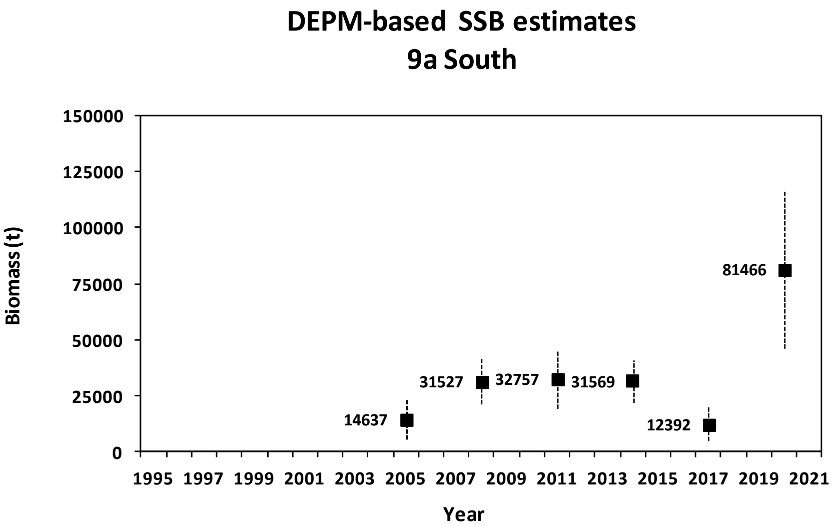


Figure 4.4.1.3. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *BOCADEVA* survey series (summer Spanish DEPM survey in Subdivision 9.a South). Series of SSB estimates (±SD) obtained from the survey series.

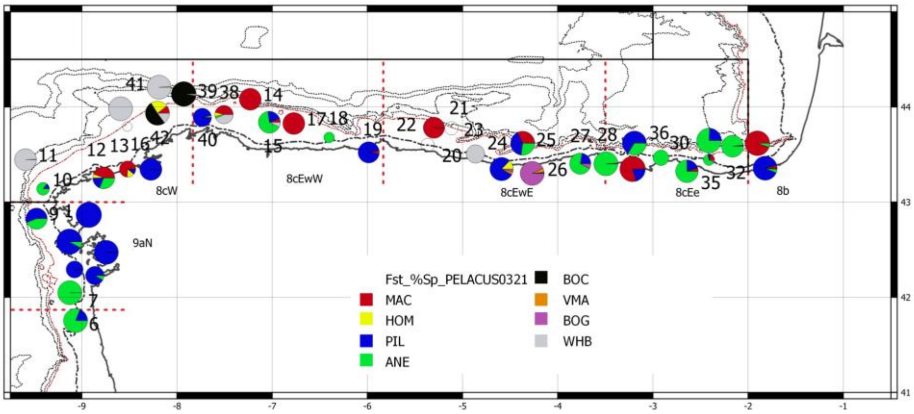


Figure 4.4.2.1. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS 0321* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c in 2021). Distribution of pelagic hauls for echo-traces identification, with indication of the species composition.

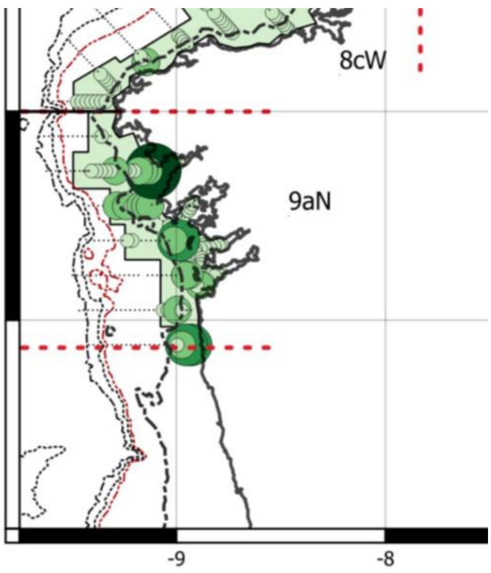


Figure 4.4.2.2. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS 0321* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c in 2021). Spatial distribution of energy allocated to anchovy in 9.a North (NASC coefficients in m^2/mn^2). Polygons are drawn to encompass the observed echoes, and polygon colour indicates density in mt/ nm^2 within each polygon.

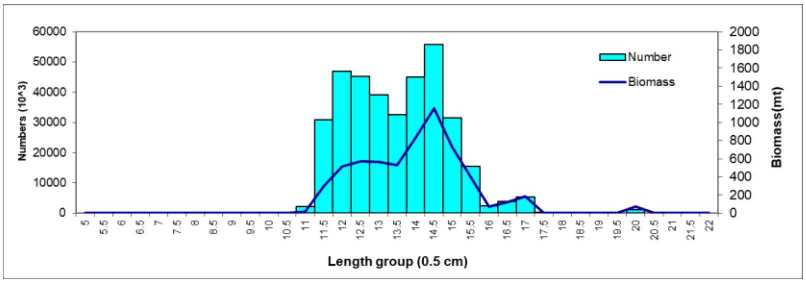


Figure 4.4.2.3. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS 0321* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c in 2021.Estimated abundance and biomass (number of fish in millions and tonnes, respectively) in Subdivision 9.a North by size class.

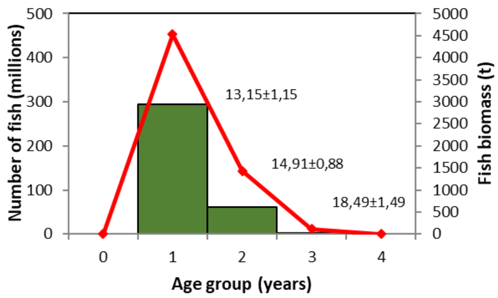


Figure 4.4.2.4. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS 0321* survey (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c in 2021). Estimated abundance and biomass (number of fish in millions and tonnes, respectively) in Subdivision 9.a North by age group, with indication of the mean size by age.

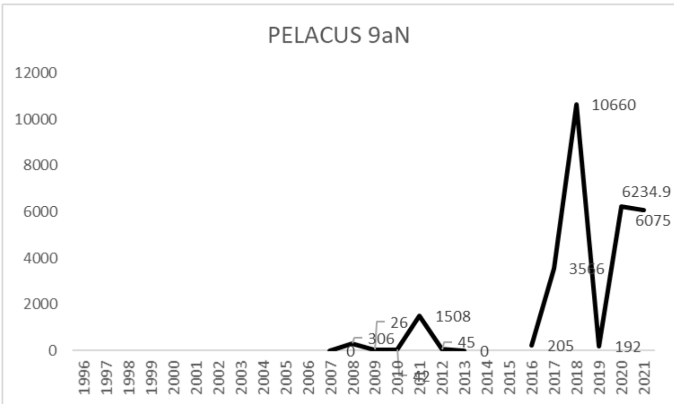


Figure 4.4.2.5. Anchovy in Division 9.a. Western component. Subdivision 9.a North. *PELACUS* survey series (spring Spanish acoustic survey in Subdivision 9.a North and Subarea 8c). Historical series of acoustic estimates of anchovy biomass (t) for the Subdivision 9.a North.

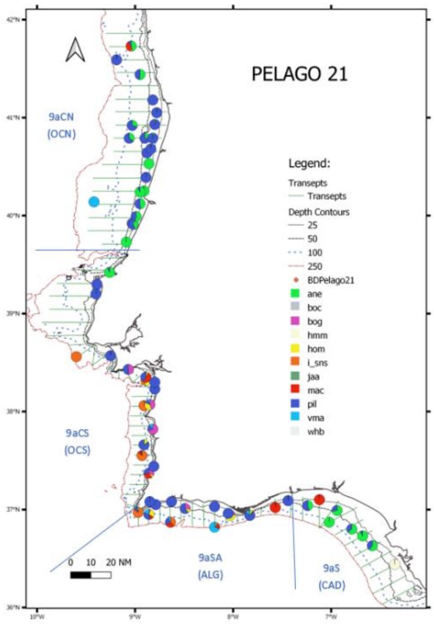


Figure 4.4.2.6. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 21* survey. Location of valid fishing stations with indication of their species composition (percentages in number).

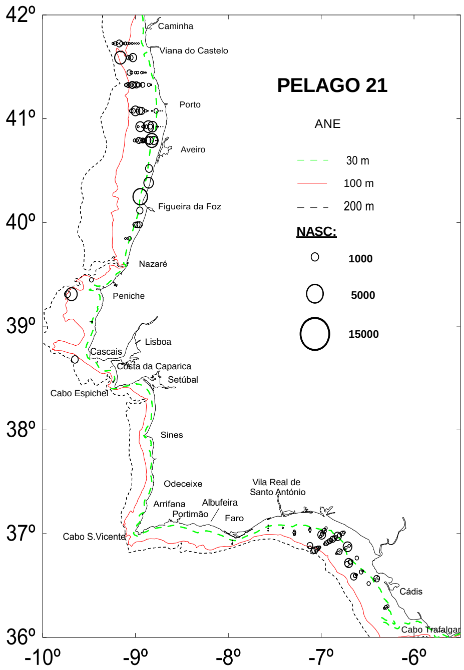


Figure 4.4.2.7. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). PELAGO 219 survey. Distribution of the NASC coefficients (m²/mn²) attributed to anchovy.

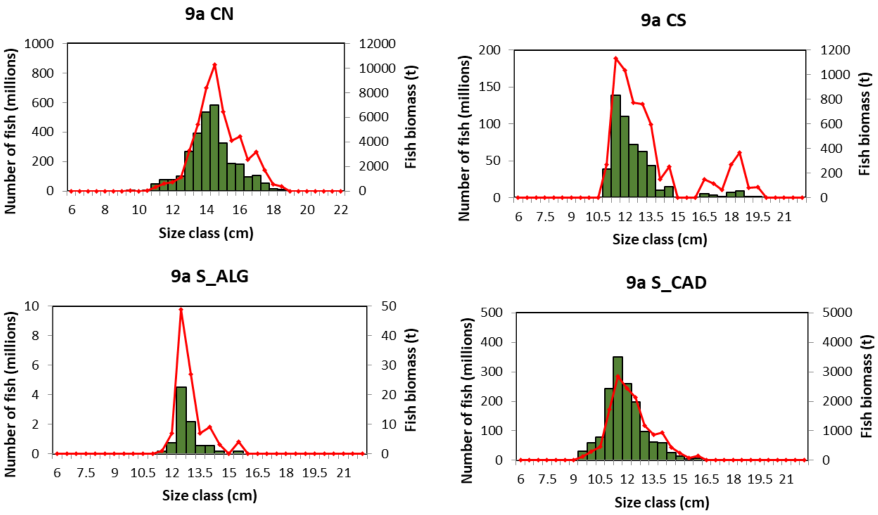


Figure 4.4.2.8. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 21* survey. Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm). Note the different scales in the y axis.

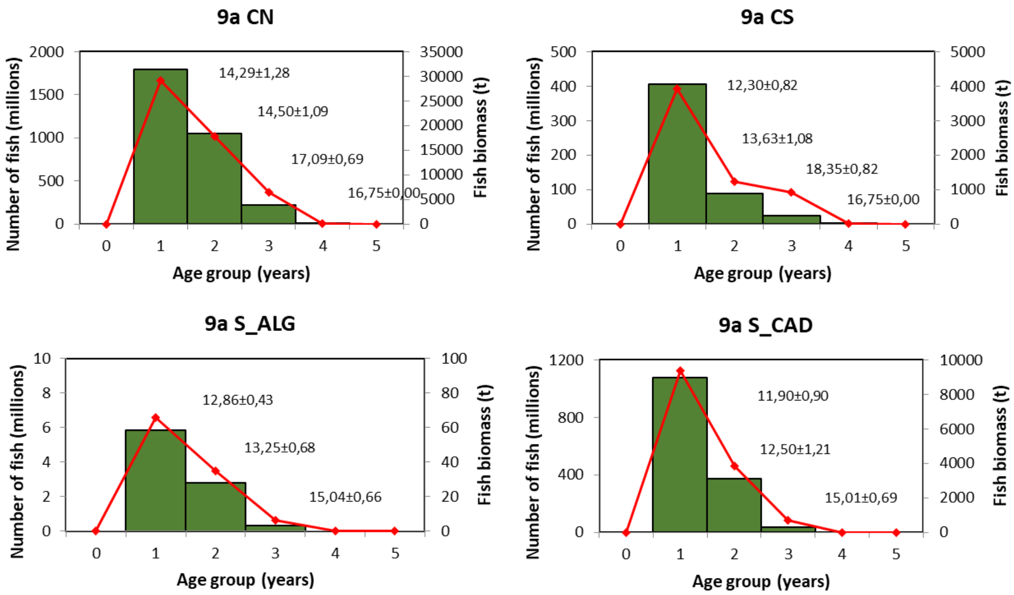


Figure 4.4.2.9. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). *PELAGO 21* survey. Estimated abundances and biomasses (number of fish in millions 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.

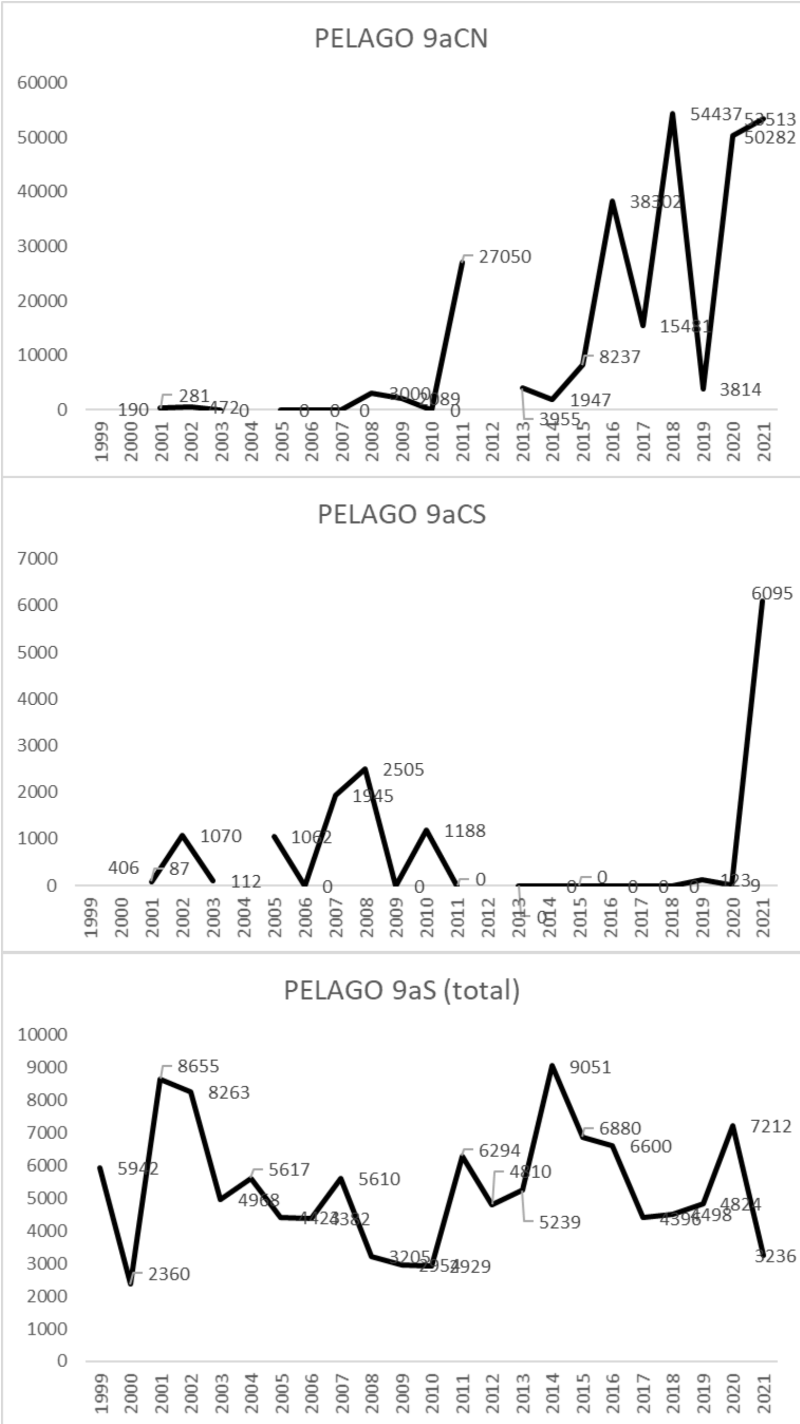
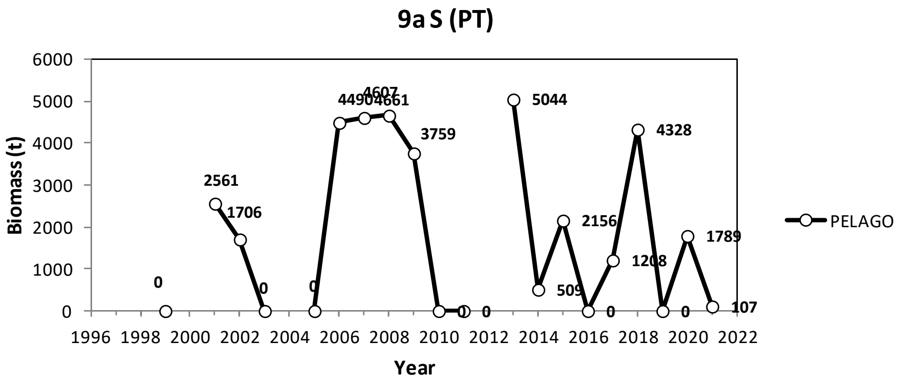


Figure 4.4.2.10. Anchovy in Division 9.a. Western and Southern components. Subdivisions 9.a Central-North to 9.a South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions 9.a Central-North to 9.a South). Historical series of regional acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.



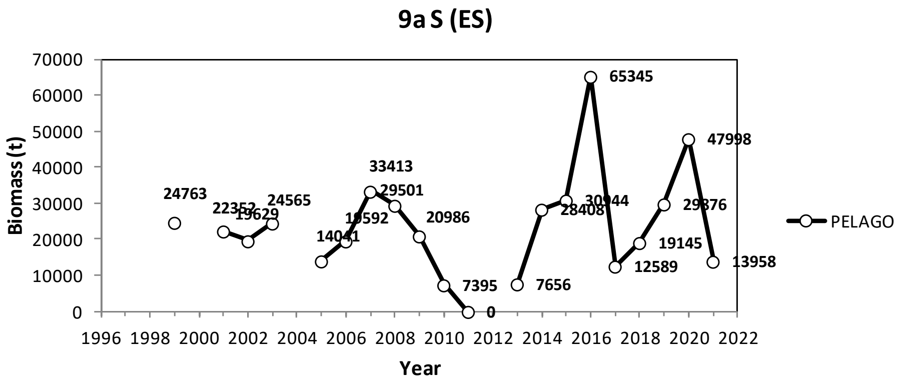


Figure 4.4.2.10. Continued. Acoustic estimates in the 9.a South differentiated by Portuguese (PT) and Spanish waters of the Gulf of Cadiz (ES). Note the different scale of the y-axis. Although estimates from Subdivision 9.a South in 2010 and 2014 were not separately provided for Algarve and Cadiz to 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.

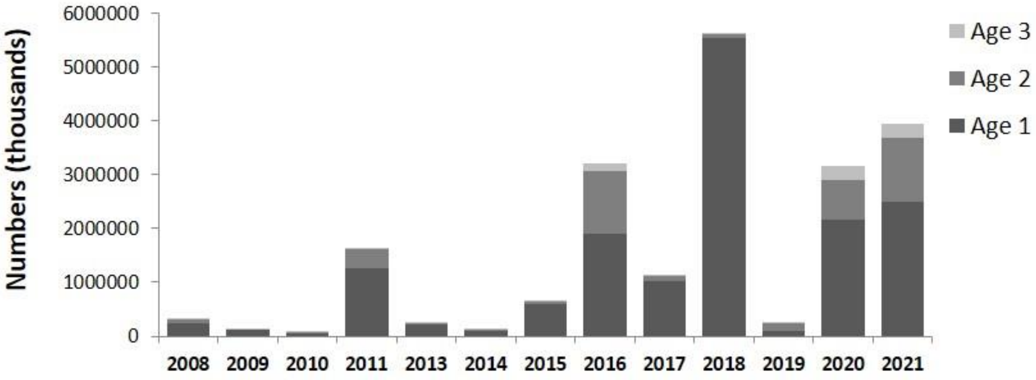
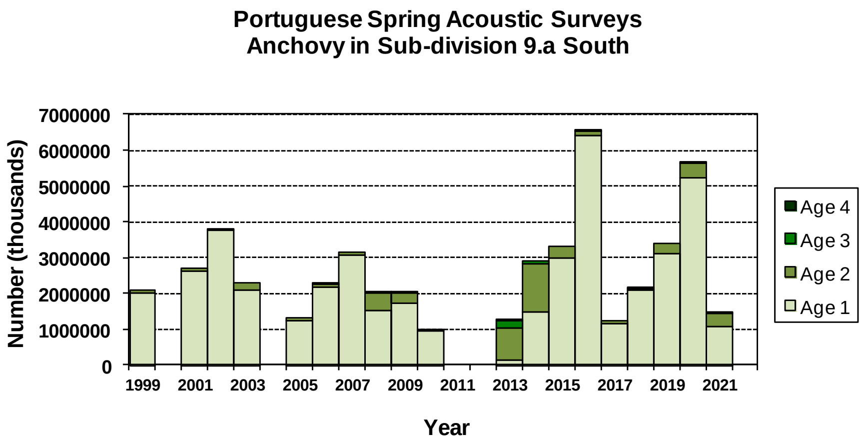


Figure 4.4.2.11. Anchovy in Division 9.a. Western component. Subdivisions 9.a North to Central-South. Annual trends of the estimated population by age class from the *PELACUS* (9a North)+*PELAGO* (9a Central-North and Central-South) Spring acoustic surveys. Age composition for 2020 only derived from the *PELAGO* survey given the *PELACUS* was not carried out.



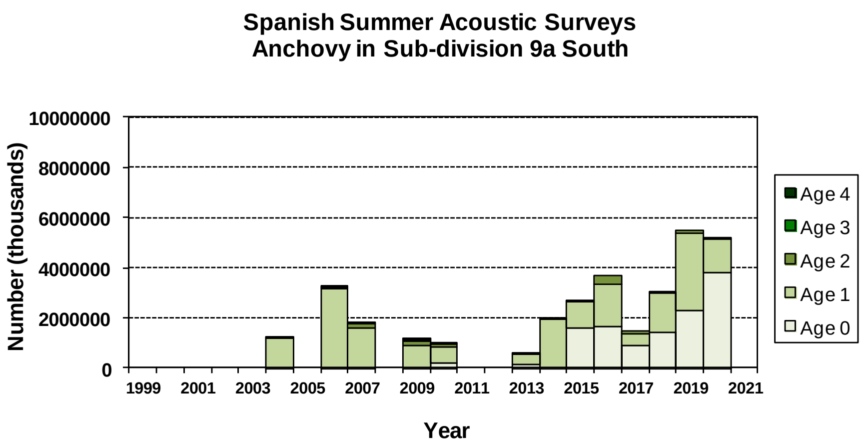


Figure 4.4.2.12. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. Annual trends of the estimated population by age class from the Algarve + Gulf of Cadiz areas by the *PELAGO* Portuguese Spring (upper plot) and *ECO-CADIZ* Spanish summer (lower plot) acoustic surveys. Portuguese estimates until 2012 have been age-structured using Spanish ALKs from the commercial fishery in the second quarter in the year.

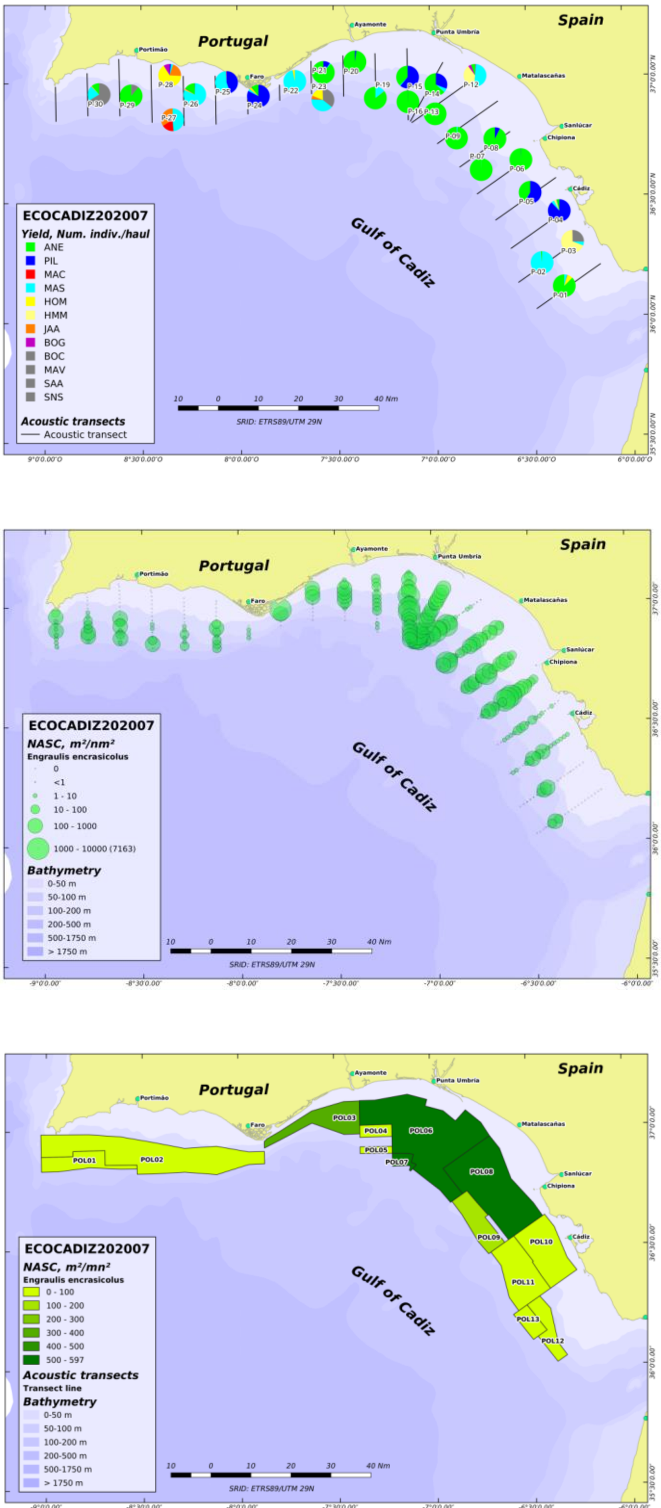


Figure 4.4.2.13. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ 2020-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Top: Location of valid fishing stations with indication of their species composition (percentages in number). Middle: Distribution of the backscattering energy (Nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

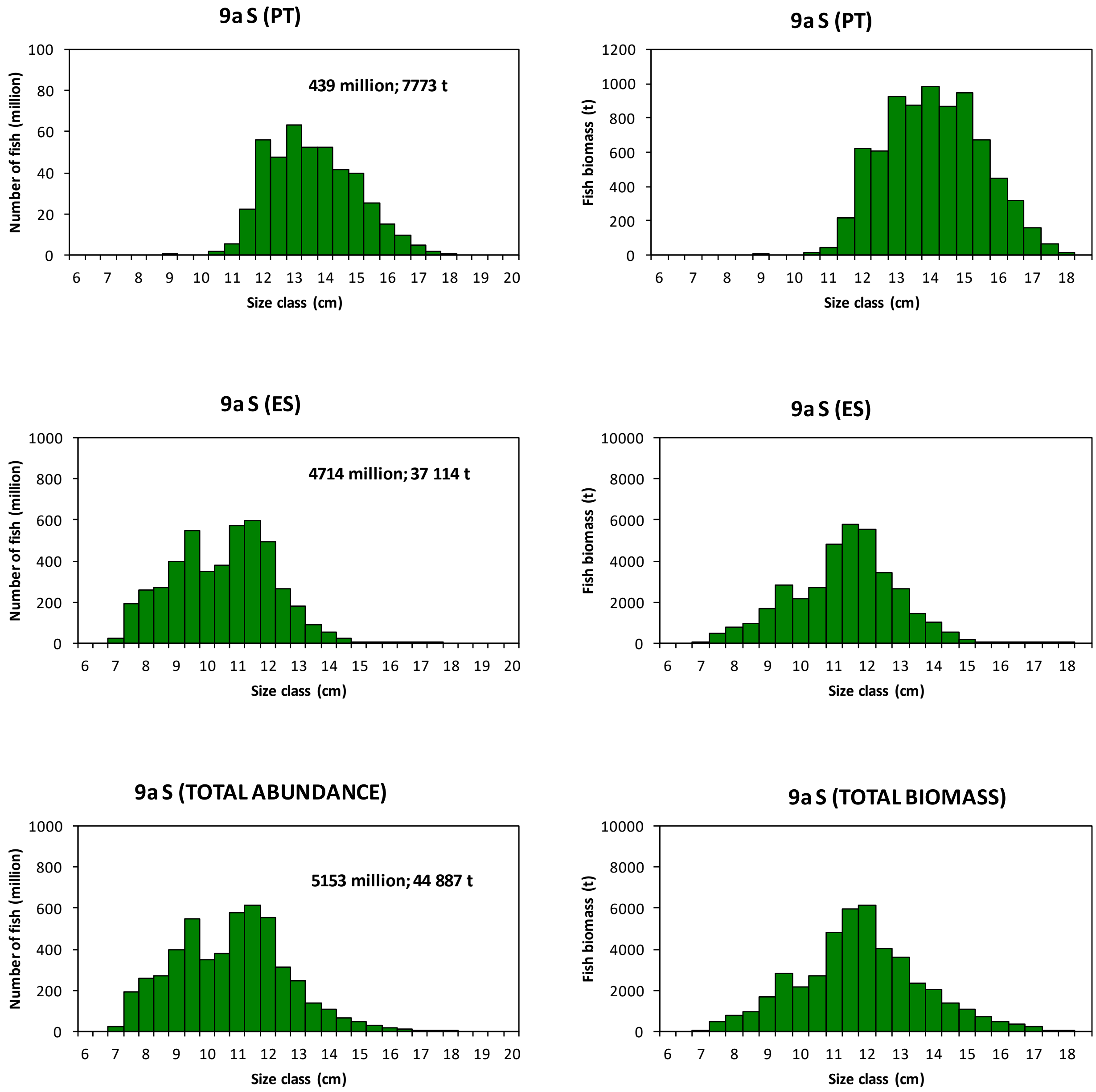


Figure 4.4.2.14. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ 2020-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm). Note the different scales in the y-axis.

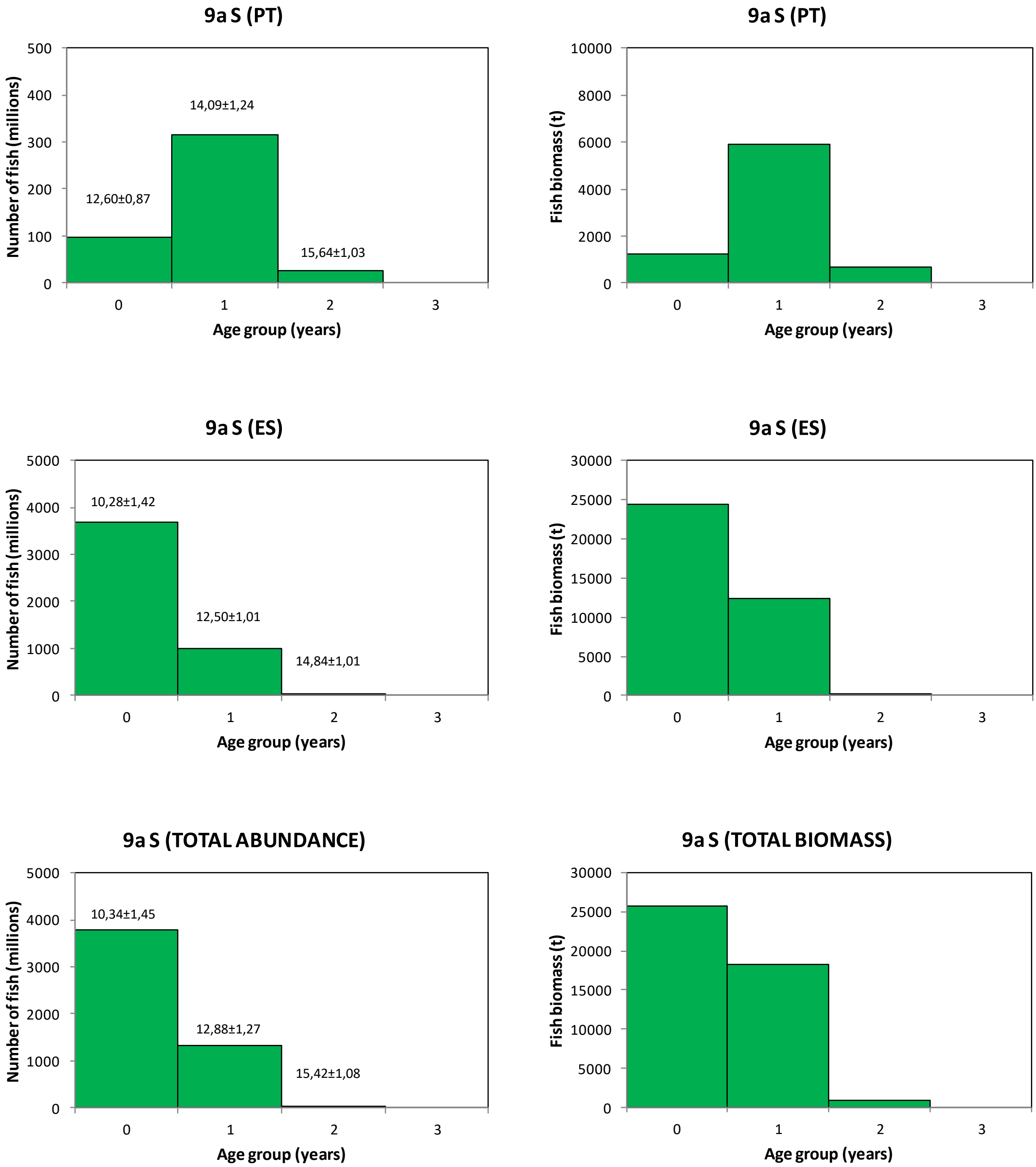


Figure 4.4.2.15. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ 2020-07* survey (summer Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by age group, with indication of the mean size by age. Note the different scales in the y-axis.

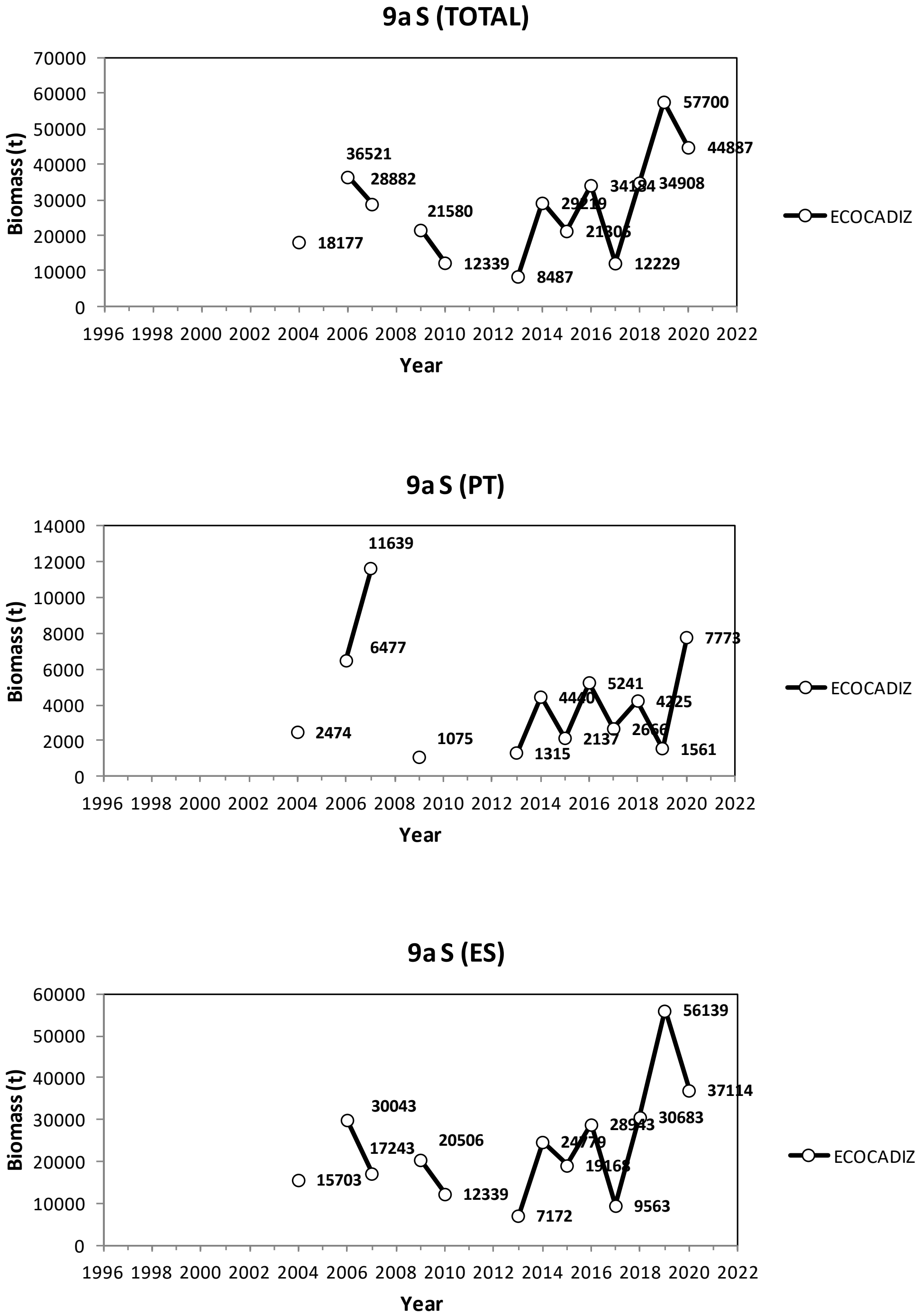


Figure 4.4.2.16. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision 9.a South). Historical series of overall and regional (Portuguese, PT, and Spanish waters of the Gulf of Cadiz, ES) acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.

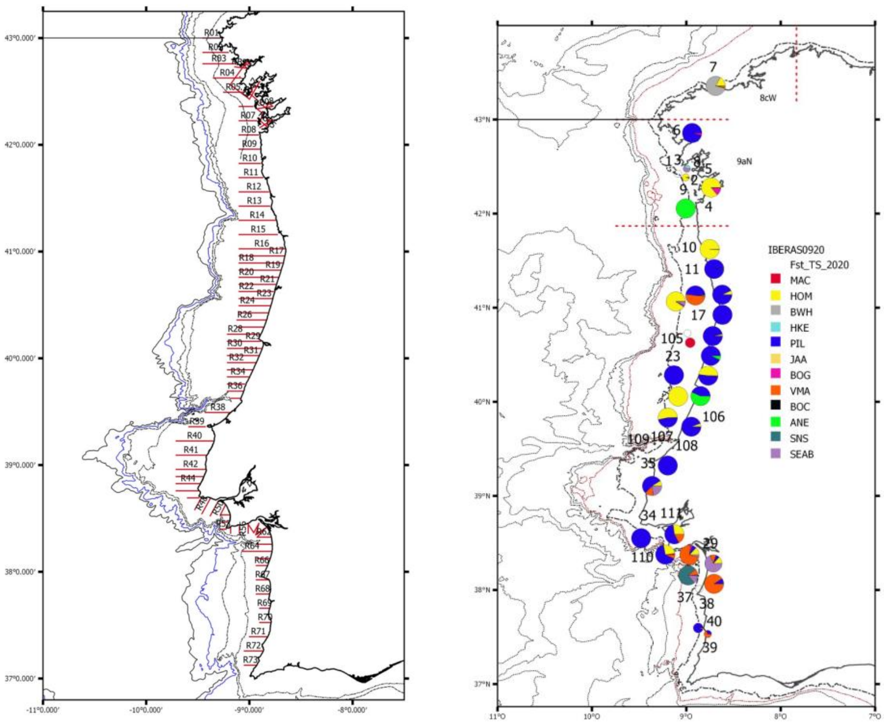


Figure 4.4.3.1. Anchovy in Division 9.a. Western component. Subdivisions 9.a North, 9.a Central-North and 9.a Central-South. *IBERAS 0920* survey (autumn Spanish-Portuguese acoustic survey in subdivisions 9.aNorth to Central-South). Left: sampling grid. Right: location of valid fishing stations with indication of their species composition (percentages in number).

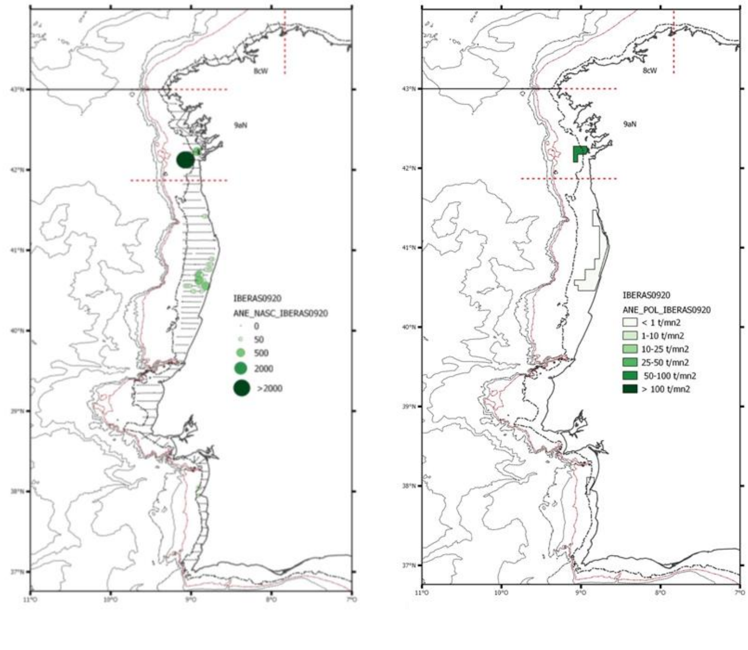


Figure 4.4.3.2. Anchovy in Division 9.a. Western component. Subdivisions 9.a North, 9.a Central-North and 9.a Central-South. *IBERAS 0920* survey (autumn Spanish-Portuguese acoustic survey in subdivisions 9.a North to Central-South). Left: distribution of the backscattering energy (Nautical area scattering 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.

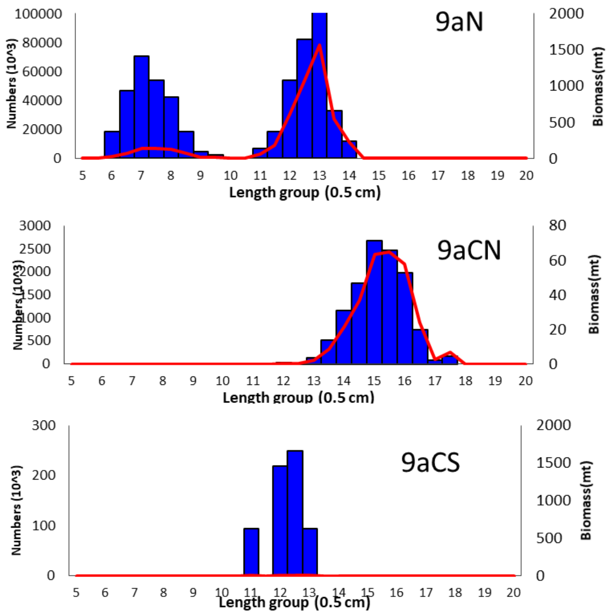


Figure 4.4.3.3. Anchovy in Division 9.a. Western component. Subdivisions 9.a North, 9.a Central-North and 9.a Central-South. *IBERAS 0920* survey (autumn Spanish-Portuguese acoustic survey in subdivisions 9.a North to Central-South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm). Note the different scales in the y-axis.

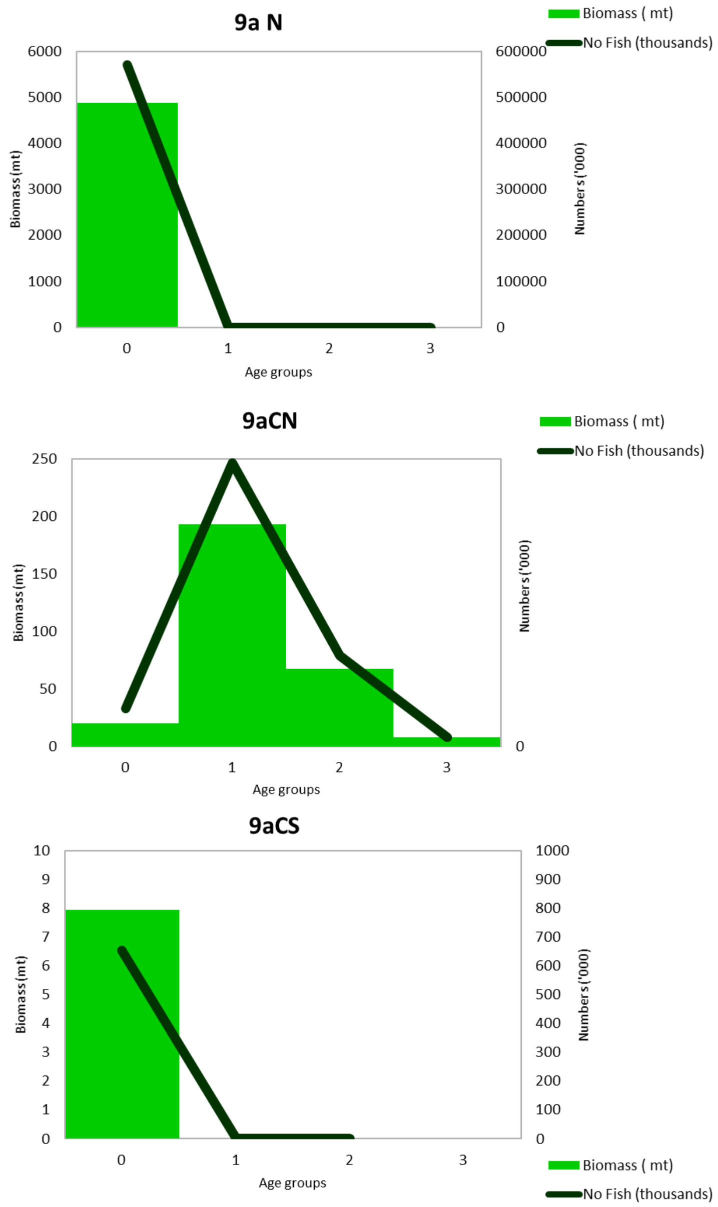


Figure 4.4.3.4. Anchovy in Division 9.a. Western component. Subdivisions 9.a North, 9.a Central-North and 9.a Central-South. *IBERAS 0919* survey (autumn Spanish-Portuguese acoustic survey in subdivisions 9.a North to Central-South). Estimated abundances and biomasses (number of fish in millions and 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.

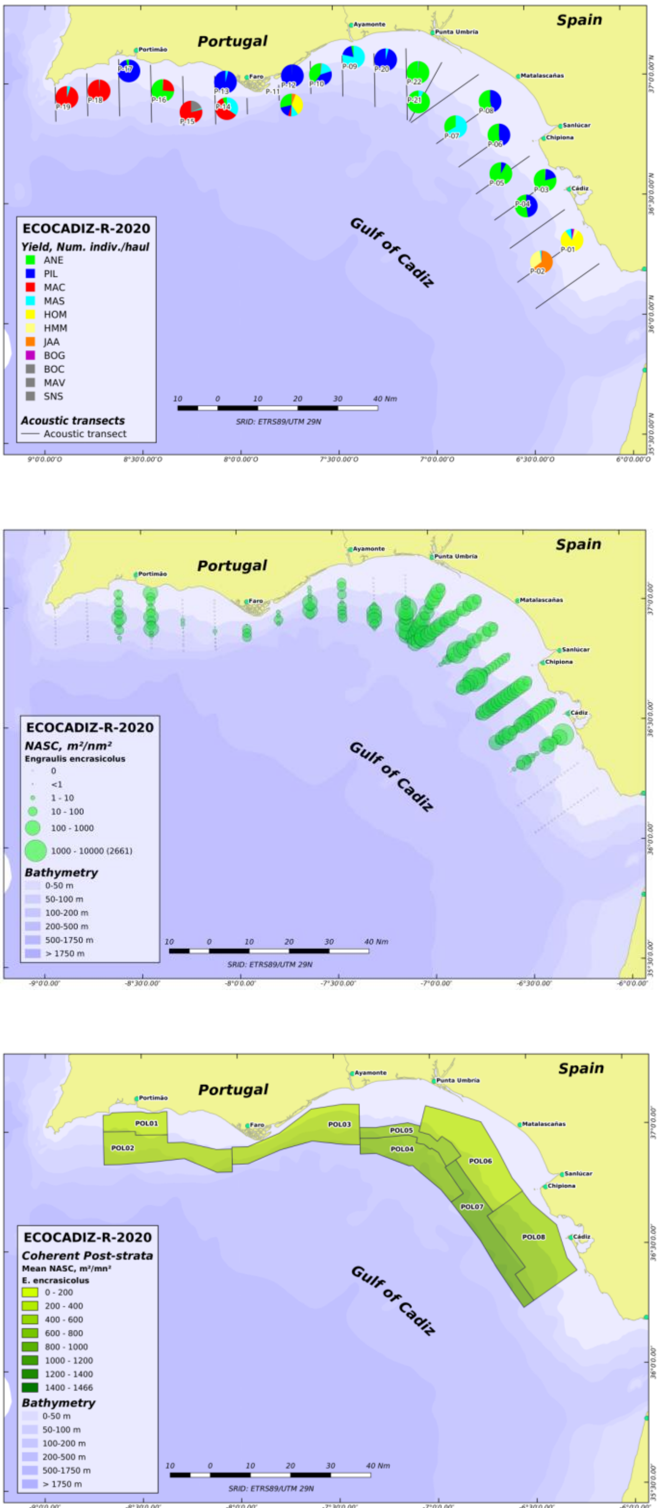


Figure 4.4.3.5. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2020-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Top: Location of valid fishing stations with indication of their species composition (percentages in number). Middle: Distribution 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.

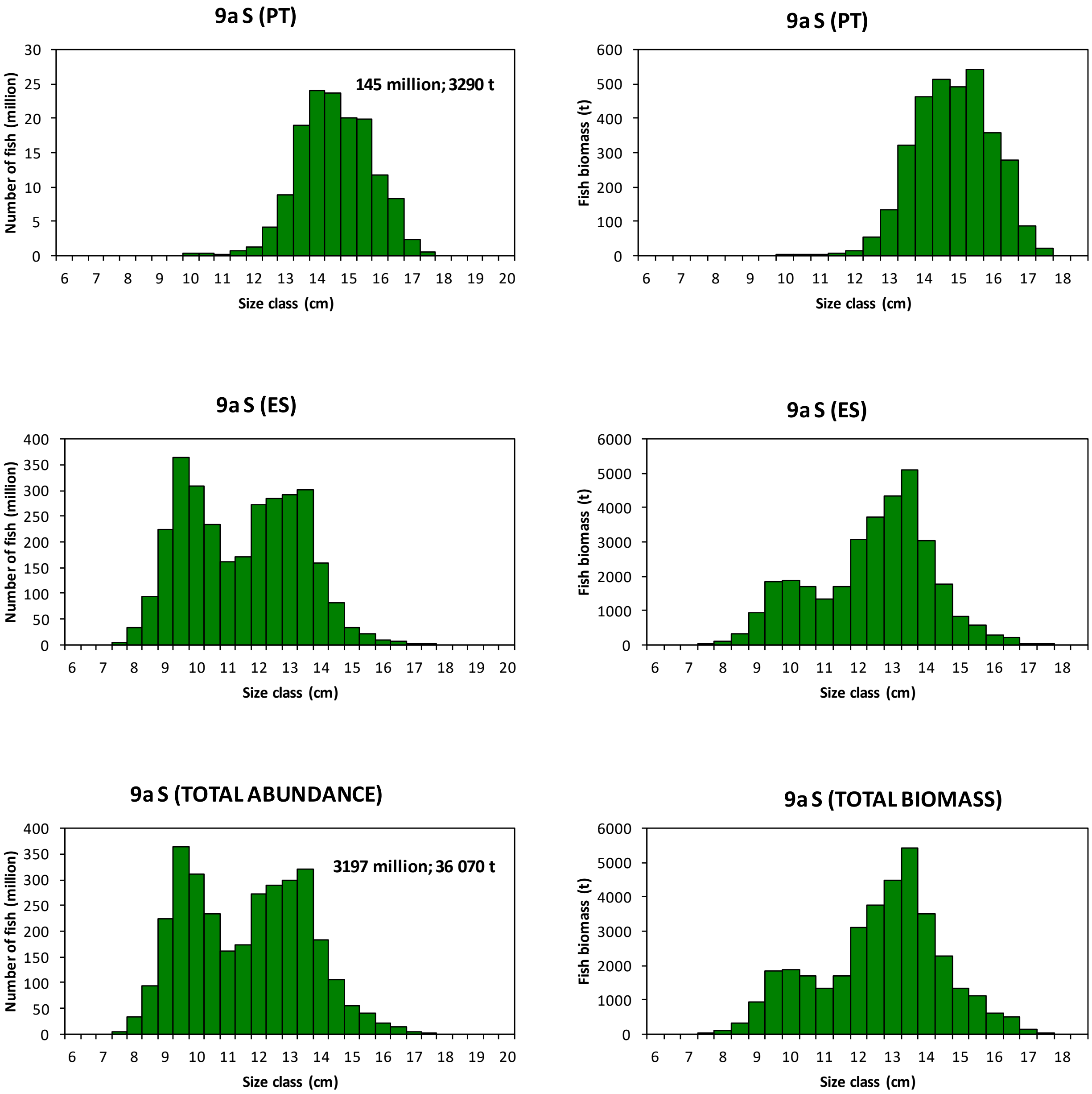


Figure 4.4.3.6. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2020-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by length class (cm). Note the different scales in the y-axis.

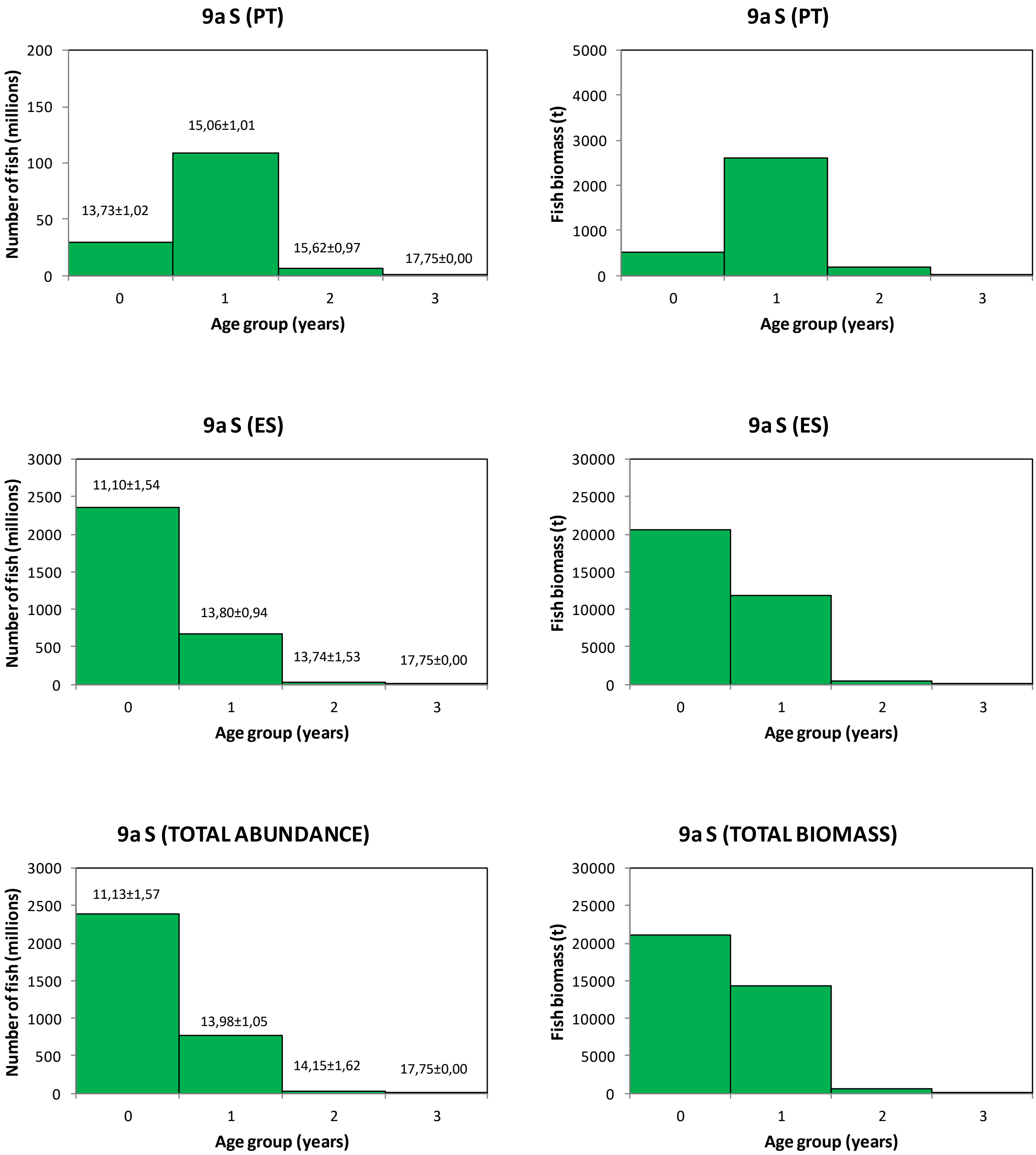
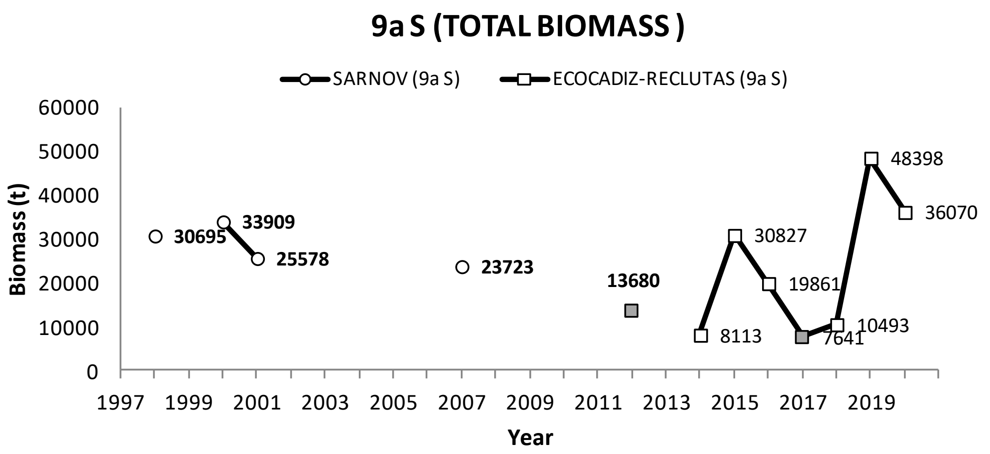
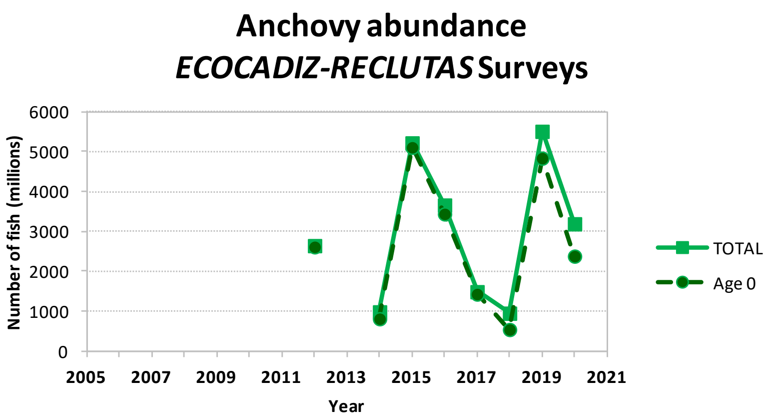


Figure 4.4.3.7. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS 2020-10* survey (autumn Spanish acoustic survey in Subdivision 9.a South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area by age group, with indication of the mean size by age. Note the different scales in the y-axis.





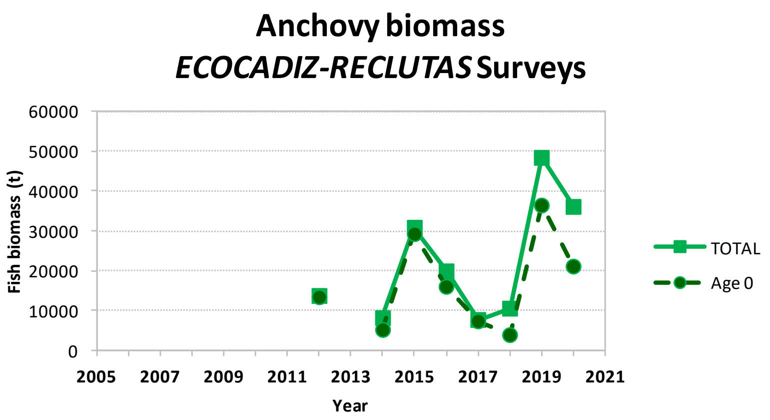
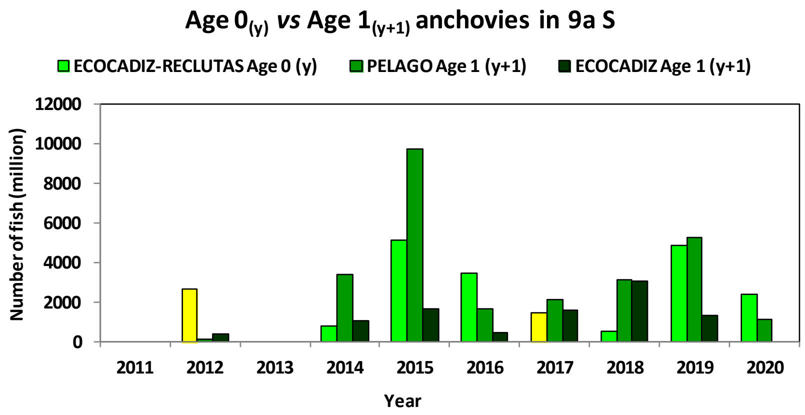
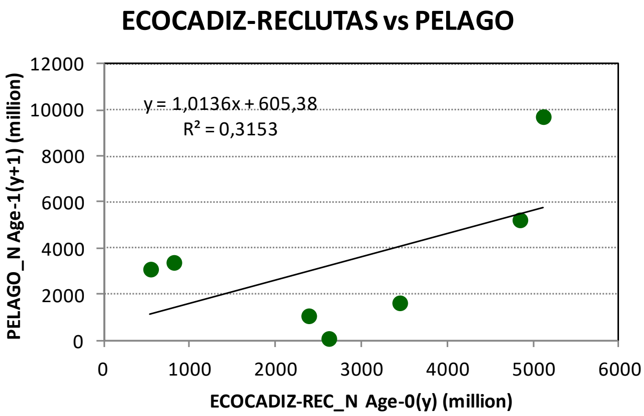


Figure 4.4.3.8. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Top: historical series of overall acoustic estimates of anchovy biomass (t), (squares). The estimates from the older Portuguese *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.





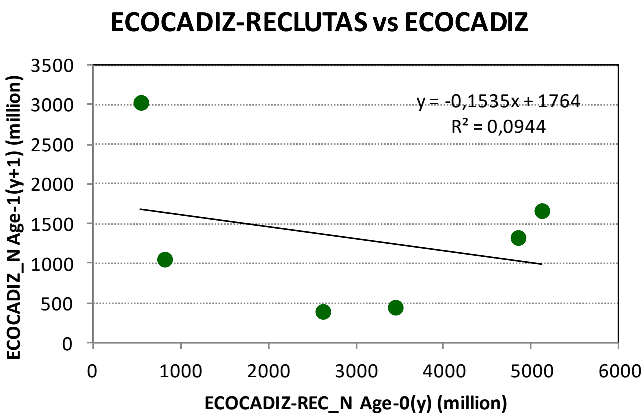


Figure 4.4.3.9. Anchovy in Division 9.a. Southern component. Subdivision 9.a South. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision 9.a South). Correspondence between acoustic estimates of abundance of Age 0 anchovies from *ECOCADIZ-RECLUTAS* surveys in the autumn of 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 (this last data point was removed from the regression fittings). *ECOCADIZ* 2021 will be conducted after the WG.

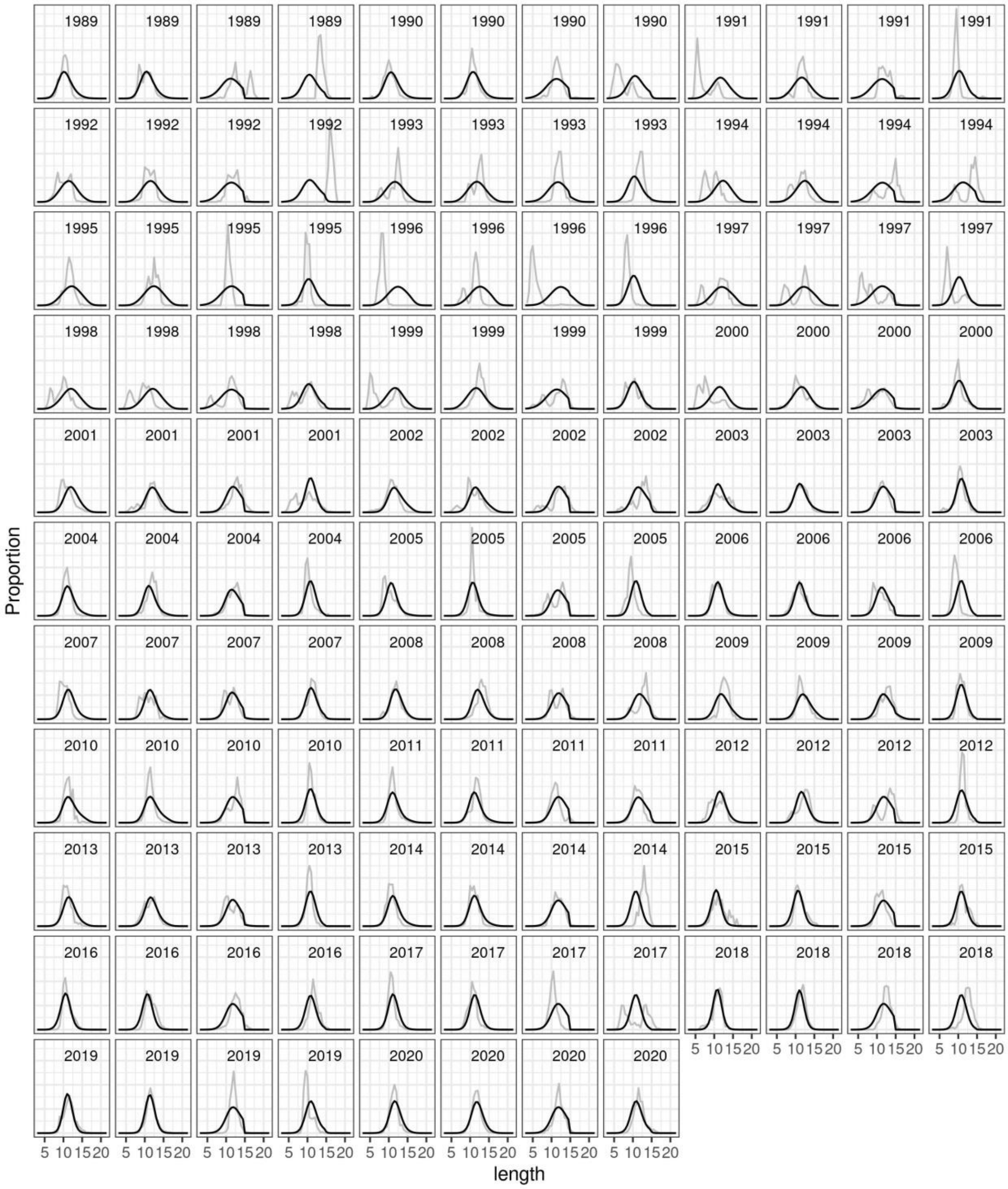


Figure 4.6.2.1.2.1. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated catches length distribution by quarters from 1989 to 2020. Black lines represent estimated data while grey lines represent observed data.

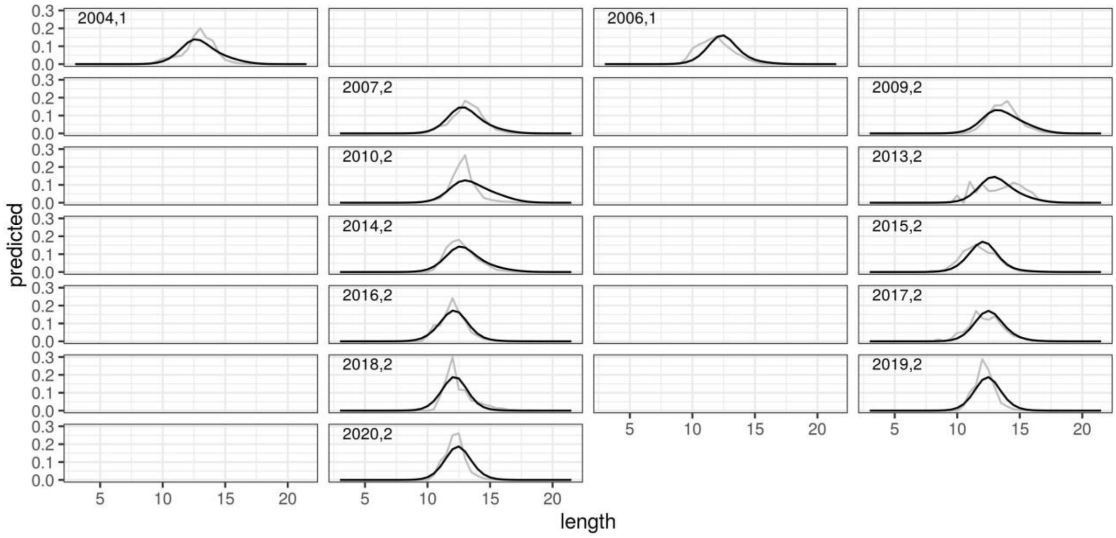


Figure 4.6.2.1.2.2. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated catches length distribution for *ECOCADIZ* survey from 2004 to 2020. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter. 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.

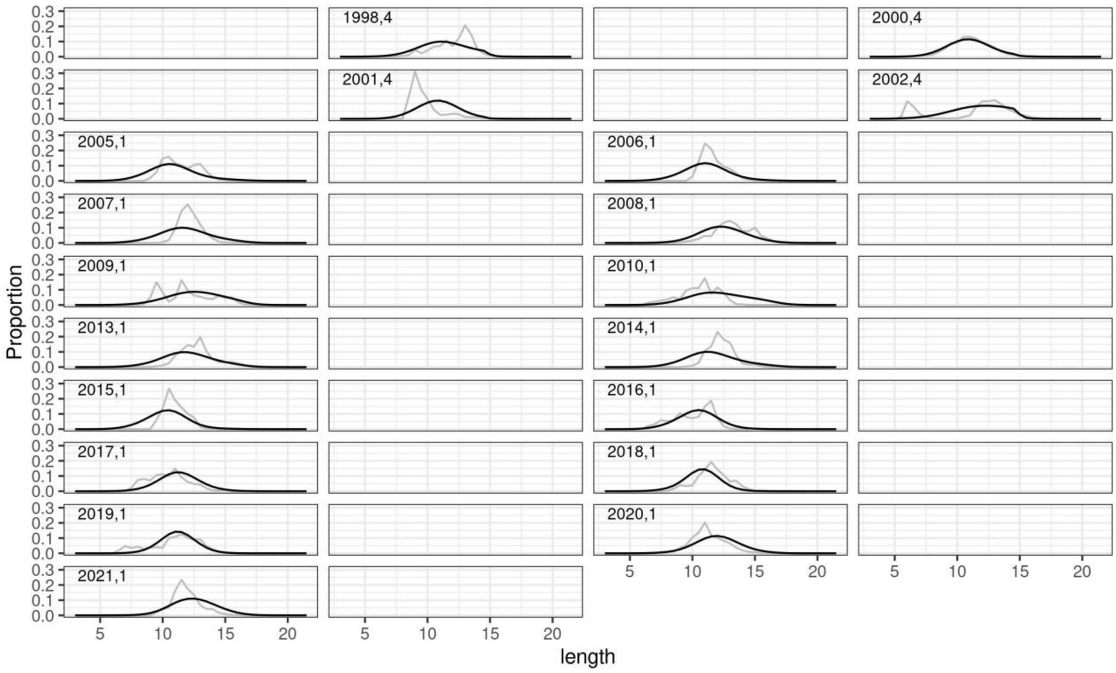


Figure 4.6.2.1.2.3. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated catches length distribution for *PELAGO* survey from 1998 to 2020. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter.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

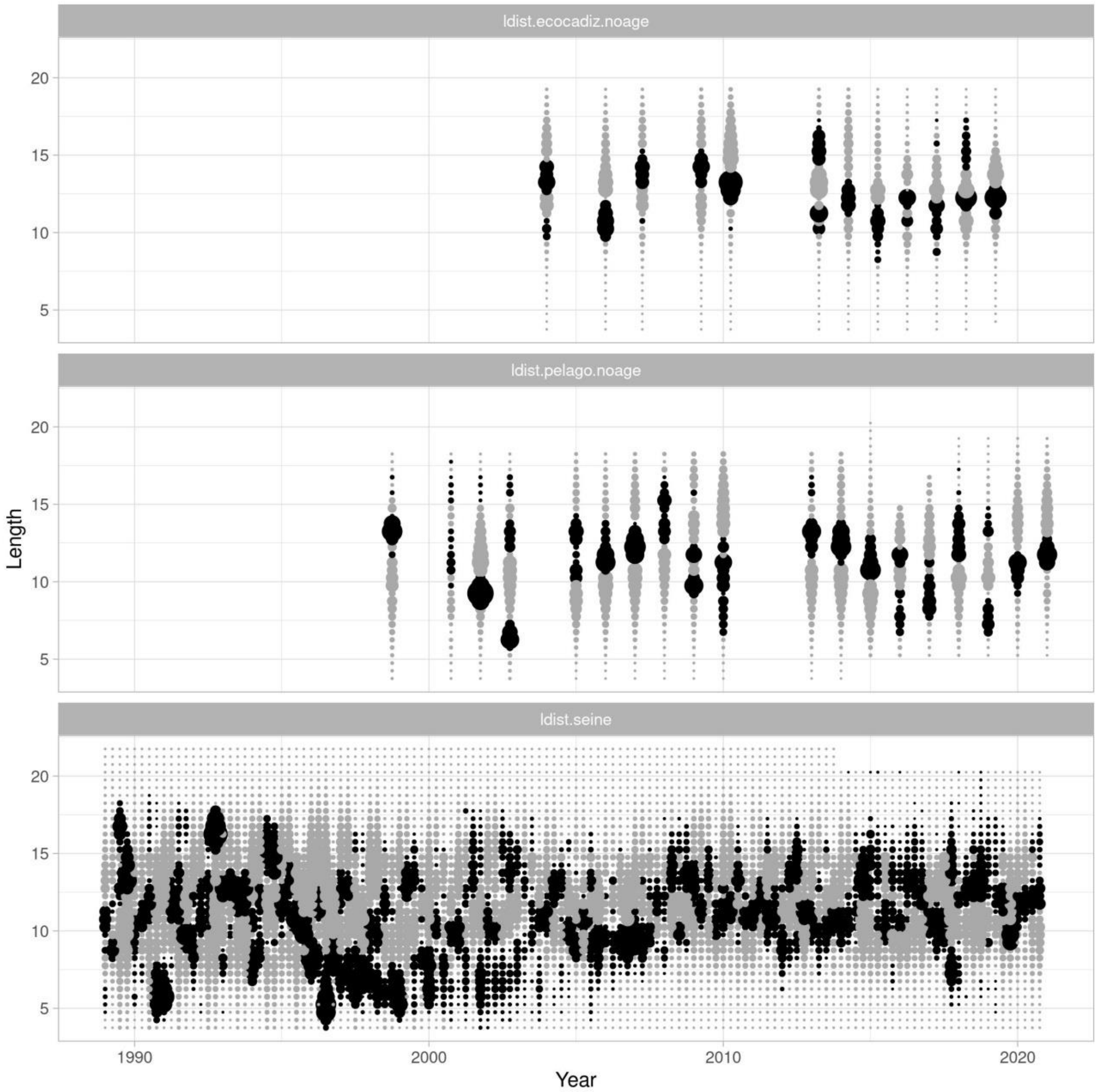


Figure 4.6.2.1.2.4. Anchovy in Division 9.a. Southern component. Standardised residual plots for the fitted length distribution from the *ECOCADIZ* survey, *PELAGO* survey and commercial fleet. Black points denote a model underestimate and grey points an overestimate. The size of the points denotes the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

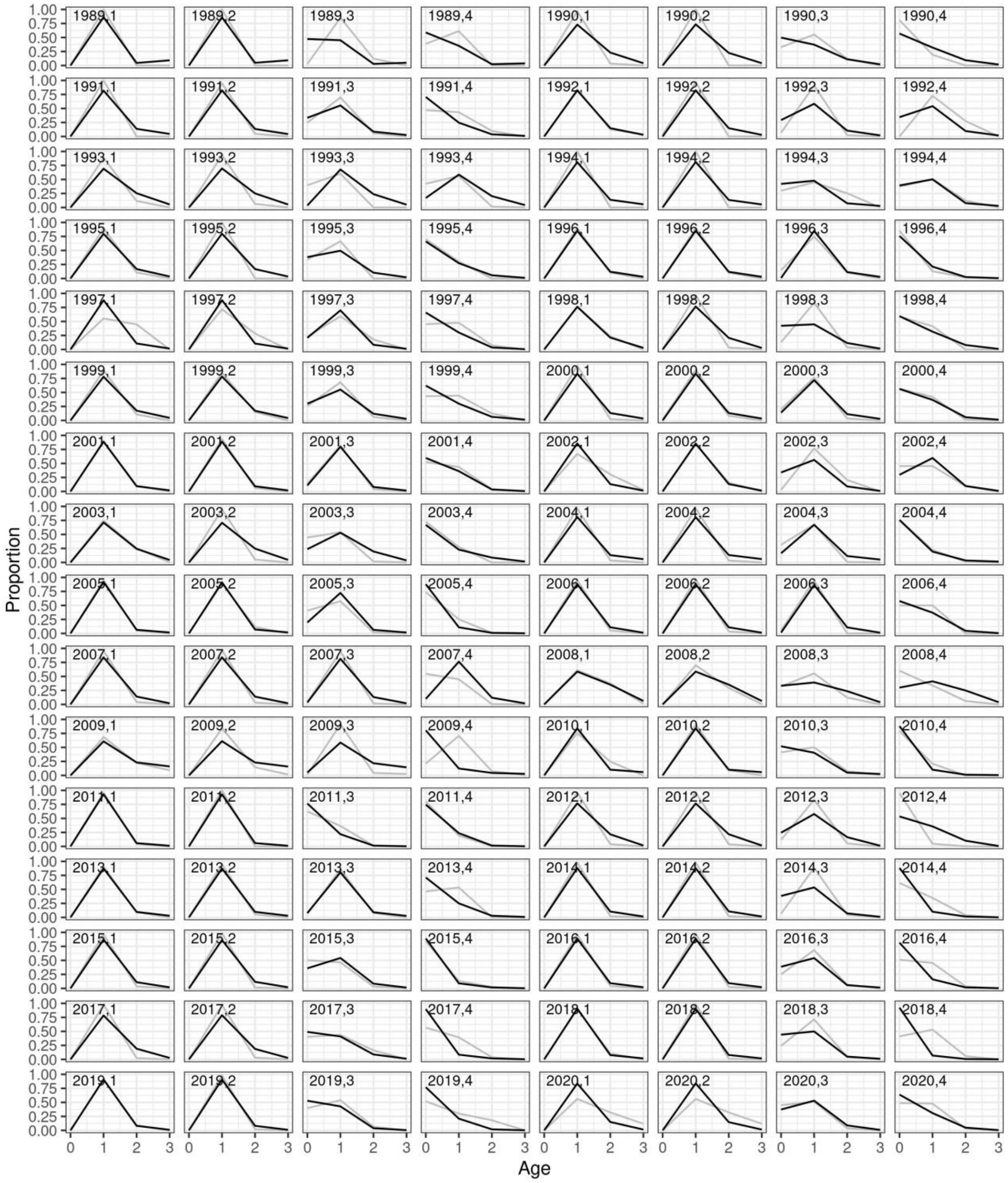


Figure 4.6.2.1.2.5. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated quarterly catches age distribution from 1989 to 2020. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter.

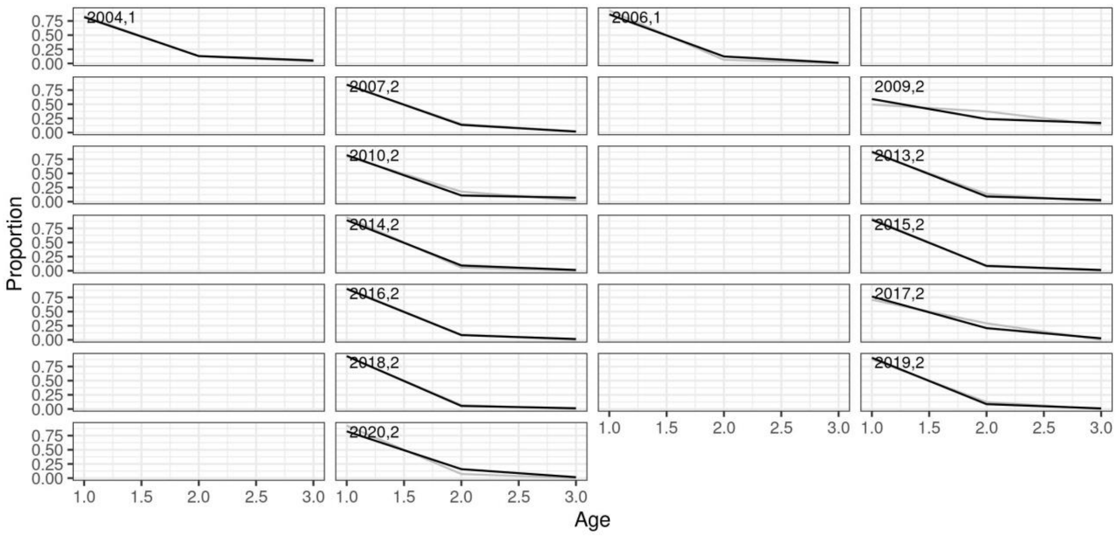


Figure 4.6.2.1.2.6. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated *ECO-CADIZ* survey age distribution from 2004 to 2020. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter. Note that 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.

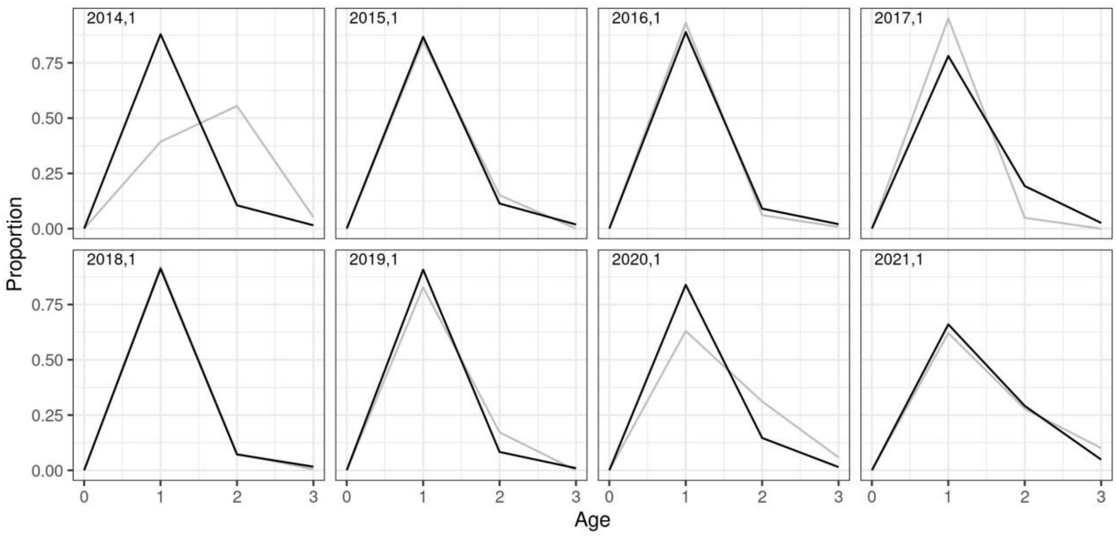


Figure 4.6.2.1.2.7. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated *PELAGO* survey age distribution from 2014 to 2021. Black lines represent estimated data while grey lines represent observed data. The number next to the year indicates the quarter. Note that the 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.

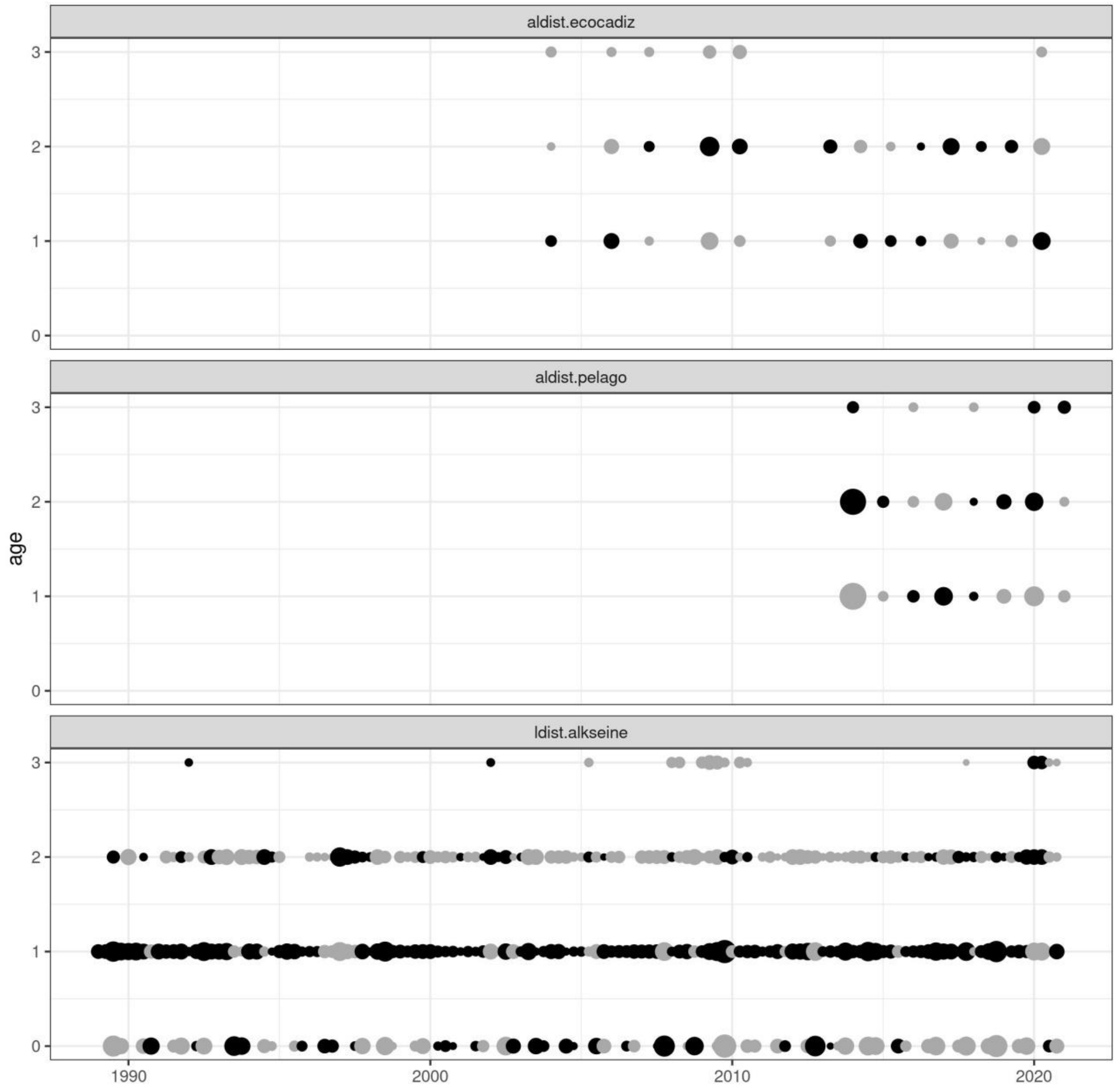


Figure 4.6.2.1.2.8. Anchovy in Division 9.a. Southern component. Standardised residual plots for the fitted age distribution from the *ECOCADIZ* survey, *PELAGO* survey and commercial fleet. Black points denote a model underestimate and grey points an overestimate. The size of the points denotes the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

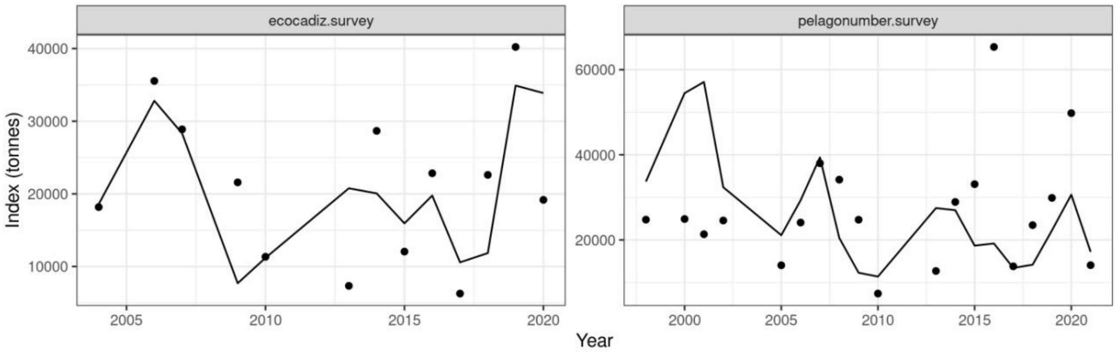


Figure 4.6.2.1.2.9. Anchovy in Division 9.a. Southern component. Comparison between observed and estimated survey biomass indices. Black points represent observed data while black line represents estimated data.

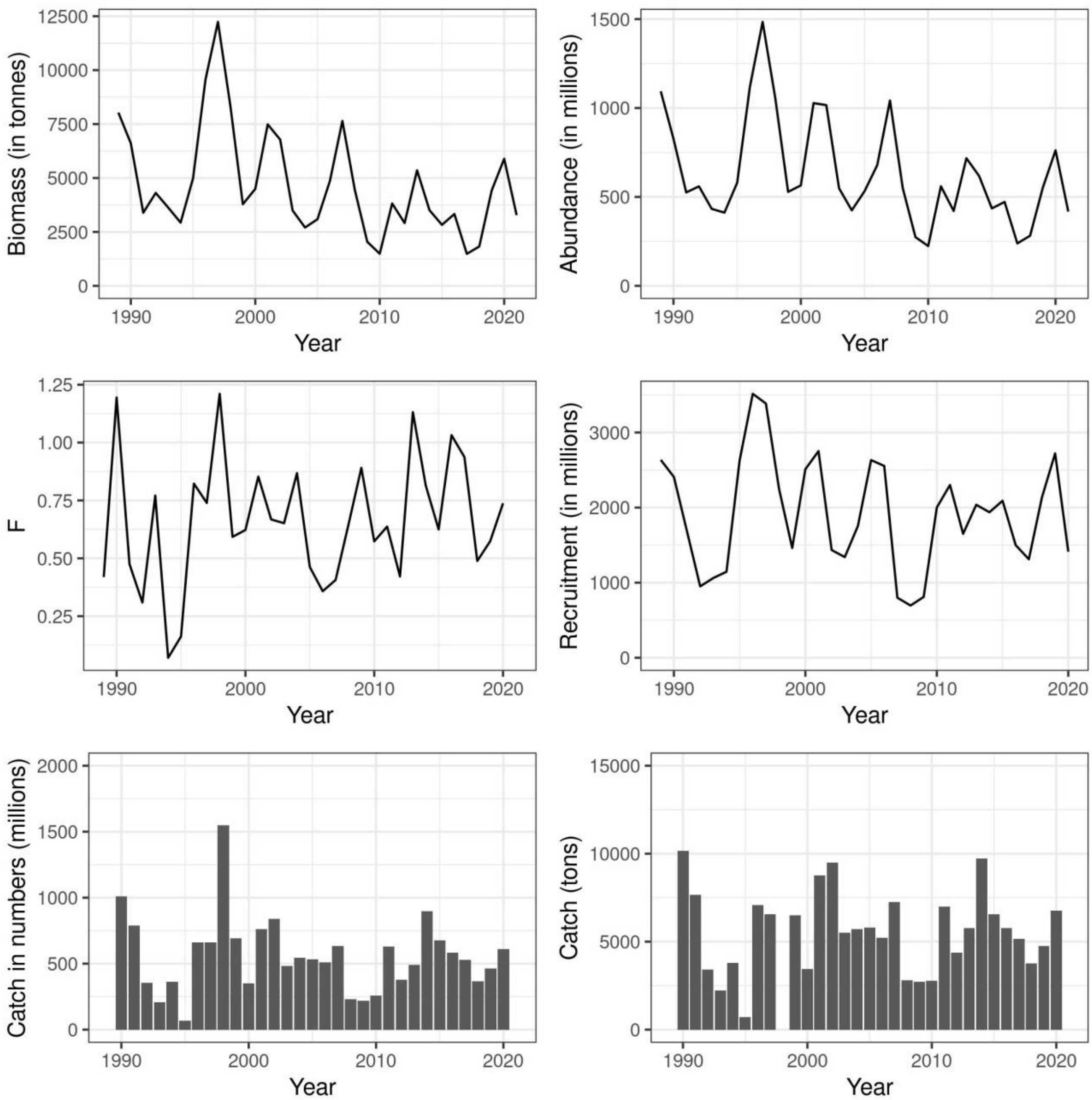


Figure 4.6.2.1.3.1. Anchovy in Division 9.a. Southern component. Annual model estimates for abundance with more than one year of age (in numbers and biomass), recruitment and fishing mortality compared with annual catch time-series (in numbers and biomass). Measures were summarised at the end of June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

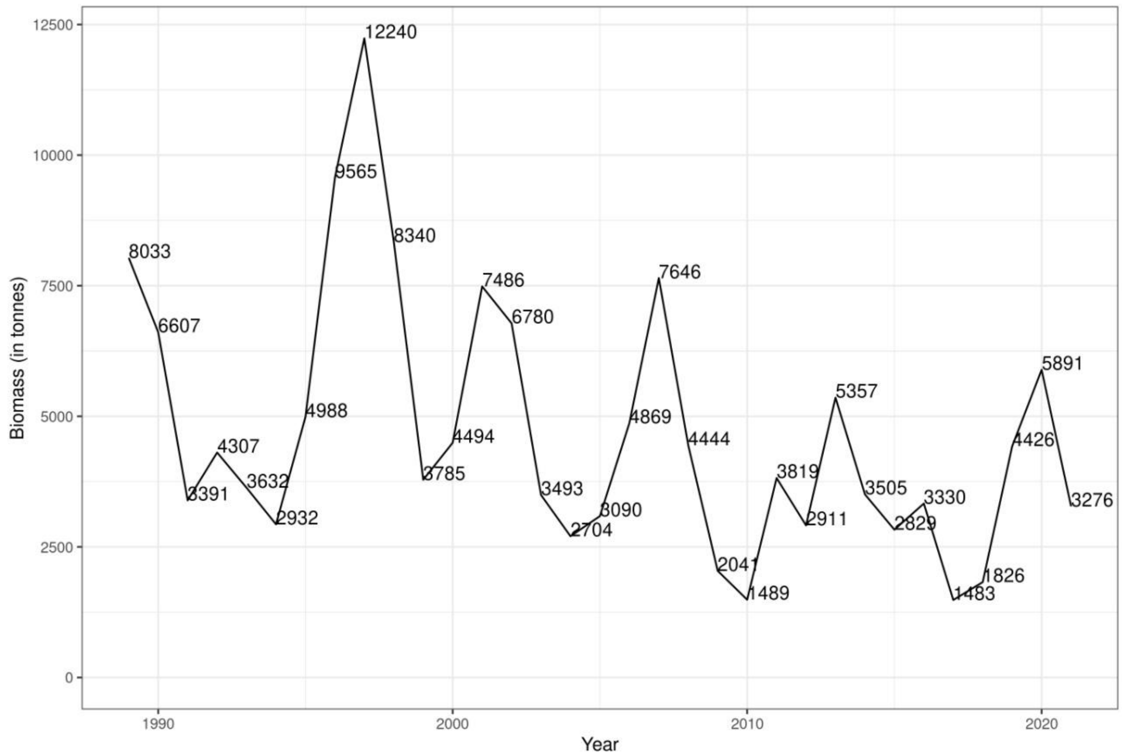


Figure 4.6.2.1.3.2. Anchovy in Division 9.a. Southern component. Time-series of estimated biomass at the end of June each year, assuming that a year starts in July and ends in June of the next year. For this stock, it is assumed that there are no individuals of age 0 at that time of the year, then this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

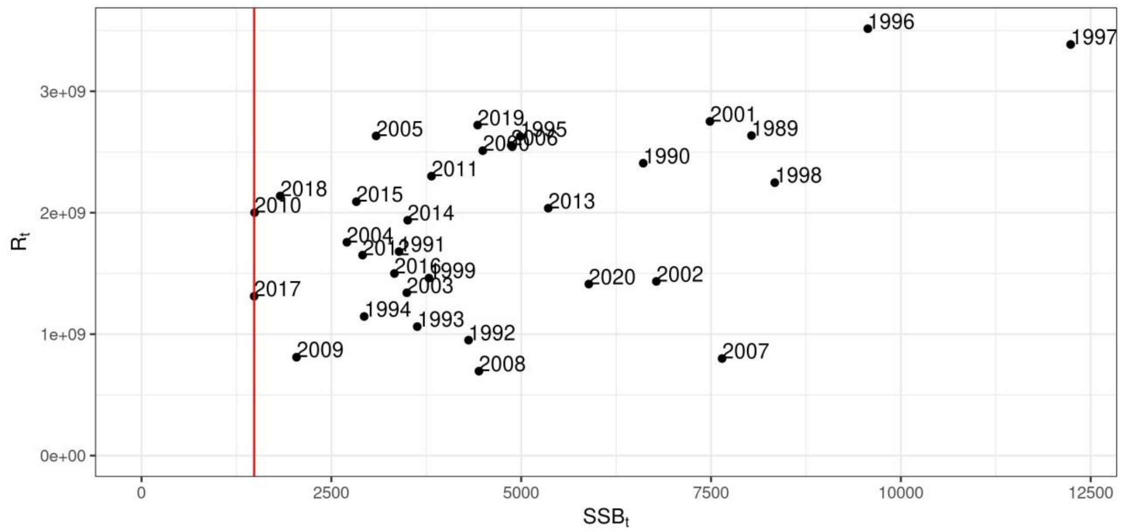


Figure 4.7.2.1. Anchovy in Division 9.a. Southern component. Estimated Stock–Spawning biomass vs. Recruitment plot. Red line indicates the B_{lim} value (B_{lim}=B_{loss}=SSB_{2017}= 1483.48 t).

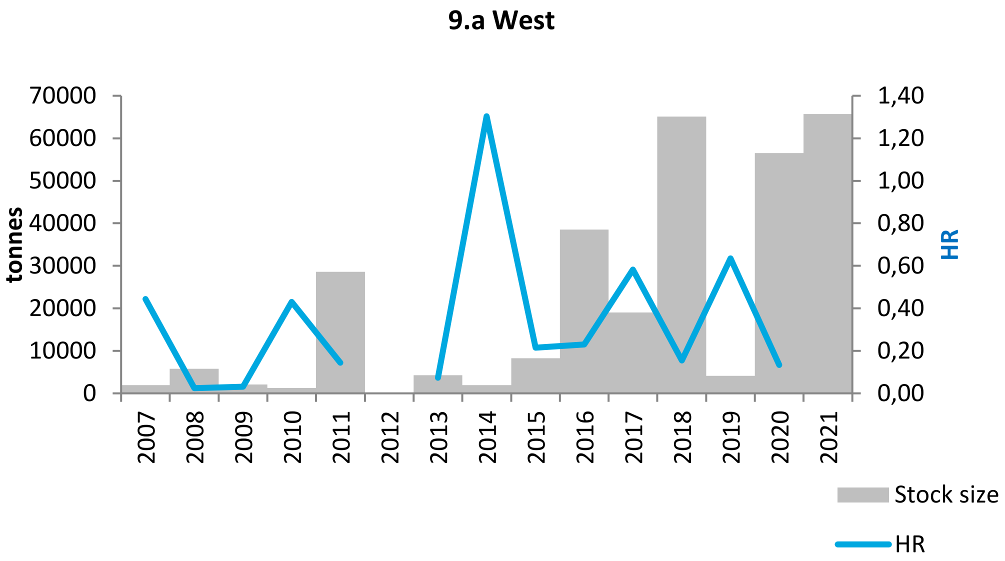


Figure 4.8.1.1. Anchovy in Division 9.a. Western Component. Stock biomass survey index and harvest rates. Harvest rates were estimated with the biomass of the surveys of a given year and the catches of the management period, i.e. 2007 corresponds to the period 07/2007 to 06/2008.

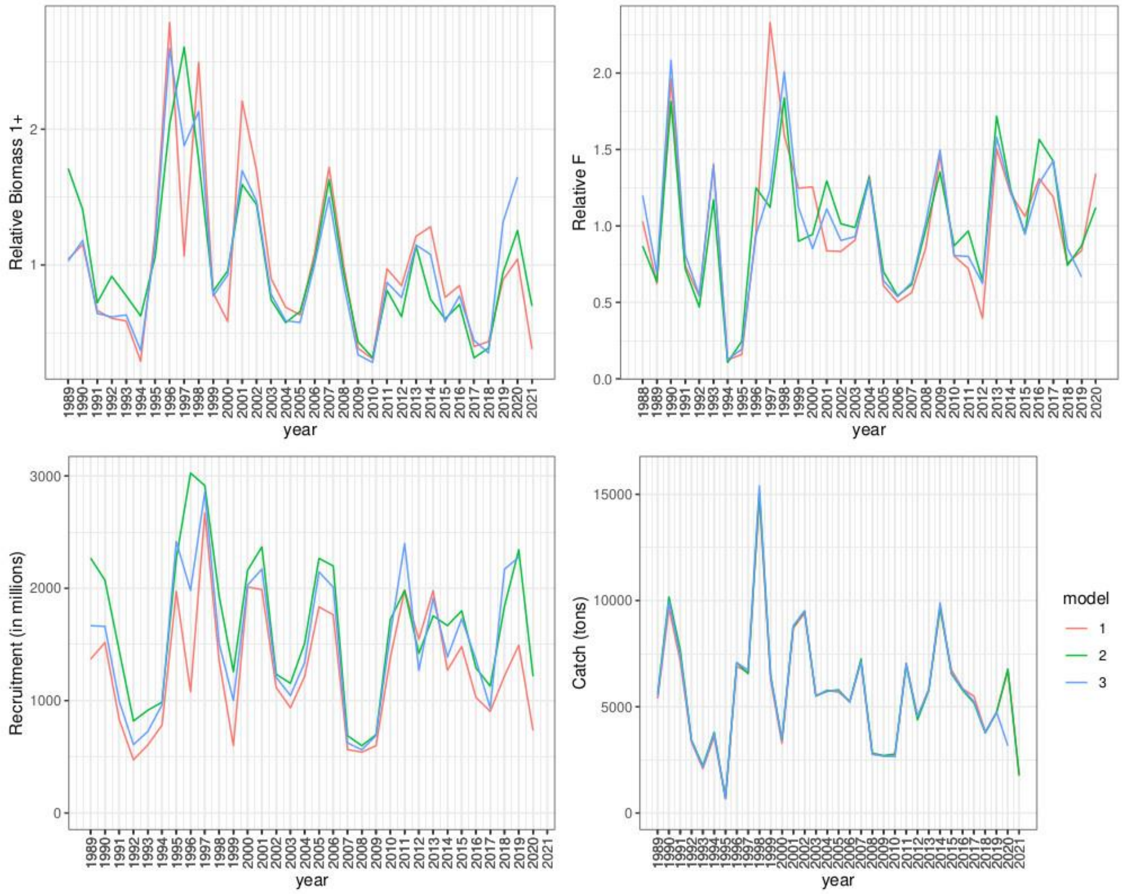


Figure 4.11.1. Anchovy in Division 9.a. Southern component. Comparison of time-series estimates from different model implementations. 1. Without data for age–length key and length distribution in first and second quarters of 2020 (pink); 2. Assuming the join length distribution of 2018 and 2019 together with the age–length key of *PELAGO 2020* survey for first and second quarters of 2020 (green); 3. Model used for the assessment in June 2020 (blue). Top panels: annual model estimates for relative abundance of individuals with more than one year of age and relative fishing mortality, bottom panels: recruitment and catches (in tons). 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.

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 divisions 8a, b, d and in Subarea 7 as a single-stock unit. The assessment of this stock as a single unit 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 Subarea 7.

Information from the ICES WKSAR workshop (ICES, 2016) suggests higher growth rates for the populations of the English Channel and Celtic Seas 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 evidence of connectivity between the Bay of Biscay and Subarea 7 sardine populations, and considering 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 interbenchmark 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. Those two rectangles use to typically account for 25% of the French sardine catches reported in the Bay of Biscay. In 2020, they account for 49%.

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 2020 were 6 772 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 2020, 24 596 tonnes were landed. About 86% of French catches are taken by purse-seiners while the remaining 14% is reported by pelagic trawlers (mainly pairtrawlers). 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 pairtrawlers 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. Sardine in 8abd. Official landlings reported to ICES (1989–2020).

	8 a,b,d									
year	France	Spain	Netherlands	Ireland	UK	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
2007	13231	1263	0	0	0	48	0	0	0	16814

year	8 a,b,d France	Spain	Netherlands	Ireland	UK	Denmark	Germany	Lithuania	Belgium	Total
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
2021	24596	6746	0	0	0	0	0	0	0	31368

Table 6.2.1.2. Sardine in 8abd. Sardine landings by France (1983–2020) and Spain (1996–2020) 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

Year	France	Spain	Total
2020	24596	6772	31368

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 as well as the numbers-at-age, percentage at age length-at-age weight at age and anchovy biomass at age in the Bay of Biscay (8abcd) and the egg abundance of sardine in 8abd. Since 2020 the SSB for sardine will be estimate annually as well as the numbers-at-age, percentage at age, weight at age and length-at-age to be available as inputs for the assessment. This year the daily egg production (P_0) (eggs /m²), daily mortality rates (z) and total daily egg production (P_{tot})(eggs) estimates were as well estimate trying to obtain it for all the historical series (**Table 6.2.2.1.1**). The following years those parameters will be estimate for the previous years to complete the series and to have a historical series of a more precise egg index as a proxy of the biomass for the past in 8abd. For the time been, this estimates P_0, z and P_{tot} are available for years 2002, 2008, 2011, 2014, 2017, 2018, 2019, 2020 and 2021. Currently, the input used for the assessment is the total egg abundance in the 8abd without the Northwest part to be consistent with the historical series.

The survey took place from the 30th of April to the 24th of May. All the methodology concerning the survey and the estimates performance, are described in detail in the . A detailed report of the survey and results 2021 is attached as a working document in ICES WGACEGG 2021 in **annex** 3 (**Santos Mocoroa. M *et al*. BIOMAN 2021).**

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 was 5.57E+12 eggs, considered the whole area surveyed. Considering the 8abd the estimate was 4.47E+12 and removing part of the Northwest for assessment propose, to be consistent with the historical series, the total egg abundance was 4.02E+12 eggs, below the time-series average (5.68E+12) (**Figure 6.2.2.1.1, Table 6.2.2.1.2**). The sardine eggs were encountered all along the Cantabrian coast, from the coast to 200m depth. The survey stopped at 6º20'W but the western limit of the spawning was not found in the Cantabrian coast, a considerable amount of eggs were encountered in the last transect completed to the west. In the French platform sardine eggs were encountered all along the East of the 100m depth isoline, until 47º23'N. Due to the bad weather it was not possible to survey the limit of the division 8a (48ºN) but as the Northwest part of the spawning has to be removed to be consistent with the historical series, this did not affect the estimation in 8abd to be an input for the assessment proposes (**Figure 6.2.2.1.2**)

In the sampling with the PairoVET net (vertical sampling) from 740 stations a total of 250 (34%) had sardine eggs with an average of 161 eggs/m² per station in the positive stations, a maximum of 1500 egg m² in a station and a total number of 40 330 eggs/m². In the sampling with CUFES (horizontal sampling) a total of 546 stations (32%) had sardine from 1709 stations. (**Figure 6.2.2.1.2**)

To estimate the reproductive parameters for sardine in the Bay of Biscay from BIOMAN survey, 21 adult hauls were available. Mean weight and mean length are showed in **Figure 6.2.2.1.3**. Age composition and mature fish expressed in times one within each haul are showed in **Figure 6.2.2.1.4**. All the samples were processed, and the histology analysis and oocytes count were conducted but the estimates of the batch fecundity, spawning frequency and spawning stock biomass are still in process.

Table 6.2.2.1.1. Sardine in 8abd. Daily egg production (P_0) (eggs /m2), daily mortality rates (z) and total daily egg production (P_{tot})(eggs) estimates and their corresponding standard error (S.e.) and coefficient of variation (CV) for all the area surveyed area, 8abd and 8abd without NW from BIOMAN 2021.

	ALL AREA			8abd			8abdwithoutNW		
Parameter	**Value**	**S.e.**	**CV**	**Value**	**S.e.**	**CV**	**Value**	**S.e.**	**CV**
P0	60.06	8.86	0.1475	62.39	9.98	0.1599	61.05	9.53	0.1561
z	0.09	0.085	0.9058	0.16	0.092	0.5671	0.16	0.090	0.5732
Ptot	2.1E+12	3.1E+11	0.1475	1.9E+12	3.0E+11	0.1599	1.7E+12	2.6E+11	0.1561

Table 6.2.2.1.2. Sardine in 8abd. Time-series for sardine, total egg abundances (Σ(egg_St*area_st)) in numbers of eggs, without the Northwest, the one adopted as an input for the assessment of sardine in 8abd.

Year	TotAb_8abd_without N
1999	1 056 821 462 500
2000	5 033 603 614 700
2001	2 202 319 921 500
2002	7 818 653 994 900
2003	3 264 118 502 300
2004	7 834 185 034 700
2005	10 869 189 010 400
2006	3 837 276 560 100
2007	2 330 112 023 800
2008	9 366 752 841 900
2009	6 051 260 723 200
2010	10 345 025 232 600
2011	4 290 385 672 700
2012	5 599 540 844 800
2013	5 473 978 901 400
2014	8 209 126 018 300
2015	5 519 555 053 500
2016	8 557 696 286 000
2017	5 985 351 434 300
2018	4 673 100 206 300
2019	4 494 514 516 239
2020	3 754 705 767 993
2021	4 018 637 729 660
Mean	**5 677 648 319 730**
Std Dev	**2 625 372 082 071**
CV	**46.2%**

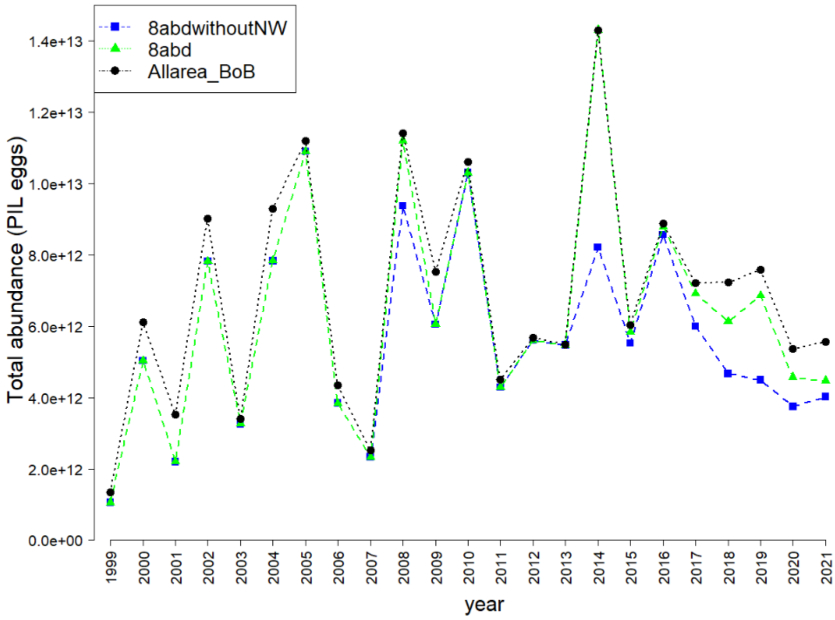


Figure 6.2.2.1.1. Sardine in 8abd. historical series for sardine egg abundances in all the area surveyed (black line), in 8abd (green line) and 8abd without Northwest stations (blue line) including 2021 value.

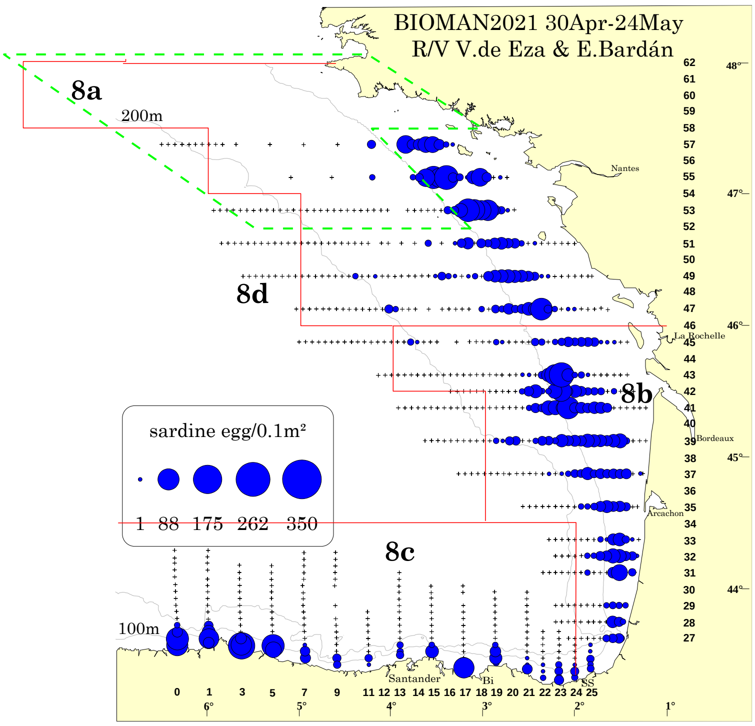


Figure 6.2.2.1.2. Sardine in 8abd. Spatial distribution and abundance of sardine eggs per 0.1m² from the DEPM survey BIOMAN2021 obtained with PairoVET (vertical sampling). The dash green line represents the stations removed for assessment propose in 8abd to be consistent with the historical series. Red lines represent the limits of 8abcd.

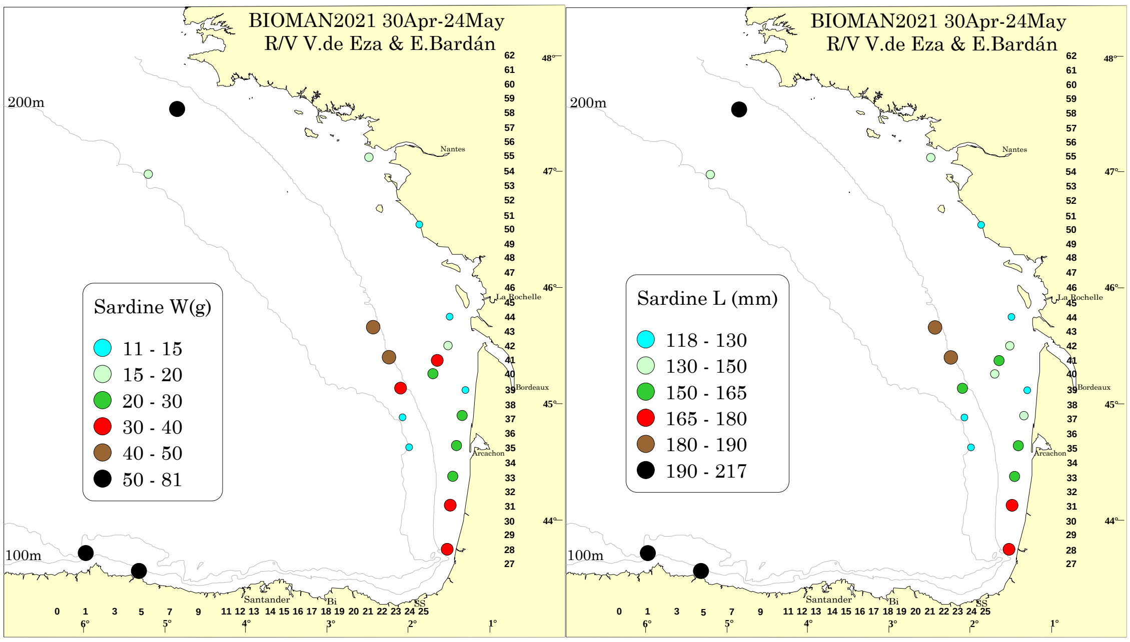


Figure 6.2.2.1.3. Sardine in 8abd. Sardine spatial distribution of mean weight (left) and mean length (right) in the Bay of Biscay from BIOMAN 2021 survey.

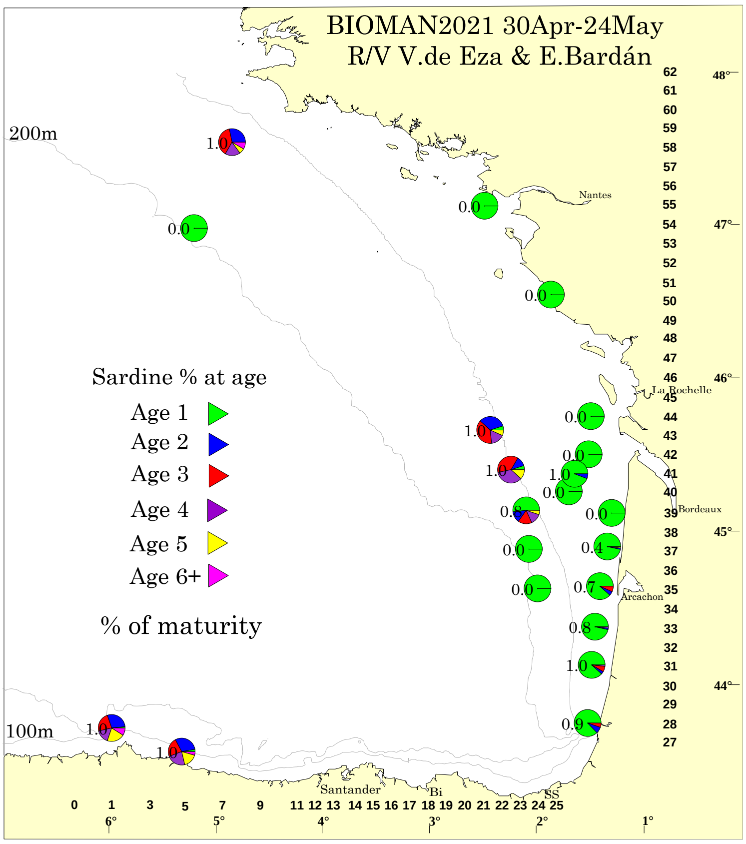


Figure 6.2.2.1.4. Sardine in 8abd. Sardine spatial distribution of percentage at age and mature individuals expressed in in each haul in the Bay of Biscay from BIOMAN 2021 survey. The different colours are the different ages and the numbers in each circle are the mature individuals expressed in times one.

6.2.2.2 Acoustic spring survey (PELGAS): 8ab

The biomass estimates of sardine observed during PELGAS21 is **333 000** tons, which is constant with the previous survey in 2019, the biomass reaching a medium level of the PELGAS series. It must be noticed that the sardine abundance index is very variable, and it could be explained that this survey doesn't cover the total area of potential presence of sardine, and it is possible that some years, this population could expand present up to the North, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs. It is also possible that sometimes, a part of the population could be present in very coastal waters, when the R/V Thalassa is unable to operate in those waters. The estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (8ab) sardine population.

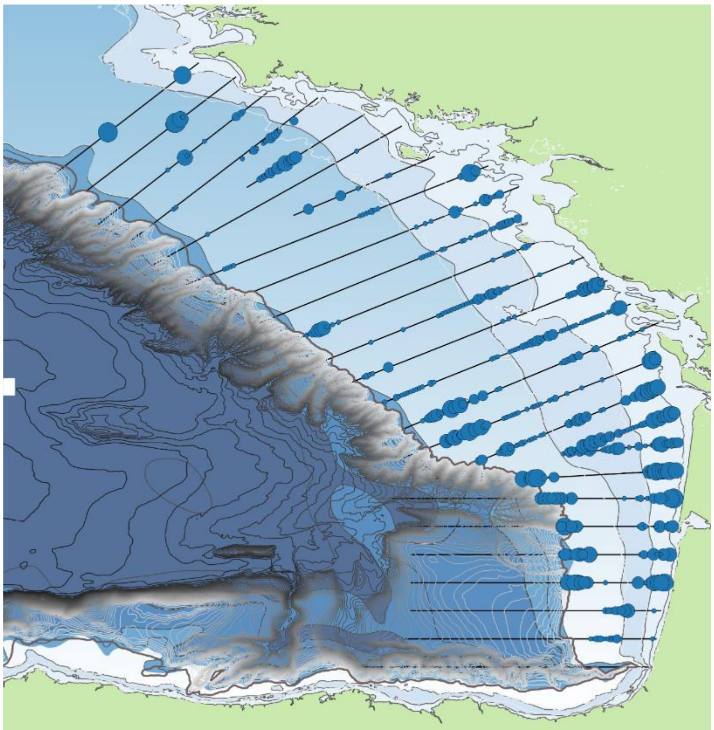


Figure 6.2.2.2.1. Sardine in 8abd. distribution of sardine observed by acoustics during PELGAS21.

Sardine was distributed all along the French coast of the Bay of Biscay, from the South to the Loire river. The small sardine was present this year, rarely pure, regularly mixed with sprat along the coast or mix with anchovy particularly at the shelf break. This appearance, in minority compared to anchovy of small sardine (age 1 exclusively – see below) but well present along the shelf break is completely new since the beginning of the PELGAS series.

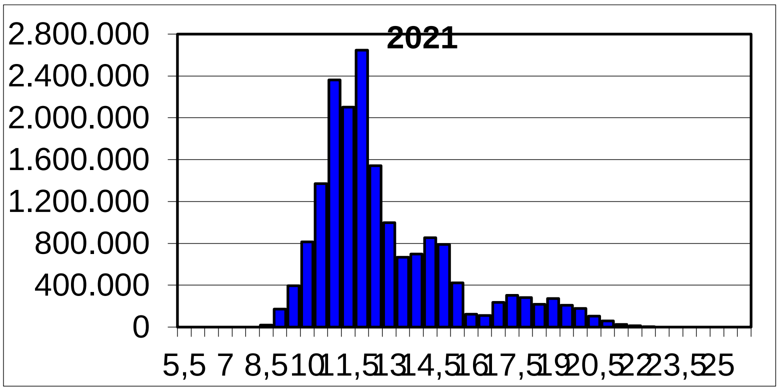


Figure 6.2.2.2.2. Sardine in 8abd. length distribution of sardine as observed during PELGAS21.

Length distributions in the trawl hauls were estimated from random samples. The population length distributions have been estimated by a weighted average of the length distribution in the hauls. Weights used are the acoustic biomass estimated in the post-stratification regions comprising each trawl haul. The global length distribution of sardine is shown in Figure 6.2.2.2.2.

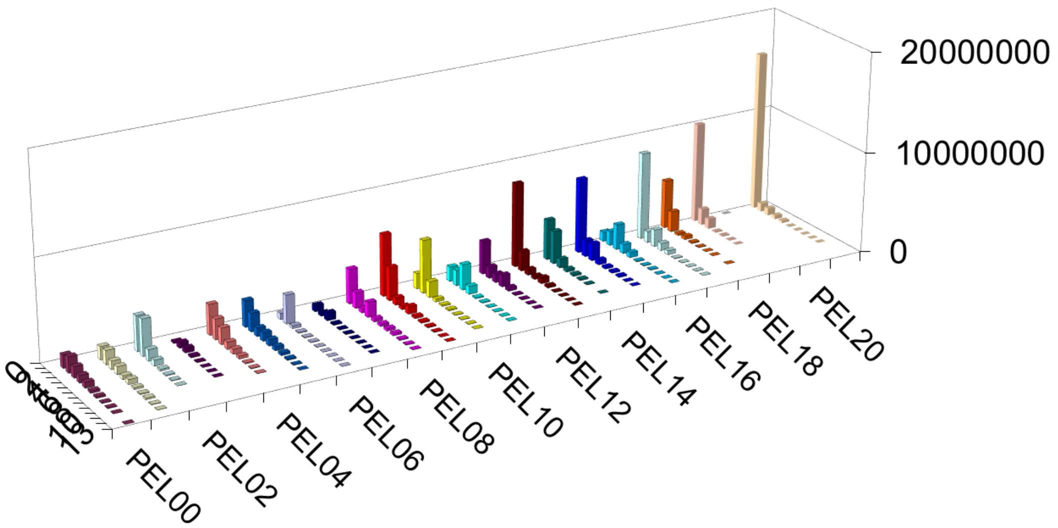


Figure 6.2.2.2.3. Sardine in 8abd. Age composition of sardine as estimated by the acoustic survey PELGAS since 2000.

PELGAS series of sardine abundances at age (2000-2021) is shown in Figure 6.2.2.2.3. 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 no more 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 one of the best recruitment ever and who seems to contribute not that much to the total abundance of sardine in 2018 (and 2019) in the bay of Biscay. 2019 seemed to be the best recruitment ever and the population is becoming more and more young (81% of the fish are 1 year old). In addition, 2021 is again the best recruitment ever, with a proportion of age 1 reaching 88 %.

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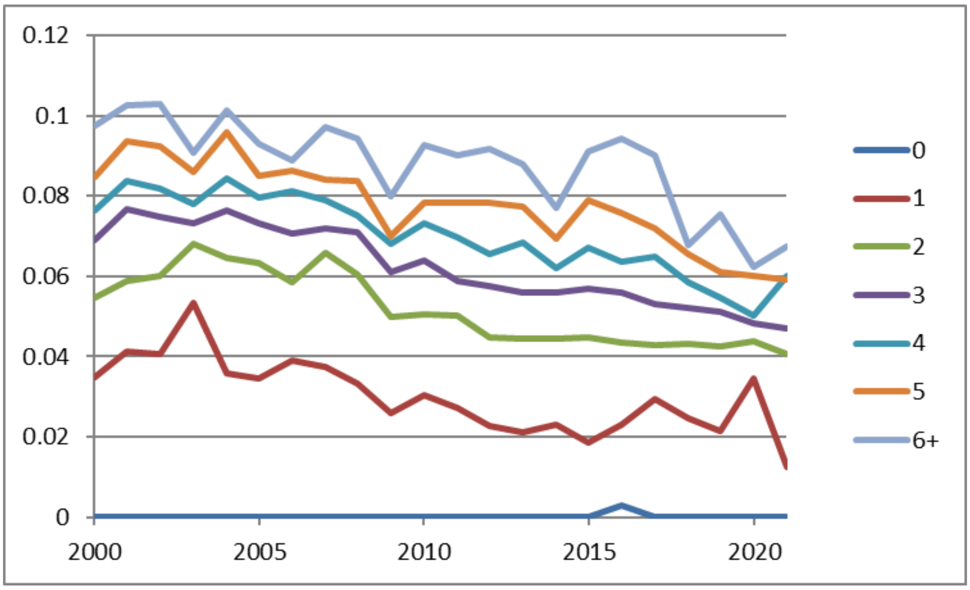

Figure 6.2.2.2.4. Sardine in 8abd. Evolution of mean weight at age (g) of sardine along PELGAS series.

The PELGAS sardine mean weights at age series (Figure 6.2.2.2.4) 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 age 2, but ages 1 continue to show a decreasing weight at age. The values are particularly noticeable, one-year old sardines were about 40 grams at the beginning of the serie, and reach only 12.5 grams this year.

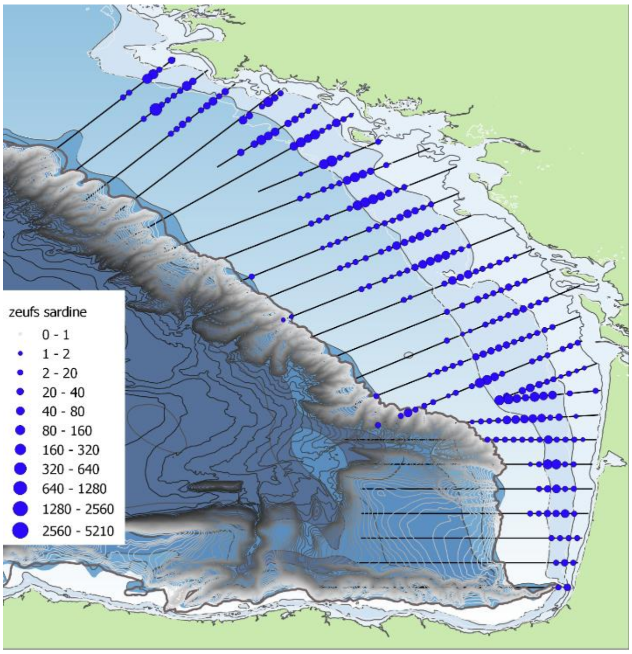

Figure 6.2.2.2.5. Sardine in 8abd. Distribution of sardine eggs observed with CUFES during PELGAS21.

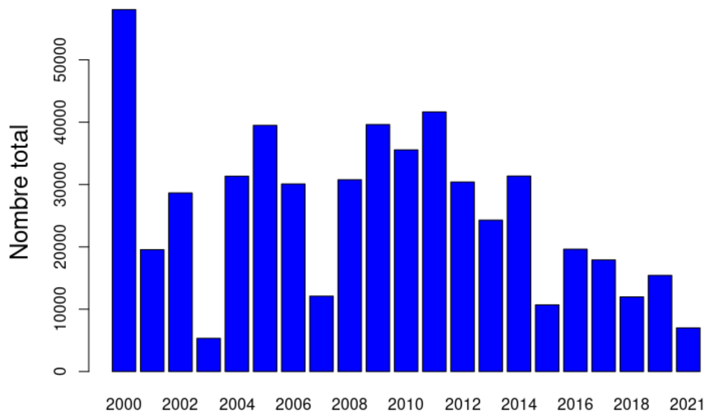

Figure 6.2.2.2.6. Sardine in 8abd. Number of eggs observed during PELGAS surveys from 2000 to 2021

2021 was marked by a low abundance of sardine eggs as compared to the PELGAS time-series (Figure 6.2.2.2.5 and Figure 6.2.2.2.6). It must be noticed that this year the numerous one-year-old individuals were not fully mature: 67 % of the age1 were totally immature (stage1) and 17 % were starting their maturation (stage 2 of the maturity scale) at the time of the survey. Only 16 % age 1 were fully mature. Almost all of the older individuals (age 2 and more) were spawning.

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 divisions 8a, b, d ranges from 10 to 28 cm. In 2020, a peak is observed in the catch-at size distributions around 17-18 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 2020 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 2020 for France and Spain are shown in Tables 6.2.3.2.1 to 6.2.3.2.4.

Table 6.2.3.1.1. Sardine in 8abd. French Sardine catch at length composition (thousands) in ICES divisions 8a,b in 2020.

Length * (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
10				140	140
10.5				70	70
11				210	210
11.5					
12	142			70	212
12.5	427		153	210	790
13	772	308	77	560	1 717
13.5	795	770	249	560	2 374
14	1 113	924	574	840	3 451
14.5	1 072	1 926	1 243	420	4 661
15	1 799	3 928	4 053	1 190	10 970
15.5	1 680	3 851	8 546	1 890	15 967
16	2 234	16 098	21 960	5 459	45 751
16.5	2 577	29 346	40 877	14 489	87 289
17	5 110	28 806	57 433	21 488	112 837
17.5	5 545	14 326	50 043	23 308	93 222
18	6 774	9 859	37 778	14 419	68 830
18.5	7 645	5 469	18 679	7 909	39 702
19	7 211	2 773	11 720	5 249	26 953
19.5	4 630	2 850	5 421	3 710	16 611
20	2 718	2 234	2 438	1 820	9 210
20.5	1 710	1 078	994	840	4 622
21	1 169	154	497	350	2 170
21.5	580	231	373	210	1 394
22	104	77	124		305
22.5	194	77		70	341
23	57	77			134
23.5					
24					
24.5					
25					
Total number	56 058	125 162	263 232	105 481	549 933
Official catch (t)	2 800	5 600	11 160	5 036	**24 596**

Table 6.2.3.1.2. Sardine in 8abd. Spanish sardine catch-at-length composition (thousands) in ICES Division 8b in 2020.

Length * (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
10					
10.5	4				4
11					
11.5				3	3
12	18				18
12.5	184			37	221
13	996			178	1 174
13.5	2 280	1		476	2 757
14	4 920			431	5 351
14.5	7 880	2		370	8 252
15	9 650	5		287	9 942
15.5	7 810	47		595	8 452
16	5 710	157		2 930	8 797
16.5	3 880	215	1	8 660	12 756
17	2 880	216	12	14 400	17 508
17.5	2 060	59	28	16 100	18 246
18	1 480	33	30	16 900	18 443
18.5	1 020	4	42	14 400	15 466
19	876	1	52	10 900	11 829
19.5	490		41	6 770	7 301
20	359	1	11	4 060	4 431
20.5	144		3	2 500	2 647
21	131		6	1 530	1 667
21.5	31		1	736	768
22	17			539	556
22.5	10			184	194
23				67	67
23.5				29	29
24				16	16
24.5					
25				17	17
25.5					
26				5	5
26.5					
27				5	5
27.5					
28				2	2

Length * (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
Total number	52 830	741	228	103 119	156 917
Official catch (t)	1 674	28	12	5 033	**6 747**

Table 6.2.3.1.3. Sardine in 8abd. Spanish 2020 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	11.776	1877.96	1889.73
1	43507.2	556.076	114.698	30189.1	74367.1
2	5300.24	176.951	123.655	37961.5	43562.4
3	2102.87	27.8279	79.9504	21810.3	24021
4	1416.19	7.79265	33.4534	9127.71	10585.2
5	197.236	0.16571	7.44162	2041.6	2246.45
6	127.236	0.16571	0.66779	417.99	546.059
7	178.521	0.33143	0.02068	192.367	371.24
8	0	0	0	0	0
9	0	0	0	0	0

Table 6.2.3.1.4. Sardine in 8abd. French 2020 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	10176	3388	13564
1	16568	65024	175655	56858	314105
2	20033	47150	66271	34353	167807
3	15437	10779	10081	9326	45623
4	2534	1454	389	649	5026
5	1120	455	236	391	2202

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
6	308	223			531
7	57	77	52	96	282
8	0	0	0	0	0
9	0	0	0	0	0

Table 6.2.3.2.1. Sardine in 8abd. Spanish 2020 landings in divisions 8a,b: Mean length (cm) -at-age.

	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	0	0	13.2358	14.3057	14.299
1	15.4141	17.4245	17.4544	17.647	16.3339
2	16.7401	18.6454	18.0629	17.9988	17.8417
3	18.2363	19.4307	19.1332	19.1192	19.0404
4	18.788	20.019	19.4831	19.6261	19.5126
5	20.4445	20.3689	19.9417	20.4006	20.403
6	20.8266	21.0699	20.3429	21.4009	21.2655
7	20.6609	20.7683	23.25	22.7509	21.7437
8					
9					

Table 6.2.3.2.2. Sardine in 8abd. Spanish 2020 landings in divisions 8a,b: Mean weight (kg) -at-age.

	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0	0	0	0.01887	0.02206	0.02204
1	0.02922	0.03701	0.04188	0.04314	0.03495
2	0.03693	0.03824	0.04654	0.04594	0.04482
3	0.04748	0.04346	0.05576	0.05577	0.05503
4	0.05211	0.04762	0.05913	0.06073	0.05956
5	0.06545	0.06345	0.06357	0.06884	0.06853
6	0.06899	0.06345	0.0676	0.08057	0.07785

	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
7	0.0674	0.06345	0.10352	0.09713	0.0828
8					
9					

Table 6.2.3.2.3. Sardine in 8abd. France 2020 landings in ICES Division 8,b: mean length (cm) -at-age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0			15.3	13.97	14.9678
1	15.75	16.32	17.07	17.57	16.9356
2	18	17.25	17.79	18.2	17.7473
3	19.13	18.88	19.14	19.37	19.1222
4	20.15	20.07	20.85	20.87	20.274
5	20.89	20.65	20.49	20.51	20.7301
6	20.75	20.52			20.6534
7	23	23	20.5	20.5	21.6879
8					
9					

Table 6.2.3.2.4. Sardine in 8abd. French 2020 landings in ICES Division 8b: mean weight (kg) -at-age.

Age	First Quarter	Second Quarter	Third quarter	Fourth Quarter	Whole Year
0			0.02874	0.02167	0.02697
1	0.03148	0.03513	0.04035	0.04413	0.03949
2	0.0476	0.04172	0.04592	0.04928	0.04563
3	0.05751	0.05518	0.05755	0.05979	0.05743
4	0.06753	0.06668	0.07507	0.07526	0.06887
5	0.07553	0.0729	0.07114	0.07136	0.07378
6	0.07394	0.07141			0.07288
7	0.10175	0.10175	0.07122	0.07122	0.08573

8	0	0	0
9			

6.2.3.3 Maturity

The maturity ogive is provided yearly by the PELGAS survey, carried out in May, from the visual examination of gonads according a maturity scale (stage 1- 5). Age 1 is the only age group which has partial maturity, and usually it has been assessed to be about 0.7580 (mean of maturity in 2017-2019). However, in 2021 a larger fraction of the age 1 individuals were immature. About 66% of age 1 fishes were immature (a value corresponding to the unweighted mean of the proportion age 1 fishes in stage 1 of maturity. This implies that only about 33% of age 1 fishes were mature. In addition, about 17% of the age 1 fishes were at stage 2. If half of these fishes were as well immature that would drop down the percentage of immature fishes to about 25%. The group decided to run a sensitivity analysis of the assessment to these two values of maturity-at-age 1 (33% and 25%).

On the other hand the BIOMAN survey, carried out in May, aiming to provide a DEPM estimate of sardine SSB, estimated an unweighted % of maturity-at-age 1 of about 37% in weight (based on maturity stage 1 individuals too). Such estimate to be unbiassed requires the amount of samples in space to be proportional to abundance. The sampling may have not been actually proportional to abundance and, by comparing with the acoustic estimates of abundance at age 1 from the PELGAS survey, it might have required more adult samples in the coastal areas where fishes were mostly immature. For a rough alternative estimation of maturity we counted twice the samples coming from the immature area (by doubling the amount of fishes coming from those areas), and this produced new estimates of maturity-at-age 1 of about 26% in weight. These two values of maturity from the BIOMAN survey endorses the current value adopted from PELGAS of 33% which is place halfway between the two, and also endorse to carry out a sensitivity analysis to a lower maturity value around 25%.

6.3 Stock assessment

6.3.1 Historical stock development

Model used: SS3

Since 2019 this stock is assessed using SS3. The procedure is described in the stock annex following the WKPELA benchmark (2017). It was updated in 2019 following the IBPSardine interbenchmark (ICES, 2019). The interbenchmark 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% for B_{lim}. 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 third one following the interbenchmark in 2019.

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 below B_{lim} in 2021. SSB has decreased strongly from 2010 to 2012 to the lower value of the series and has been stable until 2017. SSB has since then had a decreasing trend with 2021 the lowest value of the time-series. 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. Recruitment has been variable over time. Recruitment in 2020 is the highest of the time-series. The 2020 cohort represent 66% of individuals in 2021 but only a quarter of the SSB because of the lowest individual weight and large proportion of immature fish (66%). This partly explains why SSB is lower than in previous year.

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

Year	Recruitment (thousand)	SSB (tonnes)	Total Catch (tonnes)	F(2–5)
2000	4226920	133755	15097	0.155
2001	5134660	151471	15005	0.160
2002	3400570	163945	18277	0.188
2003	3760940	172269	16607	0.152
2004	6951690	143769	14197	0.145
2005	2261310	171256	16360	0.142
2006	3495820	150491	16741	0.156
2007	6844220	134712	17323	0.165
2008	8371660	154996	21821	0.23
2009	3409220	132572	20855	0.188
2010	2591540	148213	20127	0.186
2011	4274160	119094	23208	0.25
2012	7473560	87100.5	30900	0.44
2013	5188680	93378.7	32938	0.48
2014	6902560	97290.3	35704	0.59
2015	2542420	87120.5	28756	0.51
2016	6187660	79622.4	29754	0.62
2017	4475950	99174.8	30435	0.61
2018	4794720	84329.5	32299	0.70
2019	4435970	66008.1	24579	0.53
2020	8381930	78067.8	31368	0.70
2021	4665110**	50141.7		

***Geometric mean (2002–2020).**

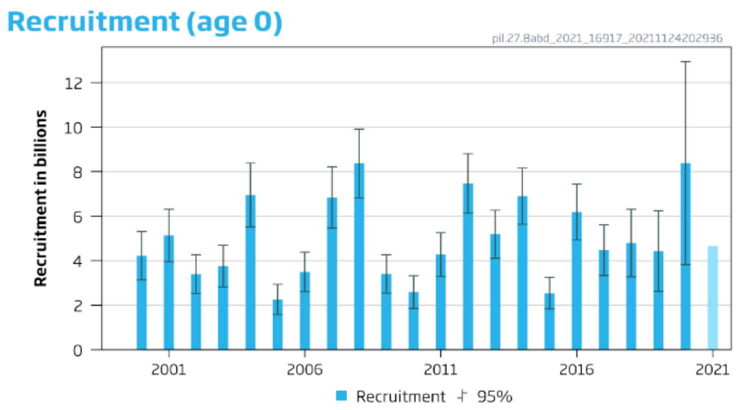

Figure 6.3.2.1. Sardine in 8abd. Recruitment estimates from SS3 outputs for sardine 8abd. Last year's value is estimated from the geometric mean (2002-2020).

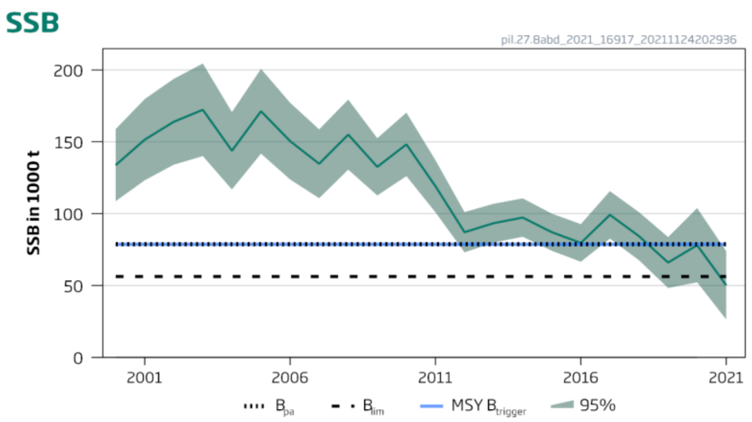

Figure 6.3.2.2. Sardine in 8abd. Spawning–stock biomass from SS3 outputs for sardine 8abd. Last year's value is estimated from the model.

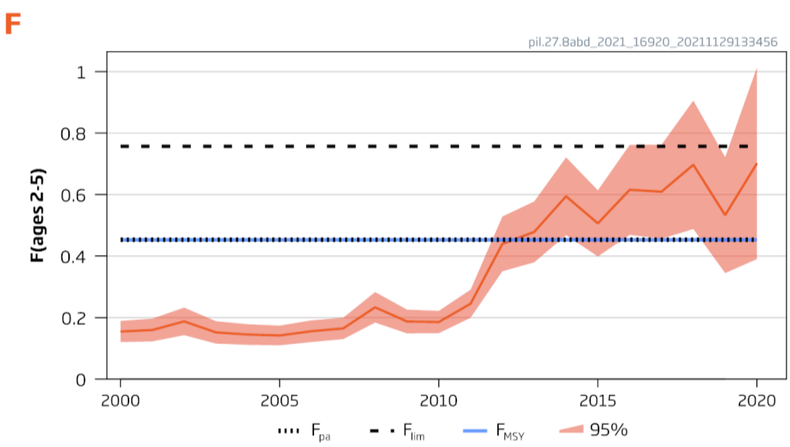

Figure 6.3.2.3. Sardine in 8abd. Fishing mortality for ages 2 to 5 derived from SS3 outputs for sardine 8abd.

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 larger residuals than other (e.g. 2009). The model fit to the survey indices is within the confidence intervals of those indices.

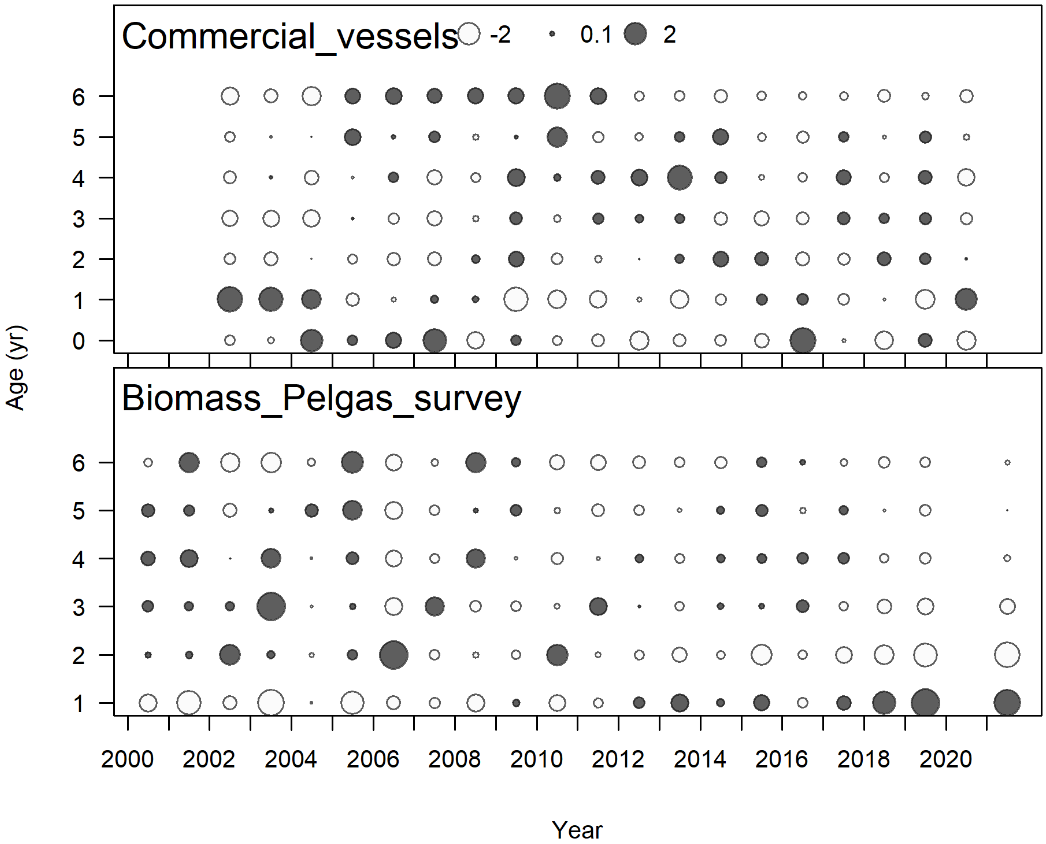

Figure 6.3.3.1. Sardine in 8abd. Fit between model and age composition from the PELGAS survey (bottom) and commercial vessels (top) up to 2021.

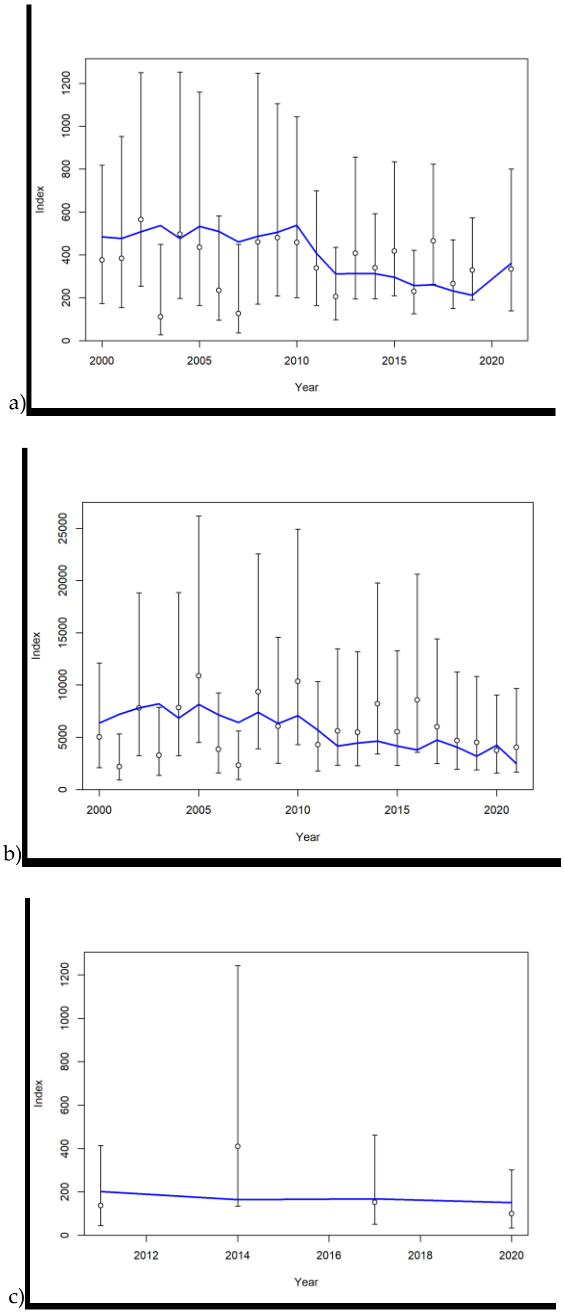

Figure 6.3.3.2. Sardine in 8abd. Fit between model and survey indices: a - Acoustic (PELGAS), b - egg count (BIOMAN), c - DEPM.

6.3.4 Retrospective pattern

Retrospective patterns for SSB, F_{bar}(2–5), apical F and recruitment were computed for years 2015–2021 (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 interbenchmark and therefore values can be compared to the work made during the interbenchmark. 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 (2021).

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

Absolute values of Mohn's rho estimates substantially differ compared with previous assessment (especially for R):

- Mohn's rho for SSB is 0.420 (previously 0.214).
- Mohn's rho for F is -0.232 (previously -0.203).
- Mohn's rho for R is 0.512 (previously 0.009).

The reason for this might be combination of two effects: 1) the strong downward deviation of the model in 2021 is related to the high number of age-1 individuals with low weight at age and low fecundity. This drives down the SSB in 2021. 2) The lack of stock structure input from PELGAS in 2020, cancelled due to COVID-19, possibly accounts for this issue as SS3 had to fill the gap possibly from the previous and next year internal estimates. The assessment next year will provide more information of the relative weight of those two effects.

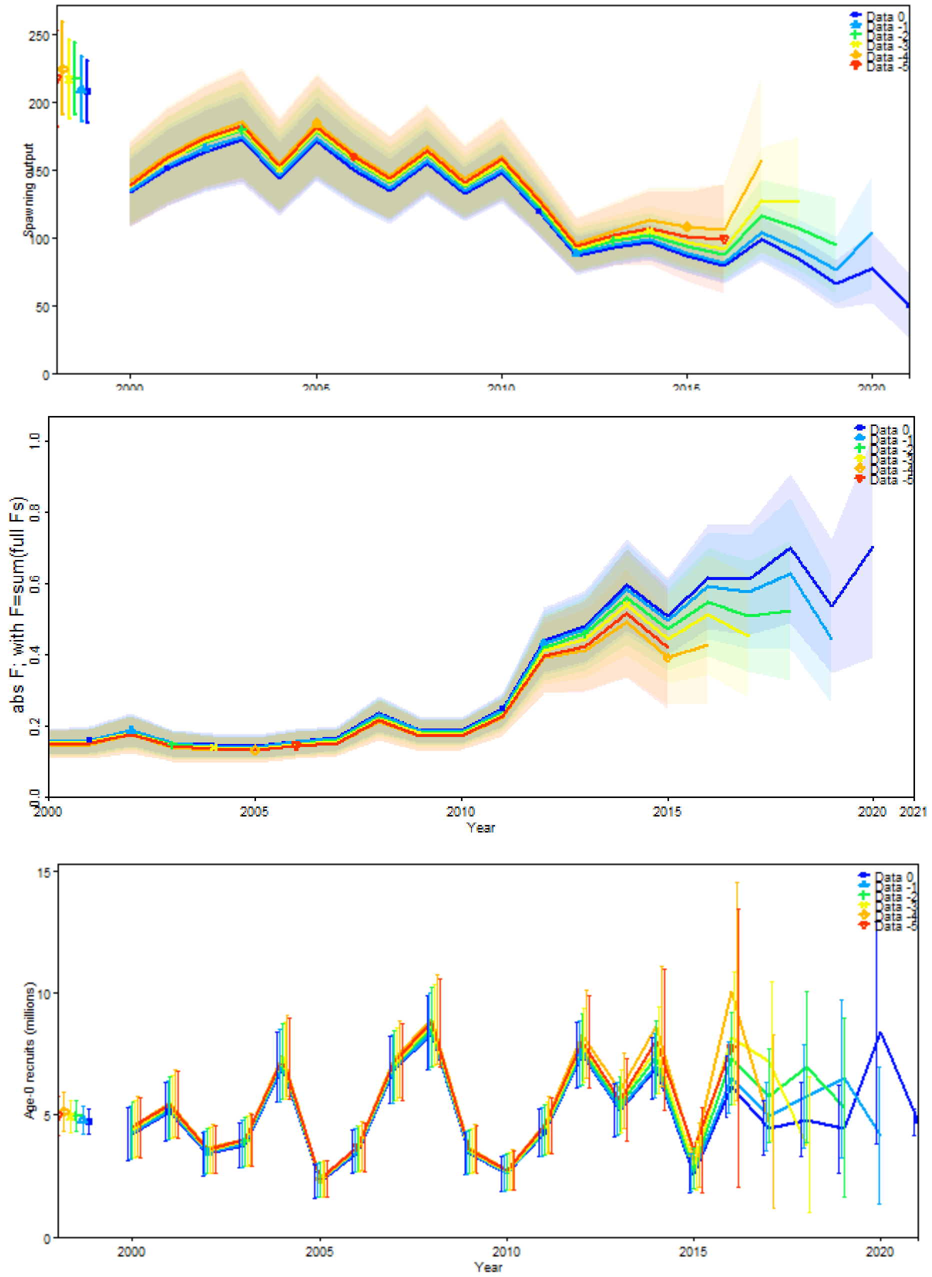

Figure 6.3.4.1. Sardine in 8abd. Summary of retrospective plots.

6.3.5 Comparison with previous assessment

The comparison is done with the run carried out at WGHANSA last year (Figures 6.3.5.1–6.3.5.3).

Uncertainties are generally 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.

This year, as for the retrospective patterns, the lack of PELGAS survey in 2020 is likely to explain the stronger differences observed between runs. In previous reports, the median SSB and F used to generally have very small differences. This year, the runs start to diverge as early as 2012 for the SSB and F. They stay within the same confidence intervals but the medians strongly differ with the SSB being overestimated and F underestimated in comparison to previous year run. There is no clear pattern for recruits. The median recruitments start to differ from 2015.

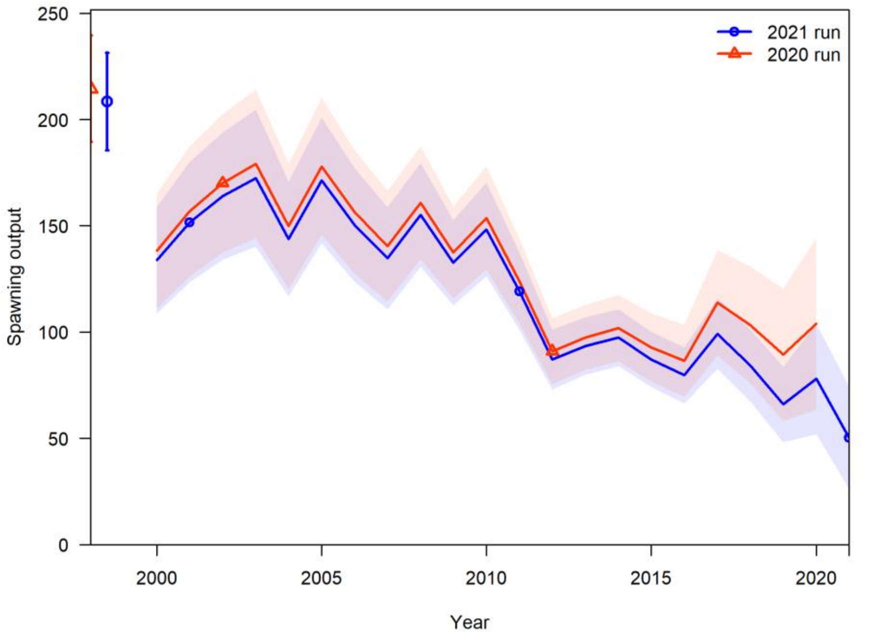

Figure 6.3.5.1. Sardine in 8abd. Comparison of SSB estimates between this year and the 2020 run.

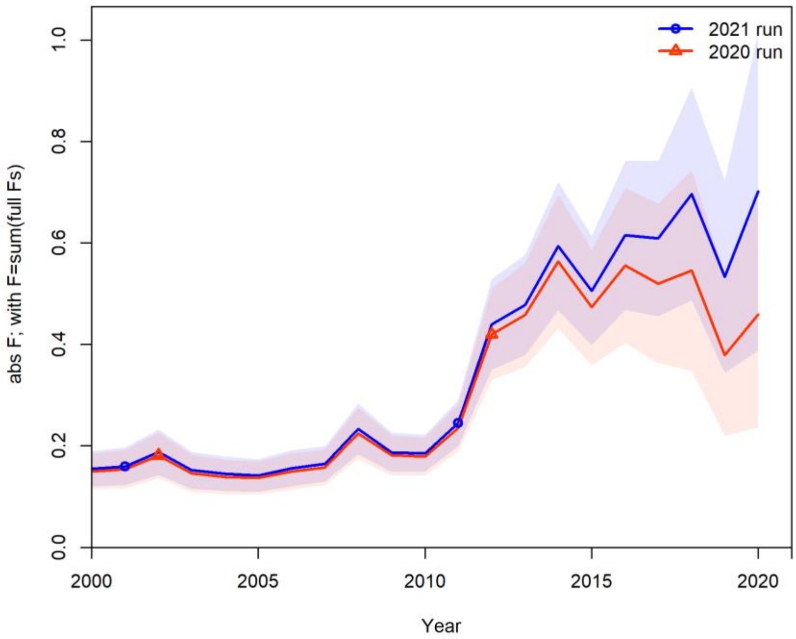

Figure 6.3.5.2. Sardine in 8abd. Comparison of fishing mortality estimates between this year and the 2020 run.

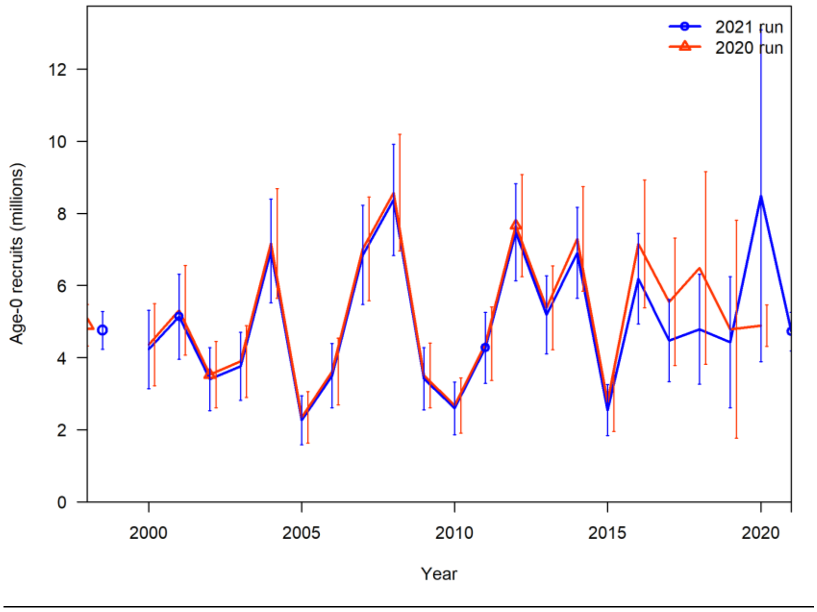

Figure 6.3.5.3. Sardine in 8abd. Comparison of Recruitment estimates between this year's and last year's runs.

6.3.6 Sensitivity analysis to a change of age-1 maturity ogive

This year, the contrast between the strong proportion of age-1 individuals in numbers and their lowest individual weight and proportion of mature is driving down the SSB in 2021. Discussions during the working group about the calculation of the maturity ogive in regards to using raw observations vs weighted maturity stage (relative to stock observed abundance during the surveys) led to test another assumption of a proportion of mature fish at age-1 of 25% instead of the estimated 33% used for the assessment. The comparison between the two runs (Figures 6.3.5.1-6.3.5.3) show little difference between runs. Estimated SSB in 2021 with Mat1=0.25 decrease by around 2000t in comparison to the run with Mat1=0.33.

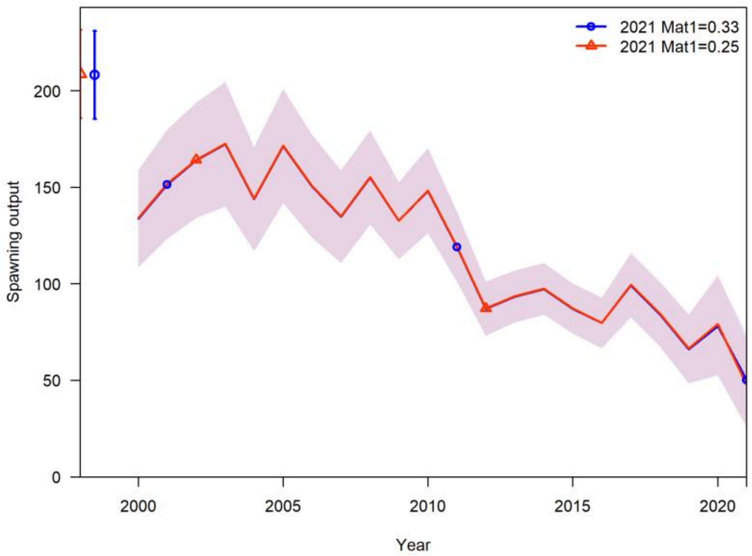

Figure 6.3.5.1. Sardine in 8abd. Comparison of SSB for two proportion of mature fish at age 1.

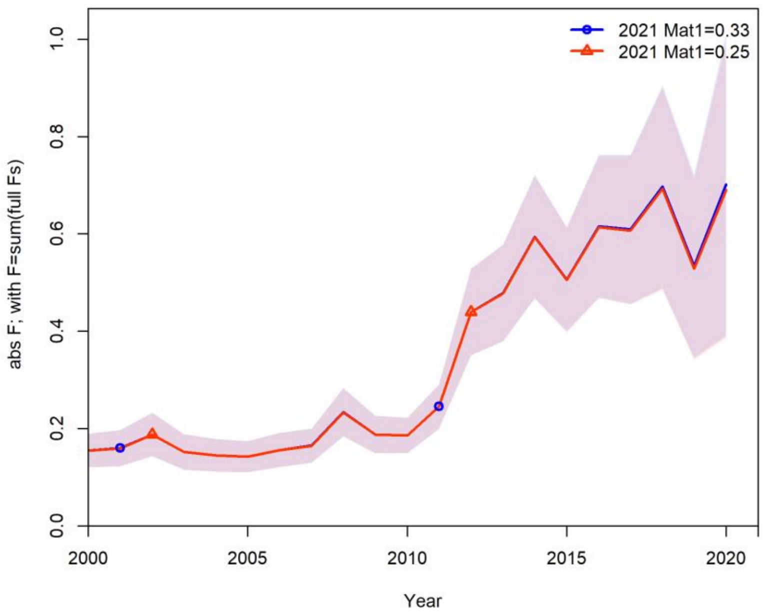

Figure 6.3.5.2. Sardine in 8abd. Comparison of fishing mortality estimates for two proportion of mature fish at age 1.

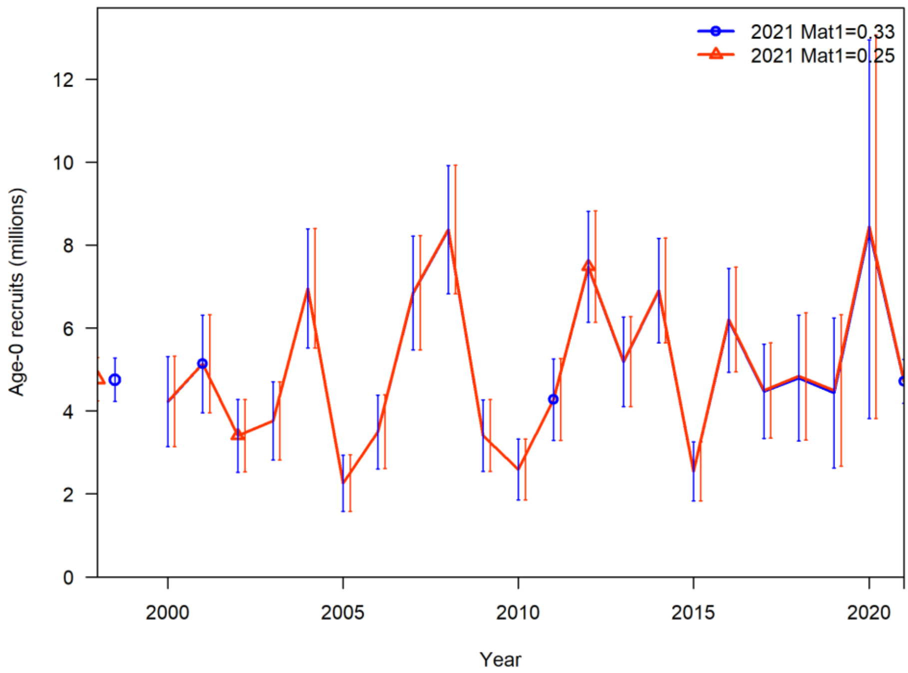

Figure 6.3.5.3. Sardine in 8abd. Comparison of recruitment estimates for two proportion of mature fish at age 1.

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 2021 by the average of PELGAS survey for the period (2018-2020). 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 2021 by the average of the PELGAS survey for 2018-2020. 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 catches were available for quarter 1 to 3.

The assumption for the catch in 2021 relies on preliminary catch statistics available from Q1-Q3. Q4 is estimated from the average proportion of Q4 catches in last 3 years (2018-2020). The assumed catches for 2021 are 30 497 tonnes.

Recruitment in the interim year and forecast year is set equal to the geometric mean of the time-series (2002-2020).

Recruitment for 2021 was assumed to be 4665 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 alternative catch options for 2022.

Table 6.4.1. Sardine in 8abd. Assumptions for the intermediate year.

Variable	Value	Notes
F ages 2–5 (2021)	0.606	Based on estimated catches for 2021
SSB (2022)	94 560 tonnes	Short-term forecast
$R_{age\ 0}$ (2021/2022)	4665 million	Geometric mean (2002–2020)
Total catch (2021)	30 497 tonnes	Preliminary value based on reported catches in Quarters 1 to 3 and predicted catches for Quarter 4
Discards (2021)	0 tonnes	Negligible

Table 6.4.2. Sardine in 8abd. Input data for the short-term forecast.

Year	Age	stock.n	stock.wt	catch.wt	Mat	M	F
2021	0	4665.122	0	0.025433	0	1.071	0.0073792
	1	2843.913	0.023767	0.038300	0.77938	0.6912	0.2340251
	2	552.195	0.042867	0.047000	0.99923	0.5463	0.3997189
	3	217.560	0.051800	0.057033	1	0.4752	0.5235520
	4	66.239	0.057567	0.064833	1	0.4356	0.5235520
	5	31.889	0.064233	0.070467	1	0.4122	0.5235520
	6+	11.896	0.073567	0.075300	1	0.3978	0.5235520
2022	0		0.0000	0.026578	0	1.071	0.0082640
	1		0.023489	0.037800	0.74514	0.6912	0.2620878
	2		0.042756	0.046900	0.99974	0.5463	0.4476503
	3		0.051700	0.056644	1	0.4752	0.5863327
	4		0.057256	0.066744	1	0.4356	0.5863327
	5		0.063778	0.070722	1	0.4122	0.5863327
	6+		0.075522	0.076300	1	0.3978	0.5863327
2023	0		0.0000	0.026578	0	1.071	0.0082640
	1		0.023489	0.037800	0.74514	0.6912	0.2620878
	2		0.042756	0.046900	0.99974	0.5463	0.4476503
	3		0.051700	0.056644	1	0.4752	0.5863327
	4		0.057256	0.066744	1	0.4356	0.5863327
	5		0.063778	0.070722	1	0.4122	0.5863327
	6+		0.075522	0.076300	1	0.3978	0.5863327

Table 6.4.3. Sardine in 8abd. Catch option table for 2022.

Basis	Catch (2022)	F (2022)	SSB (2023)	% SSB change *	% catch change **	% advice change ***
ICES advice basis						
MSY approach: FMSY	28 187	0.453	86 646	-8	-10	1
Other scenarios						
F = 0	0	0	108 797	15	-100	-100
F = F_{pa}	28 187	0.453	86 646	-8	-10	1
F = F_{lim}	42 858	0.757	75 493	-20	37	54
SSB(2023) = B_{lim}	69 405	1.519	56 300	-40	121	149
SSB(2023) = B_{pa} = MSY $B_{trigger}$	38 597	0.662	78 700	-17	23	39
F = F(2021)	35 932	0.606	80 719	-15	15	29

*** 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 2021, for all catch options for 2022, SSB in 2023 will stay above B_{lim} but is only above MSY $B_{trigger}$ in the case of targets of F=F_{MSY}=F_{pa} and F=F(2021). In all cases except no fishing, SSB in 2023 is expected to decrease compared with the one of 2022.

6.5 Medium-term projection

No medium-term projections were carried out.

6.6 MSY and Biological reference points

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 biomasses (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 results 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).

In 2021, ICES has been revising the definition of reference points. Fpa is now equal to $F_{p0.05}$. Therefore, that value has been updated and use in the short-term forecast this year.

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

Table 6.6.1. Sardine in 8abd. 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}	0.453	$F_{p0.5}$. The F that leads to SSB ≥ B_{lim} with 95% probability
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.

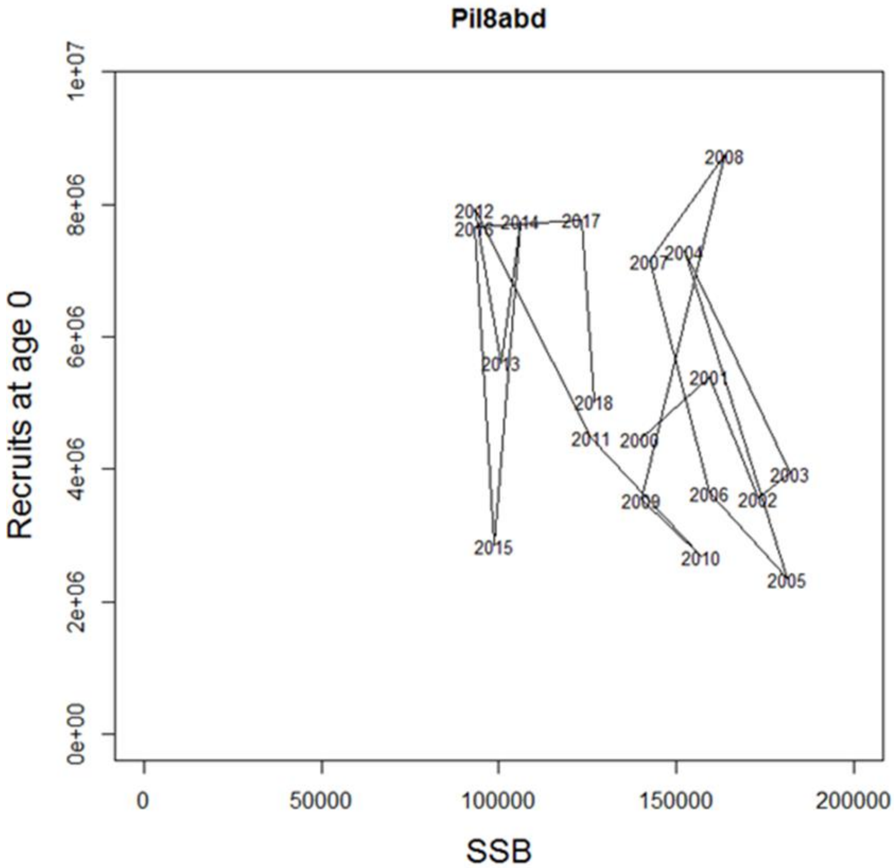

Figure 6.6.1. Sardine in 8abd. Stock–recruitment relationship for sardine in 8abd.

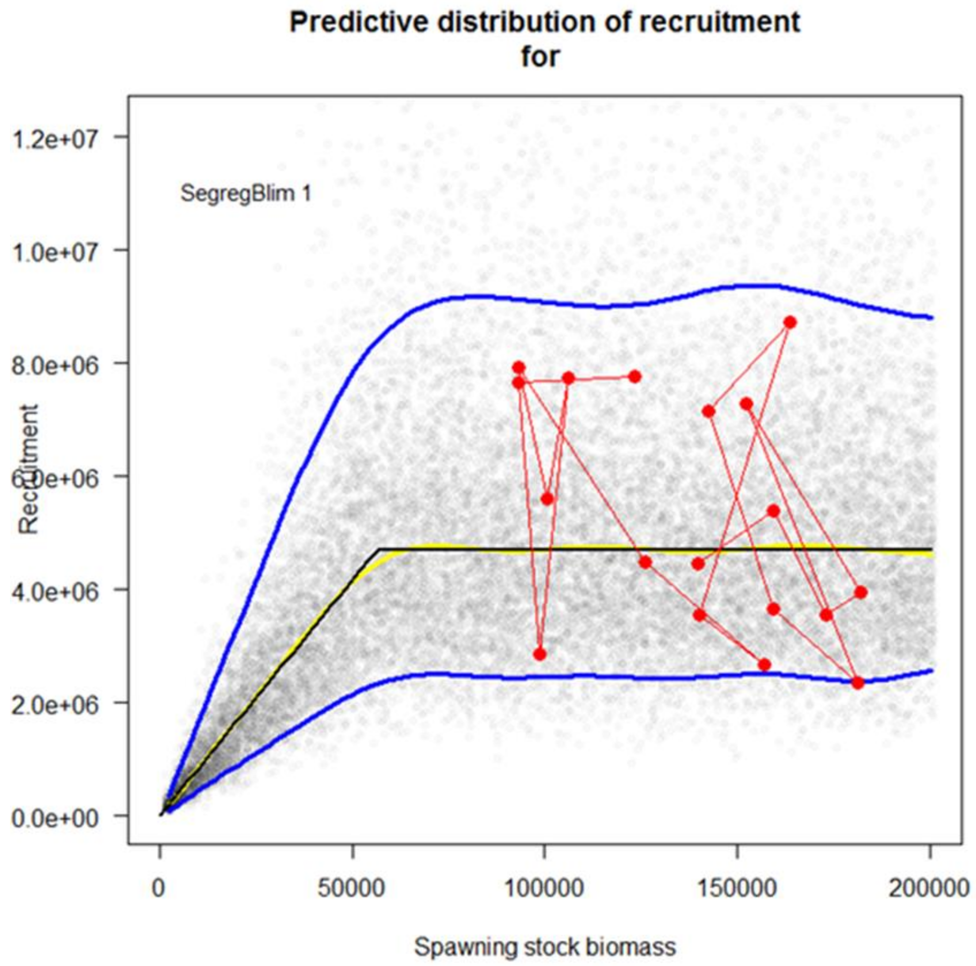

Figure 6.6.2. Sardine in 8abd. Segmented regression model with the breakpoint fixed at B_{lim} for sardine in 8abd.

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

In 2021, no deviation from the stock annex was carried out for the assessment and forecast. The usual sources of information were available and seem qualitatively in line with those of the pre-COVID period. The assessment and forecast were then carried out accordingly to the stock annex. For clarity, the deviations carried out in 2020 have been kept in this report below:

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.

6.11 References

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7 Sardine in Subarea 7

7.1 Population structure and stock identity

Sardine stock in Subarea 7 has historically being assessed together with the Southern population in the Bay of Biscay (divisions 8.a, b and d) because no genetic differences were found between both areas (Shaw *et al*., 2012). However, research presented at ICES WKSAR workshop (ICES, 2016) showed that growth rates in the English Channel and Celtic Sea were higher than in the Bay of Biscay; there were separate spawning grounds; and all ages were present in significant abundance in both areas. This research suggests that sardine in the English Channel and Celtic Sea is a self-sustained population, and consequently sardine in Subarea 7 is considered an independent stock since 2017 (ICES, 2017).

Nevertheless, the degree of mixing occurring with the Bay of Biscay, as well as the boundary between both stocks is still unknown. Similarly, little is known about the extension of the stock in the Eastern Channel and the North Sea. Until new insights are put forward, modelling the population in Subarea 7 as an independent stock seems to be the most appropriate option.

7.2 The fishery

7.2.1 Analysis of the catch

Sardine landing data in Subarea 7 is available since 1970 but their reliability is doubtful given their high variability across years and nations. Catch data has been revised for the period 2002-2019 (ICES, 2021) and therefore data prior 2002 has been excluded of the assessment. It must be also noted that French catches from ICES rectangles 25E5 and 25E4 (Subarea 7) have been allocated to Division 8.a, as they occur in the boundary between divisions and are considered to be more closely associated with the sardine stock in divisions 8.a-b and 8.d.

Below minimum size (BMS) landing data have been reported by some countries since 2015. They increased in 2019 and 2020, representing 7 and 5% of the total catch, respectively. Reported discards represent less than 1% of the catch, and they are considered negligible (Figure 7.2.1.1).

Annual landings (i.e. landings and BMS landings) have fluctuated between 6 157 and 29 287 t since 2002, being the highest values reported at the beginning of the reviewed time-series (Figure 7.2.1.2, Table 7.2.1.1). This large temporal fluctuation in landings is primarily explained by shifts in fleets activity and species targeted over the years (ICES, 2021). Sardine landings were dominated by France, followed by England, Netherlands, and Ireland in the 2000s. However, French landings decreased significantly since 2009 because of the closure of the fishery intended for human consumption in the Seine bay (Eastern Channel) due to PCB contamination. Landings remained lower than 10 000 t between 2009 and 2015 and increased again in 2016 due to a higher contribution from England, Netherlands, and Denmark. Landings from England remain quite stable since then (average English landings since 2016 is 8 335 t), whereas the contribution from the other countries has diminished. Landings in 2020 were 71% higher than in 2019, primarily because of an increase of Danish landings (0 catch reported in 2019).

The fleet and seasonality of the fishery has also changed over the years. The main fleet in the 2000s was midwater otter trawlers, which used to fish in 7d throughout the whole year (Figures 7.2.1.3, 7.2.1.4. Table 7.2.1.2). Currently it is a seasonal fishery, and most of the sardine landings are caught by purse-seiners in the third and fourth quarters, mainly from 7e. A detailed description of the temporal evolution of the fishery can be found in the stock annex. In 2020, there has been a slightly increase of landings in ICES divisions 7h and 7e by pelagic trawlers (OTM_SPF_32-69_0_0_all) compared with last year because of the fishing activity of the Danish vessels.

7.3 Biological data

7.3.1 Size 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, the species is not their main target, and the size composition of their catches may not be representative for the sardine population. Other countries have not provided regular length or age information due to the lack of national biological sampling scheme and no DCF (data collection framework) requirement regarding that species in Subarea 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 in recent years. Since fishing season 2017–2018, these vessels have recorded fishing trip information (haul locations, total catches, bycatch, discard, and effort) on dedicated logbooks. In addition, they were 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.

Some of the data provided by the processors had to be discarded because part of their staff measured the samples with 1 cm precision instead of 0.5 cm, which created multiple peaks in the distributions. Figure 7.3.1.1 shows the combined size distribution provided by the fishing industry since 2018 after tidying up the data. No major changes are observed in the size distribution of the landings during the last three years, where the mean size was around 19.7 cm.

7.4 Fishery-independent information

7.4.1 The PELTIC survey

The PELTIC, Pelagic Ecosystem Survey in the western Channel and Celtic Sea, is an autumn acoustic survey conducted by Cefas (UK) and provides biomass estimates for sardine and other small pelagics in Subarea 7. The first surveys (2012-2016) covered only the English waters of ICES areas 7e and all of 7f, but from 2017 survey coverage expanded to include also the French waters as well as one-off coverage of waters further north of the core area (2017), part of the eastern English Channel (2018) and Cardigan Bay in the southern Irish Sea (2020 and 2021). The survey follows a typical acoustic survey design with parallel equidistant transects which are covered during daylight only from 2014 onwards. A pelagic trawl is used opportunistically to validate the species and size composition of the acoustic marks detected on the echogram. The methodology used to estimate sardine biomass is described in the stock annex and ICES (2021).

Two biomass indices are calculated from PELTIC (Figure 7.4.1.1): one representing the consistently sampled "Core" Area of the whole time-series (2013 onwards): English waters of the western Channel (excluding the Isles of Scilly) and ICES division 7f (Bristol Channel in the Celtic Sea). The second time-series, called 'Total area', is available from 2017 and represents full coverage of ICES divisions 7e (including the Isles of Scilly) and 7f.

The time-series of biomass estimated in the Core area significantly increased between 2017 and 2019, reaching the highest biomass in 2019 with 273 708 tonnes of sardine (Figure 7.4.1.2, Table 7.4.1.1). Biomass dropped in 2020 and 2021 but they are still the second highest values 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 and a 32% decline in 2021 that was not found in the Core Area (Figure 7.4.1.2, Table 7.4.1.1). The biomass in the total area in 2021 was 227 117 (0.19% coefficient of variation) tonnes. It is worth to note that a significant proportion of the sampled animals during the survey belonged to the 0-year class, suggesting high recruitment rates for the coming year (Table 7.4.1.1).

7.5 Stock assessment

The stock was benchmarked in 2021 and upgraded from category 5 to category 3 as the time-series of biomass derived from PELTIC are considered reliable indicators of trends in stock biomass (ICES, 2021). Following the assessment methods described in the stock annex, a surplus production model in continuous time (SPiCT, Pedersen and Berg, 2017) has been run to provide an indication of the status of the stock. The catch advice has been then provided based on the 1 - over – 2 rule (ICES, 2020a).

7.5.1 SPiCT

A quarterly SPiCT model was run using the settings described in the stock annex. The input data included the time-series of landings (landings and BMS landing) from 2013 to 2020 and the biomass derived from PELTIC for the core area since 2013 (Figure

7.5.1.1). The landing time-series was shortened to cover only the period where biomass index was available to help model convergence and produce a reliable output (ICES, 2021). A prior on the initial depletion level was added to inform the model that the fishery was operating before the beginning of the input data to the model.

A summary of the SPiCT outputs is given in Figure 7.5.1.2 and Table 7.5.1.1. The model indicates that fishing mortality is likely to be below F_{MSY} proxy and the biomass is above the reference B_{MSY}* 0.5 proxy. The confidence intervals of both reference points and the absolute values of biomass and fishing mortality are very high and therefore these values are not reliable.

The checklist described in Mildenberger et al. (2021) for acceptance of the assessment was followed. The diagnosis of the residuals shows the assumptions of the model are met: the catch and biomass data have normal distributions, and there are not autocorrelation or bias in the data (Figure 7.5.1.3). The retrospective patterns of the model could not be properly analysed given the short time-series of data. The model only converged eliminating information from two years, and although the retrospective trajectories for the relative biomass and fishing mortality were inside of the confidence intervals, a longer time-series is needed to analyse temporal patterns in successive assessments (Figure 7.5.1.4).

7.5.2 1-over-2 rule

Following the methods described in the stock annex, the catch advice for this stock is based on the 1-over-2 rule with a symmetric 80% uncertainty cap and a biomass safeguard (ICES, 2020a; ICES, 2020b). This harvest control rule is defined as:

$$C_y = \left\{ \left\{ \begin{array}{ll} 0.2C_{y-1} & if\ \dfrac{I_y}{(I_{y-1}+I_{y-2})/2} < 0.2 \\ C_{y-1}\dfrac{I_y}{(I_{y-1}+I_{y-2})/2} & if\ \ 0.2 \le \dfrac{I_y}{(I_{y-1}+I_{y-2})/2} \le 1.8 \\ 1.8C_{y-1} & if\ \dfrac{I_y}{(I_{y-1}+I_{y-2})/2} > 1.8 \end{array} \right\} \cdot \left[min\left(1, \dfrac{Icurrent}{Istat}\right)\right] \right.$$

where C_y and I_y represent the advised catch and the biomass indicator for year y, respectively. The first and third cases of the formula correspond to the application of an 80% symmetrical uncertainty cap. The last term in the equation refers to the biomass safeguard based on a trigger index value (Istat). If the biomass index falls below Istat, the advised catch will be reduced in proportion to the drop of the biomass index in relation to Istat.

The biomass estimates derived from PELTIC in the total area were used as the biomass index and the Istat has been estimated as 109 965 t (see section 7.7). Catch advice has not been provided so far for this stock, and in these cases the ICES guidance recommends using the average catches of the last two years (ICES, 2020a; ICES, 2020b). However, the sardine stock in Subarea 7 is likely to be moderately exploited (see outputs of the SPiCT model in Figure 7.5.1.2) and catches in the last decade were lower than in the past because of a decrease of the bycatch fisheries and the activity of opportunistic fleets (ICES, 2021). Furthermore, the harvest rates in the last two years are the lowest in the time-series (Table 7.5.1.2). Therefore, the implementation of the 1-over-2 rule using the average catches in the last two years would produce a low catch advice, although the stock is likely to support higher exploitation rates. The working group explored different approaches to initiate the 1-over-2 rule: 1) The general ICES guidelines of using the average landings of the last two years; 2) average landings of the last 5 years; 3) average landings of the full time-series (2002-2020); 4) mean of the landings that would have been obtained in 2019 and 2020 if an average exploitation rate was applied; 5) mean of the landings that would have been obtained in 2019 and 2020 if the ratio between the sum of the landings in the last four years and the sum of the biomass in the last 4 years was applied; and 6) mean of the landings that would have obtained in 2019 and 2020 if the fishing mortality was equal to F_{MSY}. For the latter approach, the actual landings in 2019 and 2020 were divided by the relative fishing mortality for 2019 and 2020 derived from the SPiCT model (Table 7.5.1.3).

The working group considered that the use of the average harvest rate (approach 4 in Table 7.5.1.3.) could be a reasonable approach to minimise the impact of the recent low harvest rates on the advice. However, because this approach has not been tested in a Management Strategy Evaluation, ICES applied the current guidance to initiate the rule for this stock.

An overview of the application of the 1-over-2 rule is shown in the table below. The index is estimated to have decreased by 36% and thus the uncertainty cap was not applied.

Index A (2021)		227 117 tonnes
Index B (2019–2020)		353 358 tonnes
Index ratio (A/B)		0.64
Biomass safeguard (I_{stat})	Not applied	
Uncertainty cap 80%	Not applied	
Mean catches (2019-2020)		10 745 tonnes
Discard rate		Negligible
Catch advice 2022***		6 906 tonnes
% advice change^		Not applicable

***[Mean catches (2019-2020)] x [Index ratio]

^This is the first quantitative catch advice for this stock.

7.6 Short-term projections

No projections have been carried out for this stock.

7.7 Reference points

The table below summarises the reference points for sardine in Subarea 7 and their technical basis. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the proxy MSY reference points. The Istat reference point represents the biomass trigger applied into the 1-over-2 rule. The Istat value was mistakenly estimated as 92 858 t in the last benchmark (ICES, 2021) and the value has been corrected in this report. The Istat value estimated using the biomass index in the total area from 2017 to 2020 (Table 7.4.1.1), data available at the moment of the benchmark, should be 109 965 tonnes.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger\ proxy}$	$\frac{B}{B_{MSY}} = 0.5*$	Relative value from SPiCT model. B_{MSY} is estimated directly from the SPiCT assessment model and changes when the assessment is updated	(ICES, 2021)
	$F_{MSY\ proxy}$	$\frac{F}{F_{MSY}} = 1*$	Relative value from SPiCT model. F_{MSY} is estimated directly from the SPiCT assessment model and changes when the assessment is updated.	(ICES, 2021)
Precautionary approach	Istat	109 965 tonnes	Geomean(Ihist)*exp(-1.645*sd(log(Ihist)); lhist is the available historical series of the abundance index (2017-2020)	This document

7.8 Quality of the assessment

This stock was benchmarked in 2021 and the ICES framework for category 3 short-lived stocks using the 1-over-2 rule with an uncertainty cap of 80% and a biomass safeguard (ICES, 2020a) was considered the most appropriate method to provide advice. However, this harvest control rule leads to a decreasing trend of catch options in time after repeated applications and therefore should be considered as a provisional management approach (ICES, 2020a, ICES, 2020b).

Since it is the first application of the framework, the initial catch in the rule is taken from the mean of the catch from the previous two years (2019-2020). The expert group recognises that sardine landings have been very variable across years, mainly because of the inconsistent activity of the opportunistic fleets (ICES, 2021). The initiation of the rule using the ICES guidance (i.e. average landings of the last two years) will not adapt to the highly fluctuating activity of the fleet. The expert group considered alternative approaches to implement this rule for the first time in sardine in Subarea 7, but they were discarded as they deviated from the recommended practice. Alternative methods to initiate this rule in stocks with highly variable landings should be further explored and tested in a management strategy evaluation framework.

French catches from ICES rectangles 25E5 and 25E4 (Subarea 7) have been traditionally allocated to division 8.a, as they occur in the boundary between divisions, and are considered to be more closely associated with the sardine stock in divisions 8.a-b and 8.d. However, the boundary between sardine stocks in Subarea 7 and 8 is unclear and further studies are needed to support this procedure to allocate catches.

7.9 Management consideration

This is a non-quota stock and there are no management measures implemented at international level. Nevertheless, the Cornish Sardine Management Association (a partnership between the owners of 15 vessels and four local seafood processors in England) has agreed specific regulations since 2018 for the sardine fishery around the Cornwall coast (UK) as it is subject to an MSC (Marine Stewardship Council) certification.

The 1-over-2 rule performs the best when there is no time-lag between the survey producing the biomass estimate and the TAC implementation (ICES, 2020a, ICES, 2020b). This is especially important for short-lived species, as part of the observed stock will not be available for the fishery when there is a large lag in time. The PELTIC survey is conducted in October and the biomass estimate is already incorporated in the catch advice for the following year, with a time-lag of only two months. Whilst ICES aimed to provide advice for this stock every two years when it was a category 5 stock, this approach would lead to a time-lag of 14 months for the second year of the advice. Given that a new biomass estimate is available every year, the catch advice should be provided annually.

7.10 References

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Pedersen, M. W., and Berg, C. W. 2017. A stochastic surplus production model in continuous time. Fish and Fisheries, 18: 226–243.

Shaw P., McKeown, N., Van der Kooij, J. (2012) Analysis of genetic population structuring of Sardine (*Sardina pilchardus*) in Eastern Atlantic waters using nuclear microsatellite DNA markers Working Document for WKPELA, 13-17/02/2012 Copenhagen

Table 7.2.1.1. Sardine in Subarea 7. Landings reported by country (tonnes)*

	France**	UK	Nether-lands	Ireland	Germany	Denmark	Lithuania	Belgium	Spain	Poland	TOTAL
1970	1014	890	38	0	2112	0	0	0	0	0	4054
1971	1350	1242	108	0	3362	0	0	0	0	0	6062
1972	1297	2190	54	0	1553	0	0	0	0	0	5094
1973	1603	2375	17	0	2577	0	0	0	0	0	6572
1974	833	1280	15	0	1826	0	0	0	0	0	3954
1975	678	6	561	0	4043	0	0	0	0	0	5288
1976	1284	3	127	0	2346	0	0	0	0	0	3760
1977	3544	10778	623	0	183	0	0	0	0	0	15128
1978	2773	549	1523	0	1463	0	0	0	0	0	6308
1979	3247	46	1321	0	1188	0	0	0	0	0	5802
1980	3573	753	1131	0	79	0	0	0	0	0	5536
1981	1125	35	553	0	0	4471	0	0	0	0	6184
1982	908	141	928	0	0	1311	0	0	0	0	3288
1983	802	6	795	0	19	4743	0	0	0	0	6365
1984	817	1	0	0	0	1210	0	0	0	0	2028
1985	2089	20	0	0	0	3111	0	0	0	0	5220
1986	2570	30	0	0	0	3602	0	0	0	0	6202
1987	965	124	0	0	0	1573	0	0	0	0	2662
1988	2586	0	0	0	0	3234	0	0	0	0	5820
1989	1219	1660	11	0	0	4667	0	0	0	0	7557
1990	1128	2078	6	0	107	6113	0	0	0	0	9432
1991	1963	2952	0	0	8	4462	0	0	0	0	9385
1992	1777	4493	41	0	4	17843	0	0	0	0	24158
1993	1135	4917	109	0	0	13395	0	0	0	0	19556
1994	1285	2081	20	0	2	20804	0	0	0	0	24192
1995	1282	7133	107	0	66	9603	0	0	0	0	18191
1996	1563	7304	48	0	0	1396	0	0	0	0	10311
1997	3346	7280	411	0	13	1124	0	0	0	0	12174
1998	1974	6873	1647	192	100	14316	0	0	0	0	25102
1999	119	4815	5166	2375	146	3490	0	0	8	0	16119
2000	4074	4353	6586	354	436	1682	0	0	0	0	17485
2001	8589	10375	6609	1060	454	0	0	0	0	0	27087
2002	7977	7858	1905	11417	130	0	0	0	10	0	29297
2003	8186	4150	6897	4030	13	0	0	0	0	0	23276
2004	7807	2389	2187	2046	60	0	0	0	0	0	14489
2005	10605	3457	2231	922	140	0	0	0	5	0	17360
2006	11120	1925	2287	2416	246	0	0	0	2	0	17996

	France**	UK	Nether-lands	Ireland	Germany	Denmark	Lithuania	Belgium	Spain	Poland	TOTAL
2007	7315	2655	1106	28	0	4	0	0	0	0	11108
2008	8562	3470	2073	473	43	53	0	0	0	0	14674
2009	3918	2568	3406	65	0	0	0	0	0	0	9957
2010	706	2540	6645	50	62	13	0	0	0	0	10016
2011	237	3614	513	1966	5	3	0	0	0	0	6338
2012	372	4423	1637	16	587	40	0	0	0	0	7075
2013	1703	3722	1739	473	214	40	0	0	0	0	7891
2014	1100	3893	193	0	18	953	0	0	0	0	6157
2015	1208	4301	1171	555	1551	1011	0	0	0	0	9797
2016	925	9389	4697	464	1941	2286	1	1	0	0	19704
2017	820	7596	0	329	1475	2460	0	0	0	0	12680
2018	606	8143	811	89	758	263	0	1	0	0	10671
2019	671	7050	90	33	53	0	40	0	0	0	7937
2020	592	9500	185	58	0	3217	0	0	0	1	13553

***Catch data prior 2002 has not been revised and they are not used in the assessment.**
****French catches from ICES rectangles 25E5 and 25E4 are not included.**

Table 7.2.1.2 Sardine in Subarea 7. Landings by ICES division (tonnes).

	7.d	7.e	7.f	7.g	7.h	7.j	7.a	7.b	Unallo-cated
2002	9756	18035	35	164	1253	44	0	0	0
2003	15478	6815	2	321	255	123	279	4	0
2004	10001	2450	158	552	90	36	856	346	0
2005	12561	3464	204	64	182	636	224	20	0
2006	14116	1950	395	250	394	786	78	24	0
2007	8480	1592	993	0	14	28	0	0	0
2008	9395	3225	1579	365	1	100	0	10	0
2009	6389	2568	932	0	2	63	0	2	0
2010	7123	1706	1083	0	55	36	14	0	0
2011	759	1639	1884	1394	89	129	443	0	0
2012	943	3609	1555	0	952	0	16	0	0
2013	2431	3549	1095	473	342	0	0	0	0
2014	1442	3018	1698	0	0	0	0	0	0
2015	1476	6635	1604	10	66	6	0	0	0
2016	1478	9868	3026	163	169	301	0	0	4697
2017	3226	7421	1704	281	1	48	0	0	0

	7.d	7.e	7.f	7.g	7.h	7.j	7.a	7.b	Unallo-cated
2018	1335	6013	2413	79	10	10	0	0	811
2019	888	5009	2007	34	0	0	0	0	0
2020	640	7615	3638	58	1601	0	0	0	0

Table 7.4.1.1. Sardine in Subarea 7. Time-series of biomass (t) and abundance (1000s individuals) estimated from the acoustic survey PELTIC in the core and total area.

	Core Area				Total Area			
	Biomass		**Abundance**		**Biomass**		**Abundance**	
	Estimate	**CV**	**Estimate**	**CV**	**Estimate**	**CV**	**Estimate**	**CV**
2013	48391	0.33	924300	0.18				
2014	121171	0.32	3072930	0.23				
2015	134907	0.22	3332244	0.41				
2016	89918	0.34	2121684	0.23				
2017	95298	0.11	4101091	0.13	174637	0.20	10163984	0.16
2018	123003	0.14	3317972	0.14	145514	0.12	4300528	0.12
2019	273708	0.21	11256581	0.18	374617	0.19	15409434	0.15
2020	178781	0.31	3713016	0.29	332098	0.20	6476230	0.18
2021	174375	0.28	5977676	0.28	227117	0.19	8714354	0.26

Table 7.5.1.1. Sardine in Subarea 7. Summary outputs of the SPiCT model.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 36.212505
Euler time step (years):  1/16 or 0.0625
Nobs C: 32,  Nobs I1: 9

Priors
 logbkfrac  ~  dnorm[log(0.5), 0.5^2]
      logn  ~  dnorm[log(2), 2^2]
  logalpha  ~  dnorm[log(1), 2^2]
   logbeta  ~  dnorm[log(1), 2^2]

Model parameter estimates w 95% CI
           estimate        cilow        ciupp    log.est
 alpha  3.776286e+00    0.4027362 3.540862e+01  1.3287408
 beta   1.038121e+00    0.3316224 3.249765e+00  0.0374122
 r      1.867748e+00    0.1804080 1.933663e+01  0.6247333
 rc     1.051740e+00    0.1755914 6.299602e+00  0.0504455
 rold   7.319533e-01    0.1041121 5.145948e+00 -0.3120386
 m      1.539510e+04 7838.4541795 3.023672e+04  9.6418046
 K      4.810794e+04 4789.3904507 4.832293e+05 10.7812025
 q      4.059071e+00    0.3816624 4.316919e+01  1.4009541
 n      3.551731e+00    0.6823766 1.848655e+01  1.2674350
 sdb    8.366480e-02    0.0090582 7.727551e-01 -2.4809368
 sdf    3.644179e-01    0.1374244 9.663526e-01 -1.0094539
 sdi    3.159422e-01    0.1839724 5.425785e-01 -1.1521960
 sdc    3.783098e-01    0.2740978 5.221433e-01 -0.9720418
 phi1   1.365562e-01    0.0485567 3.840370e-01 -1.9910194
 phi2   2.629920e-02    0.0144547 4.784950e-02 -3.6382152
 phi3   9.086668e-01    0.3404678 2.425121e+00 -0.0957768

Deterministic reference points (Drp)
          estimate        cilow        ciupp    log.est
 Bmsyd 2.927550e+04 2839.1909504 3.018659e+05 10.2845063
 Fmsyd 5.258698e-01    0.0877957 3.149801e+00 -0.6427017
 MSYd  1.539510e+04 7838.4541795 3.023672e+04  9.6418046
Stochastic reference points (Srp)
          estimate        cilow        ciupp    log.est rel.diff.Dr
 Bmsys 2.902301e+04 2795.6888732 3.012979e+05 10.2758443 -0.00869964
 Fmsys 5.219726e-01    0.0860508 3.166217e+00 -0.6501402 -0.00746620
 MSYs  1.514823e+04 7809.0736136 2.938491e+04  9.6256392 -0.01629679

States w 95% CI (inp$msytype: s)
                   estimate        cilow        ciupp    log.est
 B_2021.75      4.041343e+04 3602.0922003 4.534157e+05 10.6069174
 F_2021.75      2.819312e-01    0.0235552 3.374423e+00 -1.2660923
 B_2021.75/Bmsy 1.392462e+00    1.0243346 1.892887e+00  0.3310731
 F_2021.75/Fmsy 5.401264e-01    0.1795707 1.624633e+00 -0.6159521

Predictions w 95% CI (inp$msytype: s)
                 prediction        cilow        ciupp    log.est
 B_2023.00      3.752809e+04 2785.7422697 5.055591e+05 10.5328449
 F_2023.00      2.819313e-01    0.0207815 3.824806e+00 -1.2660918
 B_2023.00/Bmsy 1.293046e+00    0.8205195 2.037694e+00  0.2570006
 F_2023.00/Fmsy 5.401266e-01    0.1385886 2.105056e+00 -0.6159517
 Catch_2022.00  1.119531e+04 4557.9285208 2.749824e+04  9.3232504
 E(B_inf)       4.282379e+04           NA           NA 10.6648491
```

Table 7.5.1.2. Sardine in Subarea 7. Input values used to initiate the 1-over-2 rule.

Year	Landings (t)	Biomass in total area (t)	Harvest rate (%)	Index ratio	F/FMSY*
2002	29287				
2003	23276				
2004	14488				
2005	17354				
2006	17994				
2007	11108				
2008	14675				
2009	9957				
2010	10017				
2011	6337				
2012	7075				
2013	7891				
2014	6157				
2015	9798				
2016	19702				
2017	12680	174637	7.26		
2018	10671	145514	7.33		
2019	7937	374617	2.12	2.34	0.47
2020	13553	332098	4.08	1.28	0.52
2021		227117		0.64	

***Mean values derived from the SPiCT model**

Table 7.5.1.3. Sardine in Subarea 7. Catch advice in 2022 using different approaches to initiate the 1-over-2 rule

Approach	Technical basis	Catch advice 2022
1. ICES guidance	$\bar{C}_{2019-2020} \cdot IR_{2021}$	6906
2. Average catch 2016-2020	$\bar{C}_{2016-2020} \cdot IR_{2021}$	8297
3. Average catch 2002-2020	$\bar{C}_{2002-2020} \cdot IR_{2021}$	8456
4. Expected catch if average harvest rate was applied	$\sum_{2019}^{2020} (\overline{HR}_{2017-2020} \cdot B)/2 \cdot IR_{2021}$	11807
5. Expected catch if the ratio ∑ landings /∑ biomass was applied	$\sum_{2017}^{2020} C \Big/ \sum_{2017}^{2020} B \cdot IR_{2021}$	11807
6. Expected catch in 2019-2020 if F=FMSY	$\sum_{2019}^{2020} (\frac{C}{F/F_{MSY}}) \Big/ 2 \cdot IR_{2021}$	13777

IR = index ratio; C = Catch; B = biomass; HR= harvest rate

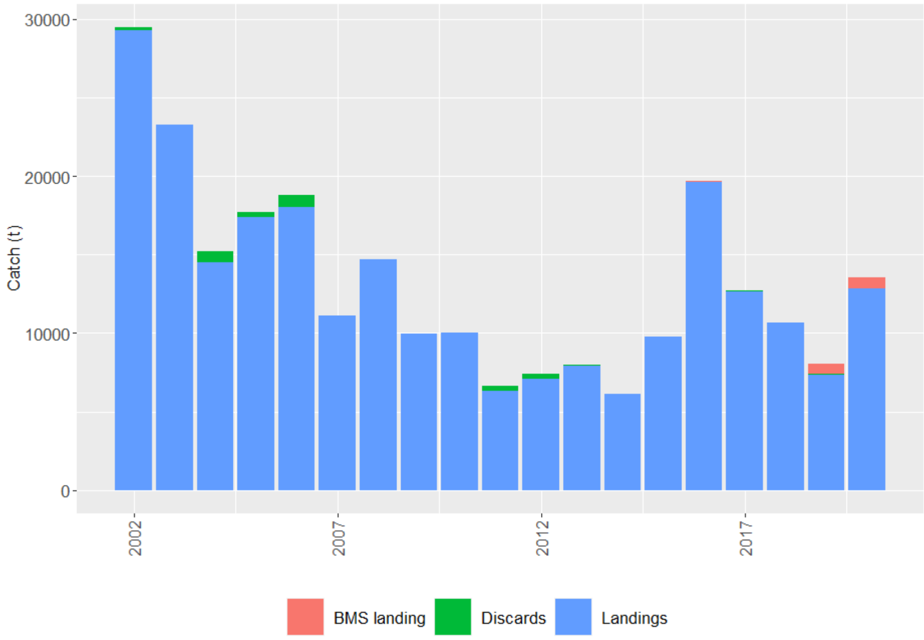

Figure 7.2.1.1. Sardine in Subarea 7. Catches by category (tonnes).

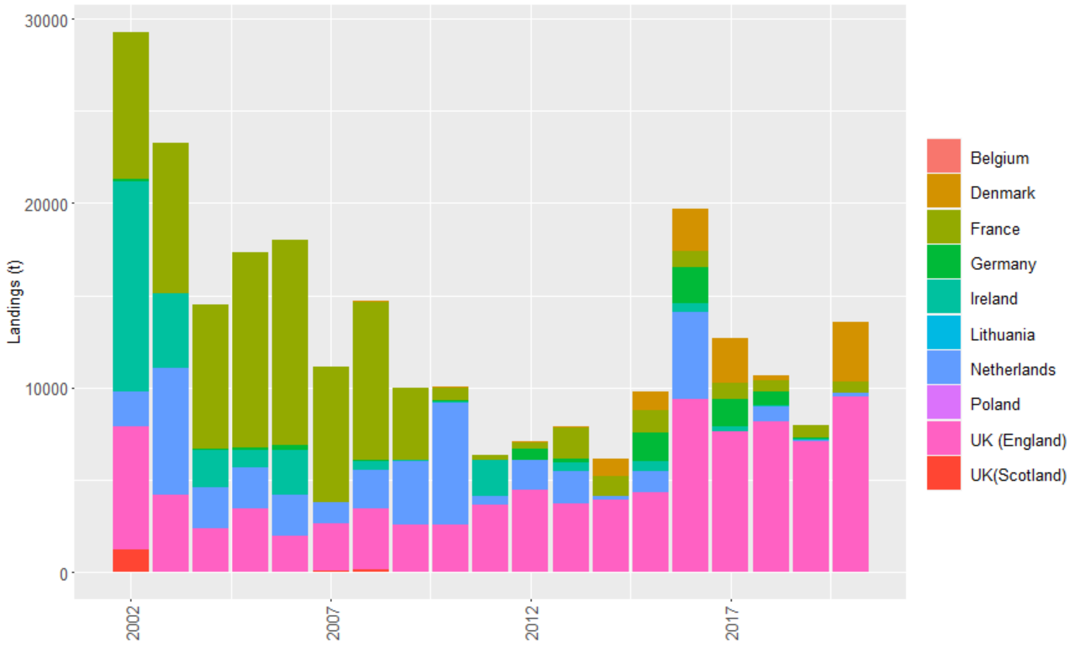

Figure 7.2.1.2. Sardine in Subarea 7. Landings reported by country (tonnes).

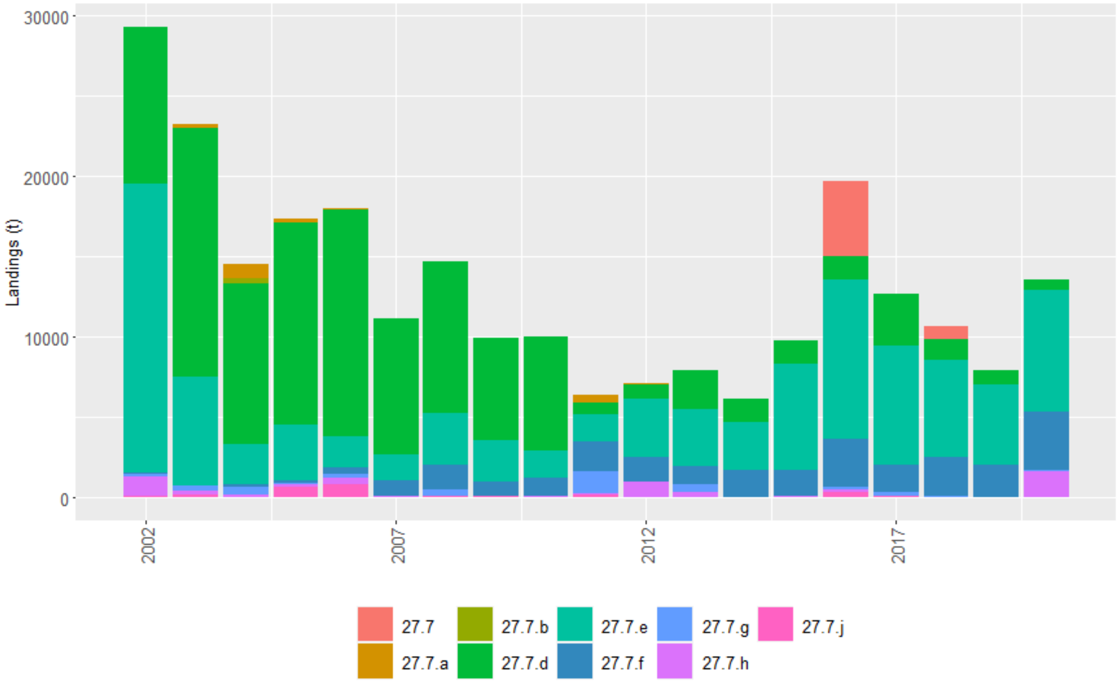

Figure 7.2.1.3. Sardine in Subarea 7. Landings by ICES division (tonnes).

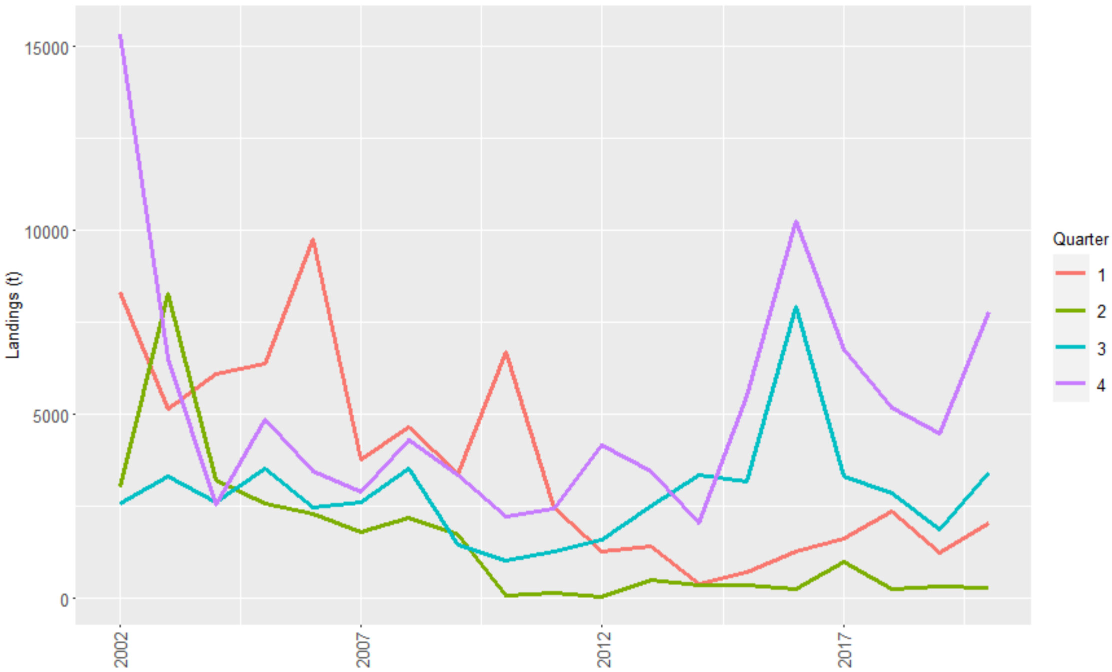

Figure 7.2.1.4. Sardine in Subarea 7. Landings by quarter (tonnes).

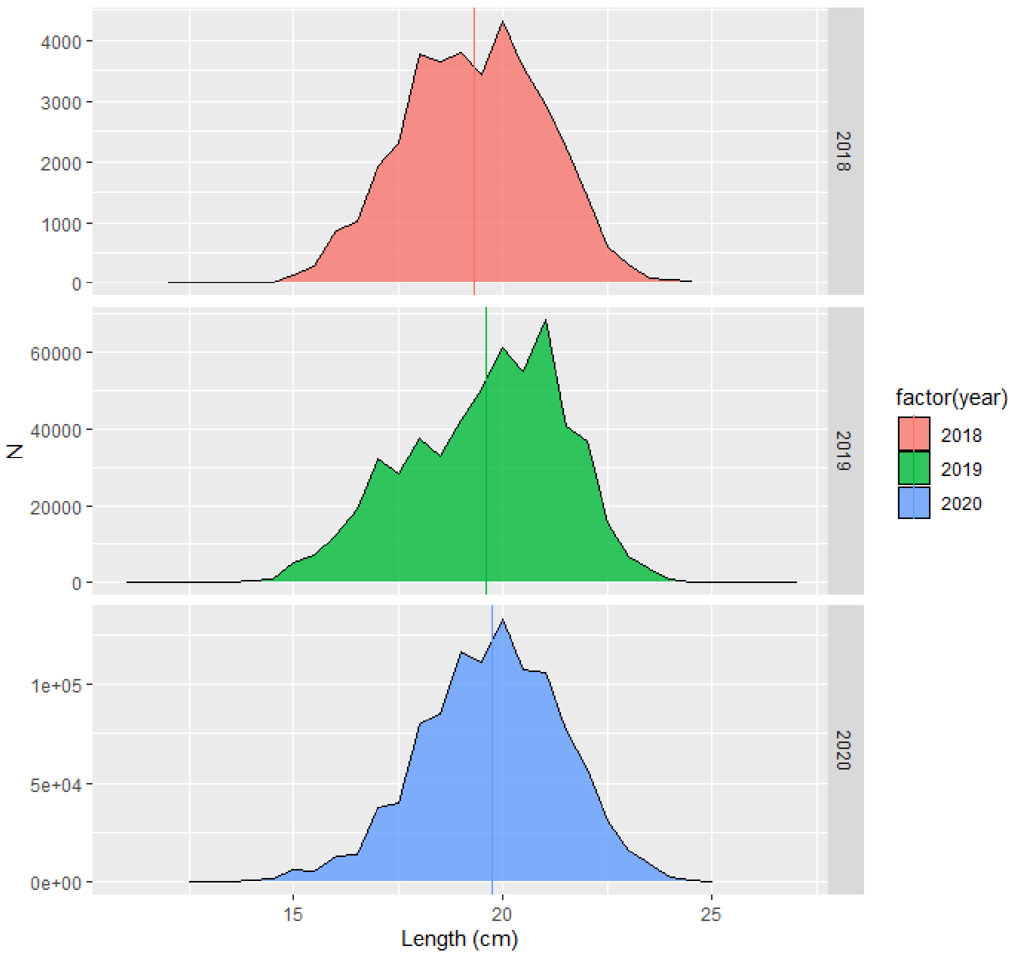

Figure 7.3.1.1. Sardine in Subarea 7. Length distribution of landings provided by the English fishing industry.

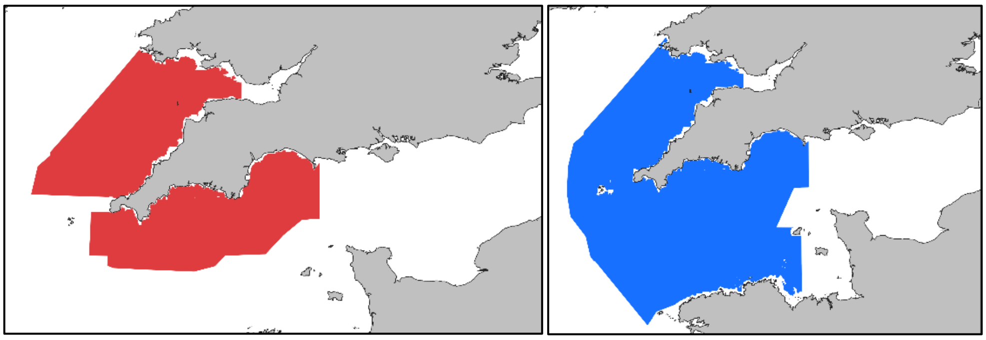

Figure 7.4.1.1. PELTIC coverage of core area since 2013 (left), and total area since 2017 (right).

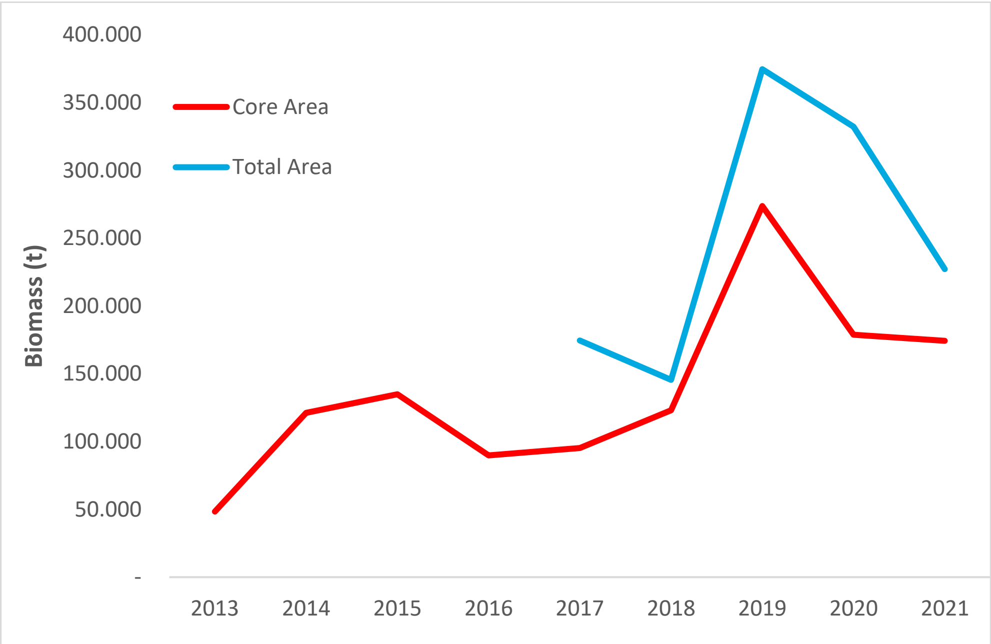

Figure 7.4.1.2. Sardine biomass in tonnes estimated from PELTIC survey in the core area (red line), covering division 7.f and English waters of 7.e, and in the total area (blue line), covering division 7.f and 7.e (also French side).

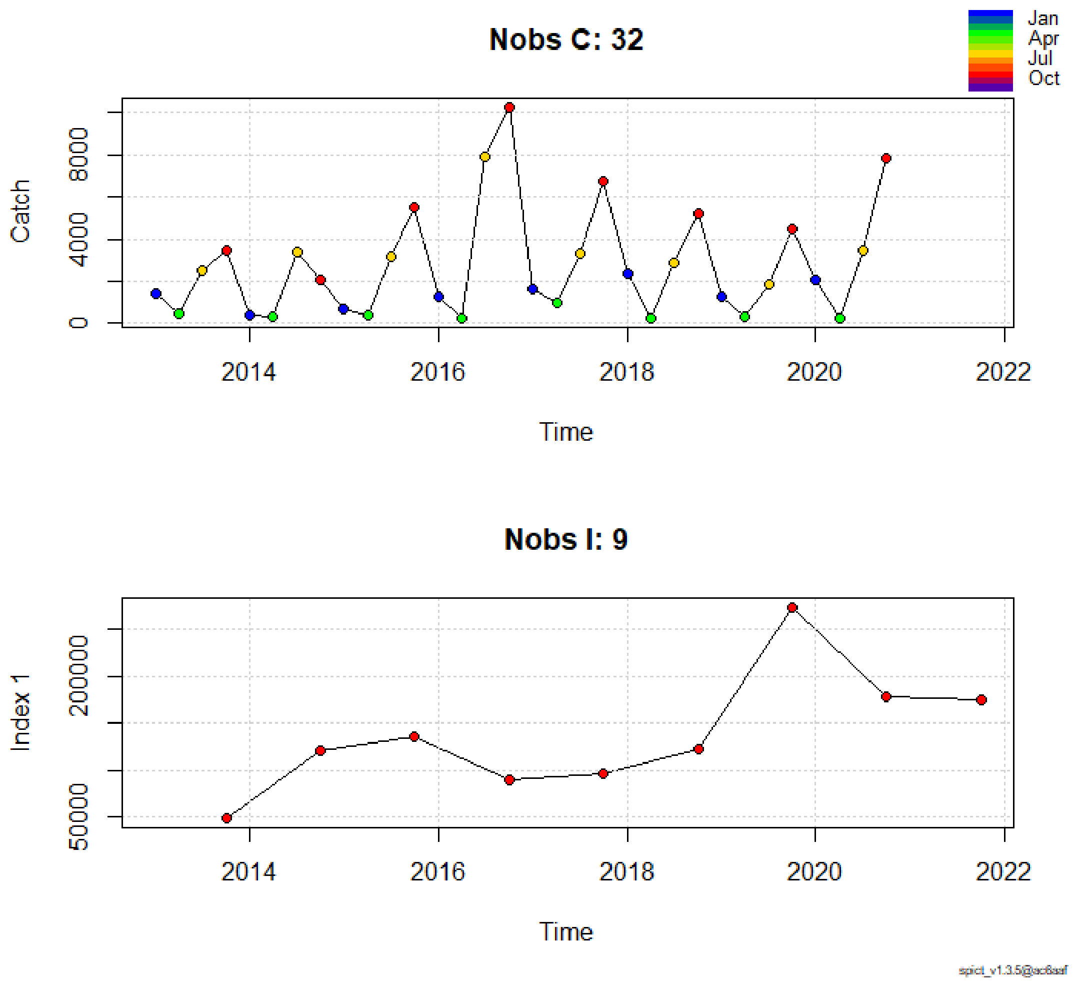

Figure 7.5.1.1. Sardine in Subarea 7. Input data of the SPiCT model. Top: landings by quarter (2013-2020). Bottom: biomass estimates in the core area (2013-2021). Blue represents quarter 1, green represents quarter 2, yellow represents quarter 3, and red represents quarter 4.

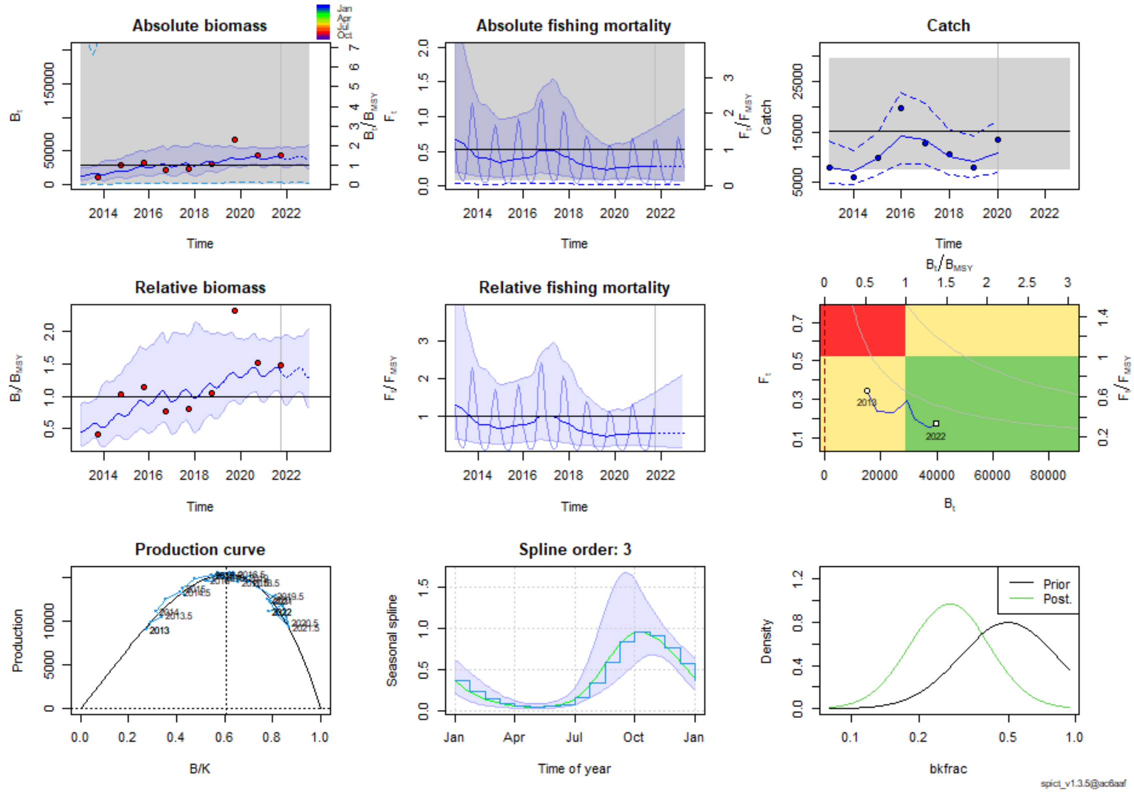

Figure 7.5.1.2. Sardine in Subarea 7. SPiCT model results. Top row: absolute biomass, absolute F estimates, and fitted catch. Middle row: relative biomass and F, and a Kobe plot comparing biomass and F. The grey area in the Kobe plot represents the uncertainty in the relative biomass and F estimates. Bottom row: production curve, seasonality of fishing mortality, and prior and posterior parameter distributions. The dashed lines are 95% CI bounds for absolute estimated values, shaded blue regions are 95% CIs for relative estimates, shaded grey regions are 95% CIs for estimated absolute reference points (horizontal lines).

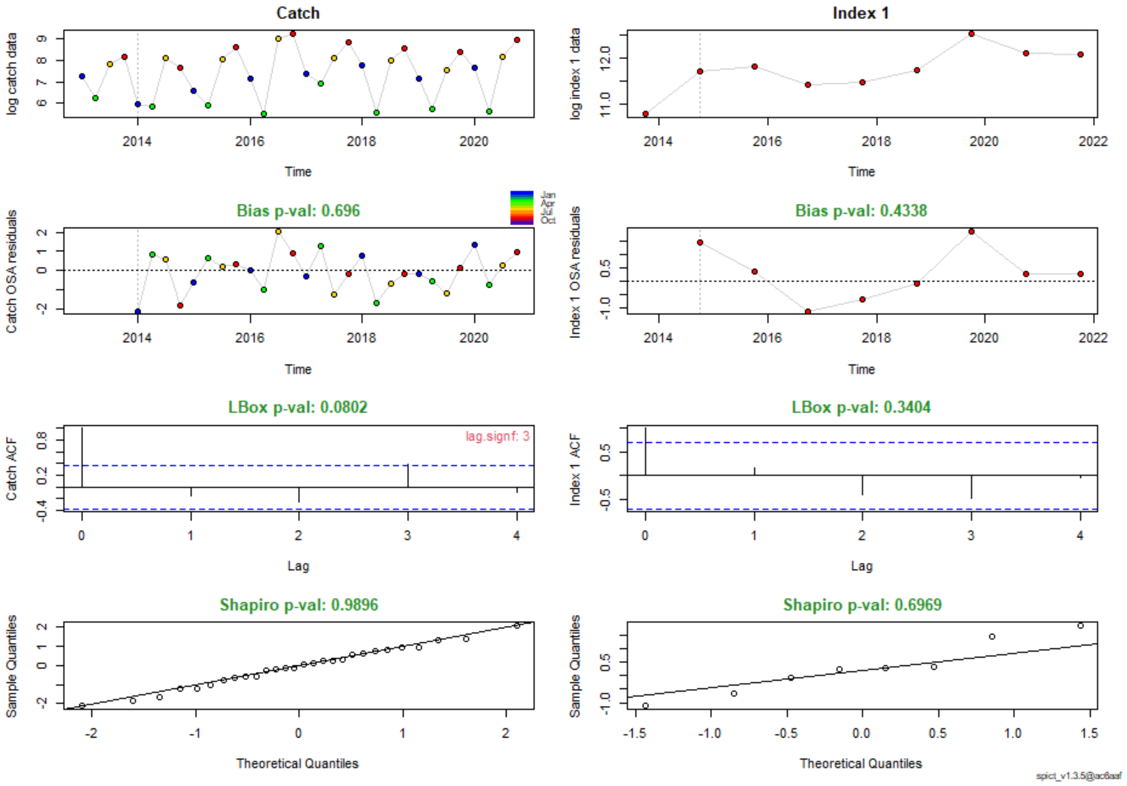

Figure 7.5.1.3. Sardine in Subarea 7. SPiCT model diagnosis.

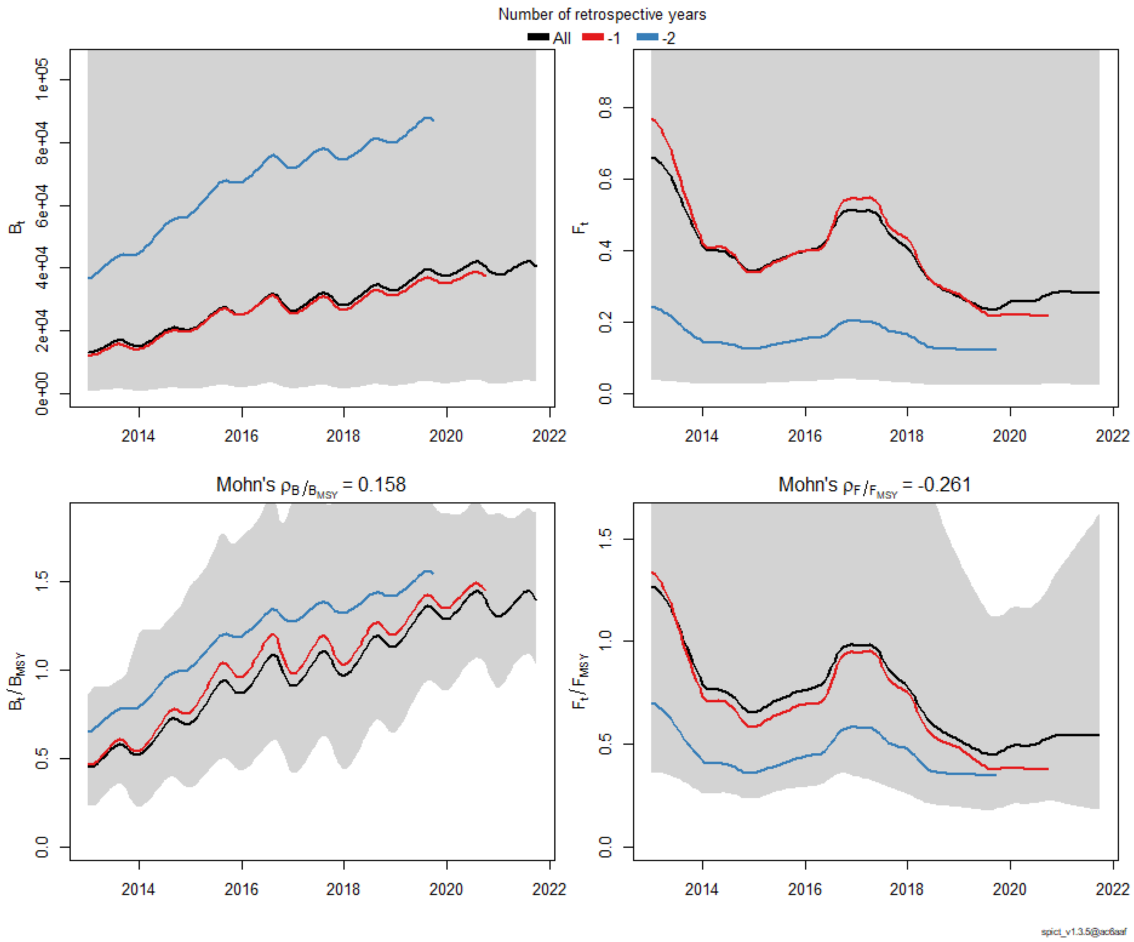

Figure 7.5.1.4. Sardine in Subarea 7. Retrospective analysis of the SPiCT model. Top row: absolute biomass and absolute F; bottom row: relative biomass and relative F.

8 Sardine in 8c and 9a

8.1 ACOM Advice Applicable to 2021, STECF advice and Political decisions

ICES advises that when the MSY approach is applied catches in 2021 should be no more than 40 434 tonnes (ICES, 2021a). This advice for 2021 replaces the advice provided in December 2020 and was issued in June 2021 after ICES received a special request from Portugal and Spain to review the catch advice for 2021 (ICES, 2021a).

In 2021 the fishery was managed according to a bilateral agreement between Portugal and Spain (Despacho n.º 33/DG/2021; BOE-A-2021-13560). Portugal and Spain agreed to implement a total catch of 45 545 t.

In Spain, purse seine fishery for sardine in Spain remained closed since October 2020 and reopened on May 3rd 2021 (with a planned closure in November 1st) (BOE-2021-7211), with a provisional quota that was updated after the advice revision in June (BOE 2021-13560), allowing to catch a total of 13 545 tonnes.

In Portugal, 2020 sardine fishery was closed on the 10th of October (Despacho n.º 9747-A/202, Diário da República, 2ª série - N.º 196 - 8 de Outubro de 2020) when the quota limit for this year was reached. In 2021, the fishery was reopened on May 17th with a provisional quota until July (Despacho nº 4626/2021, Diário da República, 2.ª série - N.º 88 - 6 de Maio de 2021). This regulation was updated in July allowing a total catch of 27 000 tonnes for 2021 (Despacho n.º 33/DG/2021).

8.2 The fishery in 2020

8.2.1 Fishing fleets in 2020

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 2020 indicate that the number of purse-seiners taking sardine were 453, with mean power of 229Kw.

In Portuguese waters, fleet data indicate that 175 vessels landed sardine with mean vessel tonnage of 70.0 GT and engine power category of 358 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 2020 are shown in Tables 8.2.2.1, 8.2.2.2 and Figure 8.2.2.1. Total 2020 landings in divisions 8c and 9a were of 22 143 tonnes, which represents an increase of 61% with respect to total 2019 landings (13 760 tonnes). The bulk of the landings (99%) were made by purse-seiners.

In Spain, sardine landings, 6 727 tonnes, represent a 70% increase in relation to values from 2019 (3 964 tonnes). In all ICES subdivisions catches experienced a large increase, but especially in the northern areas (8c and 9aN, with increases of 75% and 81% respectively), compared to a 53% increase in Cadiz.

In Portugal, sardine landings were of 15 416 tonnes, which represents an increase of 57% compared to 2019 landings, 9 796 tonnes. The increase in landings was generalized, with an increase of 41% in the Algarve and especially important in the areas in which landings had decreased in

2019, 9aCN (which experienced a 43% increase this year) and 9aCS, which increased catches by 76%.

Table 8.2.2.1 summarises the quarterly landings and their relative distribution by ICES subdivisions. In 2020, due to management regulations implemented in Spain and Portugal (see section 8.1.), the sardine fishery opened late in the year (May) and it closed at the beginning of the 4th quarter for having reached the total catches admitted. 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 to the total catch was similar to 2019, being the western Portuguese Atlantic coast (9aCN and 9aCS subdivisions) the areas that obtained almost 60% of the total catches of the stock.

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

It was not possible to estimate a total discard rate due to the COVID-19 pandemic disrupting on-board sampling. However, discards are generally negligible for this stock.

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

Sampling programs coordinated by the IEO, Spain (on-shore, observers on-board and biological sampling) were suspended in most of 2020 due to administrative problems and to the COVID-19 disruption. No length distribution was available for subdivision 8cE in quarter 3, subdivision 8cW for quarters 1, 2 and 3, subdivision 9aN in all quarters and subdivision 9aS-Cadiz in quarters 1, 2, 3. In some quarters of subdivisions 8cW, 9aCN, 9aCS and 9aS-Algarve it was possible to have a length distribution but based on very small number of samples and individuals measured.

The COVID pandemic also affected, but to a lesser extent, some of the biological samplings (including otolith samples for age readings) made by IEO in Spain and IPMA in Portugal.

During the WG, several options were explored to solve the problem of lack of sampling in some areas and quarters during 2020. Results were presented and discussed during the WGHANSA-1 meeting and are detailed in the section 8.9.

Length distribution of the available sampling during 2020 (Table 8.2.4.1) show that, as usual, smaller individuals were caught in 9aS-Cadiz subdivision. Length distributions were unimodal in all subdivisions, for both Spain and Portugal. In Spain modes were 13.5 cm in 9aS-Cadiz and 17.5 cm in 8cE. In Portugal, smaller individuals were caught in 9aCN subdivision (mode at 16 cm), in Algarve mode was at 17.5 cm and bigger individuals were present in 9aCS subdivision (mode at 20 cm).

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

Table 8.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision for the year 2020, 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, as usual, has the highest percentage in the catch. In 2020, however, the relative contribution of the 2019 year class (age 2) is much more important than in previous years, representing 58% of catches which reflects the strong 2019 recruitment. In the northernmost areas of the Atlantic coast of the stock (9aN and 9aCN), this age accounts for almost all of the catches. Age 0 was mainly caught in one of the main recruitment areas of this stock: 9aS-Cadiz (69%), but was barely landed in the northern areas of 9a division (9aN and 9aCN subdivisions), traditional recruitment areas and in which a large part of the juveniles were located during the IBERAS 2020 survey.

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, 8.3.2 and 8.3.3 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 where final results were presented and fully discussed (ICES, 2021b).

In 2020, IPMA DEPM Portuguese survey was successfully conducted, however, the Spanish survey; SAREVA0320, was cancelled due to the COVID-19 health crisis and the posterior declaration of the national state of alarm in March of 2020.

The cancellation of Spanish spring DEPM survey has led to a lack of sardine data for estimating the total stock SSB in 2020, with impact on the 2021 assessment, the first year in which this 2020 index is used in the evaluation model.

Different solutions were tested to compensate the lack of the SAREVA survey data and WGACEGG in November 2020 (ICES, 2021b) decided that the Portuguese index could be raised by a linear regression model to estimate the total SSB in the Iberian sardine stock, considering the high correlation between Spanish and Portuguese surveys (with a higher contribution to the SSB of the Portuguese in the Cantabrian Sea and Atlantic Iberian waters - mean = 78%). DEPM parameters derived from the 2020 sardine DEPM survey with their CV (%) in brackets by institution and strata are shown in Table 8.3.1.

8.3.2 Spring Iberian acoustic survey (PELACUS-PELAGO)

As part of the Iberian acoustic survey, two 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, 2020). 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 9a and 8c using acoustic methods: PELAGO and PELACUS. For the first time, in 2021, both surveys were carried out on the same vessel, R/V Miguel Oliver. The PELAGO survey was carried out in March, followed by the PELACUS survey. This same work scheme had been planned for 2020, but PELACUS could not be carried out due to the COVID pandemic.

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

During the first day of the WGHANSA-1, in a joint extraordinary meeting with the WGACEGG, the 2021 PELAGO and PELACUS results were presented, discussed and approved for use in the update of the sardine advice for 2021 (Appendix 5).

8.3.2.1 Portuguese spring acoustic survey

The PELAGO acoustic surveys have sampled the Portuguese and Bay of Cadiz continental shelves, since 1995 and until 2019 with the R/V Noruega, a 49 m trawl vessel. In 2020 and 2021 this survey was carried out on-board R/V Miguel Oliver.

The PELAGO2021 survey was conducted between the 3rd and 21st of March. Seventy-one (71) transects were acoustically sampled between Caminha and Cape Trafalgar.

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. A total of 38 pelagic trawl hauls were carried out by the research vessel and 26 additional hauls were done by 2 purse-seiners. Sardine was present in most of the fishing hauls (89%) and represented 36% of the total catch in weight and 19% in number.

Figure 8.3.2.1.3. shows the NASC values allocated to sardine. The energy attributed to this species was distributed throughout the coast, with the highest concentrations in the north, between Porto and Aveiro, and in the 9aCS subdivision.

Figures 8.3.2.1.4., 8.3.2.1.5. and Table 8.3.2.1.1. show the abundance in number and biomass by length and age class, respectively. In 9aCN the modal age was 16cm, representing age 2 individuals (accounting for the 84% of the abundance in this area), reflecting the strength of the 2019 year class, already detected last year during the IBERAS20 survey.

In 9aCS, the length distribution is bimodal with a main mode at 16 cm of age 2 individuals. The second mode of larger individuals includes mainly 5 years old sardines of the 2016 cohort. In 9aS-Algarve, the length distribution is bimodal, with a mode at 15 cm (age 1) and also larger fish of 18.5 cm, corresponding to age 3 sardines. In 9aS-Cadiz, most sardines (83% of the abundance) belong to age 1, with a mode at 14 cm length.

During 2021 PELAGO survey, age 0 sardine individuals were not detected.

In relation to total abundance in PELAGO2020, 2021 sardine estimation (10901 million individuals) showed a decrease by 42%. Compared to the abundance of age 1 individuals last year, this represents a decrease by 34%.

The sardine B1+ was estimated to be 416.5 thousand tonnes for the whole area, representing a significant increase of 8% in relation to the PELAGO2020 survey (5% increase in total biomass comparing to the 2020 survey).

8.3.2.2 Spanish spring acoustic survey

The Spanish PELACUS 0321 survey was carried out from 25th March to 18th April in the R/V Miguel Oliver. Sampling design and methodology was similar to that of the previous surveys and is summarised in Massé et al (2018) with supplementary material available online. Tracks were placed at 10 nmi, with a random start and only steamed during day hours. The survey progressed eastwards (Figure 8.3.2.2.1).

Weather conditions were good in 9aN but becoming worse northwards. As a consequence, half of the 8cW subdivision was steamed at the end of the survey. In general, in Cantabrian Sea (8c and 8b subdivisions) Northeast winds were predominant at a force 5-8.

A total of 15362 echotraces were extracted, accounting for a total NASC (sA) of 513 355 m^2 nmi^{-2}, an important increase from that recorded in 2019 (210114 m^2 nmi^{-2}).

A total of 44 fishing stations were carried out, yielding about 31 kt of fish. Of them, 11 corresponding to sardine (40% in number), which was present in 64% of the fishing stations. In 9aN a very significant increase of sardine schools was recorded. They mainly occured within the Rias and surrounding (near shore) areas. Schools were mainly located close to the surface with high densities. Figure 8.3.2.2.2 shows the species proportion (% in number) in the fishing stations, with circles proportional to the total catch in weight.

The bulk of the sardine NASC distribution was recorded in 9aN subdivision (Figure 8.3.2.2.3.). The amount of backscattering energy allocated to sardine is the highest of the time series in Spanish waters, which also shows an increasing trend since 2013, when the minimum value was observed. Besides, as the amount of fish is increasing, the center of gravity of the distribution is moving towards the western area (Galician area), and consistently going to shallower waters.

A total of 348 thousand tonnes, corresponding to 6770 million fish were estimated, most of them in the western part (9aN) (Table 8.3.2.2.). Although the significant increase in biomass in relation to that estimated in 2019, age group 1 only accounted for l4% of the total biomass, with the bulk of the fish belonging to age group 2 (60%); age 5 accounted for 14% of the biomass, which is consistent with the results obtained in 2019, when this cohort achieved the 48% of the total biomass (and number) at age of 3. The very scarce estimates of age group 1 in western waters (9aN and 8cW), with less than 2% of the total abundance did not match with the results obtained in the Cantabrian Sea where this cohort accounted for the 59% of the abundance (8cE) and up to 81% in 8b (Figure 8.3.2.2.4.).

8.3.3 Autumn acoustic survey index

For the major recruitment area in Portugal, from 1997 (SAR-PT-AUT time series) and in the recent period, from 2013 (JUVESAR time series) juvenile surveys were carried out from Lisbon to the Portuguese–Spanish border, to assess the abundance of recruits in that particular area. Since 2018, as a result of a collaboration between IPMA and IEO, the survey IBERAS estimates a recruitment index in Atlantic waters of the Iberian Peninsula, aiming to improve the estimation of the strength of the recruitment for both Ibero-Atlantic sardine and the western component of the south anchovy population.

In October 2021, an Inter-benchmark (ICES, 2021c) was accomplished for this stock and the juvenile index from autumn acoustic surveys since 1997, for the 9aCN subdivision, was decided to be included in the assessment model.

Last IBERAS survey, in 2021, was carried out on board Ramon Margalef R/V. This year the survey was divided in in two parts, due to logistical problems related to the volcanic eruption in La Palma. The first leg was carried out from 18th to 20th September covering 9aN subdivision, while the core recruitment area, 9aCN, and the northern part of the 9aCS (until Sines coast) was sampled in the second part, from 9th to 18th October. Sampling design and methodology was similar to that of the previous surveys and is summarised in Doray et al., 2021.

A total of 29 fishing stations were carried out (with two different fishing gears for shallower or medium waters) and additional samples were obtained from 9 fishing stations carried out by purse seiner vessels (Figure 8.3.3.1). For most of the stations, sardine, anchovy, mackerel and horse mackerel were present.

Sardine distribution showed larger dispersion than in previous years, but with its centre of gravity was stable around Figueira da Foz, in 9aCN subdivision, and approximately at 20m depth. The total energy allocated to sardine (NASC) was much lower than in 2020, and most of it corresponding to age 2 individuals (strong 2019 cohort) (Figures 8.3.3.2 and 8.3.3.3).

2021 recruitment for the whole surveyed area, was estimated to be 900 $x10^6$ age 0 individuals ($23x10^3$ million tonnes). Age 0 abundance in the 9aCN subdivision, which will be used in the assessment model, corresponds to 657 x 106 individuals ($17x10^3$ million tonnes) (Table 8.3.3.)

8.3.4 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 (specially for age-0 individuals), although they have interannual differences (Figure 8.3.4.1).

In 2021, ECOCADIZ survey could not be carried out due to logistical problems arising from a breakdown in the oceanographic vessel.

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

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

Mean weight-at-age in the catch are shown in Table 8.3.5.1a.

According to the stock annex, mean weights-at-age in the stock (Table 8.3.5.1b) 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 (2020) are assumed.

8.3.6 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 (2020) are assumed. Those estimates were presented during a joint session of WGHANSA-WGACEGG during the first day of the WGHANSA1 meeting (Annex 5).

8.3.7 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

M, year^{-1}	
Age 4	0.36
Age 5	0.35
Age 6	0.32

8.3.8 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 8.3.8.1 and 8.3.8.2.

8.4 Assessment Data of the state of the stock

8.4.1 Stock assessment

After the Inter-benchmark process that took place in October 2021 (ICES, 2021c), the settings of the Stock Synthesis (SS) stock assessment model were modified for the inclusion of a recruitment index based on the age 0 estimates of the autumn acoustic surveys in 9aCN from 1997 onwards. The catchability of the recruitment index was modelled with a power function and an extra additive standard deviation parameter was included for all the abundance indices (Acoustic, DEPM and recruitment). In addition, the input standard deviation of log number of recruits (sigmaR) and the recruitment deviations were fine-tuned based on the suggestions of the SS output.

The table below presents an overview of the assessment 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 catch at age data from the fishery and the SSB estimate from the DEPM surveys. 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 2021
Catch	Catch biomass 1978–2021 (tonnes)
	Catch-at-age 1978–2020 (thousands of individuals)
Spring acoustic survey (Joint SP+PT) *	Total numbers 1996–2021 (thousands of individuals)
	Numbers-at-age 1996–2021 (thousands of individuals)
DEPM survey (Joint SP+PT)	SSB 1997, 1999, 2002, 2005, 2008, 2011, 2014, 2017, 2020 (tonnes)
Autumn acoustic survey (recruitment index)	Numbers at age 0 in 9aCN (thousands of individuals)
Weight-at-age in the catch	Yearly averages 1978–2020 (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, 2020 onwards), kg
Maturity-at-age	From DEPM surveys in DEPM years, linear interpolation for years in-between (constant 1978–1998, 2020 onwards), proportions

Input data	WGHANSA 2021
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 0.74, 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–onwards. Selectivity-at-age is estimated for each period and within each period assumed to be fixed over time.
Spring acoustic survey selectivity-at-age	Selectivity assumed to be equal at all ages.
Autumn acoustic survey selectivity-at-age	Selectivity tailored to young fish (age 0)
Fishery catchability	Scaling factor, median unbiased
Spring acoustic survey catchability	Simple model with extra standard error parameter
DEPM catchability	Simple model with extra standard error parameter
Autumn acoustic survey catchability	Power model with extra standard error parameter
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. Virgin recruitment was estimated to be $R_{0,2021}$ = 19 904 100 (CV = 4%) and the initial F was estimated as $initF_{2021}$ = 0.42 $year^{-1}$. Catchability parameters are close to 1 for both the acoustic (Q = 1.35, RMSE = 0.30) and the DEPM (Q=1.26, RMSE=0.32) surveys. Catchability parameter for the recruitment index is 4.27e-07 (RMSE = 0.96). The extra standard deviation parameters are low for the spring acoustic and the DEPM surveys (0.05 and 0.07 respectively) but higher for the recruitment index (0.71). Correlations between the assessment parameters range from -0.99 to 0.45 although the majority are very close to zero. Negative correlations below -0.50 are observed between the two parameters of the power model of $Q_{recruitment\ index}$ (-0.99), R_0 and $Q_{acoustic\ survey}$ (-0.56) and between selectivity parameters from the first period (four cases) and one case in the last period.

The assumed standard error for the acoustic and the DEPM index, all years = 0.25, is consistent with the residual mean square errors estimated by the model, 0.30 and 0.32. The harmonic mean of the fishery age composition sample size, 73, is consisted with the current assumption of 75. In the case of the spring acoustic survey survey, the sample size of 25 is consistent with the precision indicated by the model (the harmonic mean for the acoustic survey is estimated to be 21).

Figures 8.4.1.1, 8.4.1.2 and 8.4.1.3 show the fit of the model to the three indices of abundance. Both are similar to the fit of the 2020 assessment model. The assessment of 2021 still shows a poor fit to the 2020 and the 2021 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. It seems that the model has a tendency to underestimate abundance in years when the survey index is large. This is also the case for the DEPM survey index, where the model shows a poor fit to the 2020 point estimate and other high values (e.g., 2008).

Figure 8.4.1.4 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 2020 have decreased, when compared to 2019, for the younger ages (until age 3) and increased for the older ages. Residuals are positive for ages 1, 2 and 3 and negative for all the other ages. The acoustic survey residuals in 2021 are positive for age two, four and five and negative for all other ages.

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 8.4.1.5). The patterns over age are dome-shaped in the three periods with the early (1978–1987) and recent periods (2006–2020) 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 2021 assessment results is shown in Table 8.4.1.4 and Figure 8.4.1.5 (in the Figure compared to the updated 2020 assessment model results). The estimate of B1+ in 2021 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. Catches assumption for 2021 are based on the EU members published legislation (see Section 8.1). 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 2021 is predicted to be 394 227 t (CV = 15%), assuming that the stock weights are equal to the mean of the last six years. This represents an increase of 7% when compared with B1+ in 2020 = 369 116 t (CV = 15%). B1+ is above B_{lim} = 196 334 t, B_{pa} = 252 523 t and MSY $B_{trigger}$ = 252 523 t of the current low productivity regime of the stock (see Section 8.7). The increase of 7% in B1+ is a consequence of the growth of individuals and not of an increase in the total numbers of individuals. Total numbers of individuals decreased by 13% from 2020 to 2021.

$F_{bar\ 2\text{–}5}$ in 2020 is estimated to be 0.070 $year^{-1}$ (CV = 16%) which represents an increase of 25% when compared to $F_{bar\ 2\text{-}5}$ in 2019. $F_{bar\ 2\text{–}5}$ is now below F_{MSY} since reference points were updated (see section 8.7).

The series of historical recruitments 1978–2021 shows a marked downward trend until 2006 and since then, has been fluctuating around historically low values. The 2019 recruitment estimate (R_{2019} = 22 047 800, CV = 17%) constitutes the highest value since 2004. The 2021 recruitment estimate (R_{2021} = 7 860 940, CV = 44%) represents a decreased of 64% when compared to the Recruitment estimate of 2019.

8.5 Retrospective pattern

Retrospective patterns for Biomass 1+, $F_{ages2\text{-}5}$ and recruitment were computed for years 2016–2021. 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 (2021). This range of runs include runs prior and after the benchmark (ICES, 2017) and the Inter-benchmark (ICES, 2021c). 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 -0.256) and recruitment (Mohn's rho of -0.144) while it overestimates $F_{ages2\text{–}5}$ (Mohn's rho of 0.221). 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

The short-term forecast assumptions were updated. The inclusion of a recruitment index in the stock assessment, after the Inter-benchmark of October 2021, allows the estimation of recruitment in the interim year. Previously, the recruitments in the interim year and in the management year were assumed to be the geometric mean of the recruitment estimates in the last five years of the assessment. Based on the new stock assessment settings, recruitment in the interim year was changed to be the value estimated in the assessment and the recruitment in the management year was the geometric mean of the last five years (now, including the interim year estimate). As a consequence, the prediction skill of the new assessment and short-term forecast improved notably (ICES, 2021c).

Catch predictions were carried out following the stock annex, Annex 3. Recruitment in the interim year (2021) is now the estimate from the assessment model and in the forecast year (2022) was set to the geometric mean of the last five years (2017–2021), R_{2022} = 8 333 147 thousand individuals. Fishing mortality in the interim year is the fishing mortality that corresponds to a catch constrain. The catch assumption for 2021 was assumed to be 40 545 tonnes based on the official documents published in Portugal and Spain prior to WGHANSA-2 (Despacho n.º 33/DG/2021; BOE-A-2021-13560). This corresponds to a $F_{ages2\text{–}5}$, 2021 = 0.107.

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 scenarios is stored in file pil.27.8c9a_scenarios in the WGHANSA SharePoint.

8.7 Reference points

Reference Points for this stock were re-evaluated at the beginning of 2021, during the **Workshop for the evaluation of the Iberian sardine HCR (WKSARHCR; ICES, 2021d).** For stocks where an appropriate management strategy evaluation (MSE) methodology has already been developed, with careful consideration of the uncertainties involved for the stock, the MSE framework should be the preferred one for the calculation of reference points (WKGMSE3, ICES, 2020). Therefore, Maximum Sustainable Yield (MSY) and Precautionary Approach (PA) reference points were re-examined during WKSARHCR workshop with the MSE framework used to evaluate a generic HCR proposed by Portugal and Spain EU members within a management plan for 2021-2026.

Following ICES (2021e) guidelines the stock–recruitment (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. B_{pa} was derived as $B_{pa} = B_{lim} * exp(1.645 * \sigma)$. In this particular case, with σ the coefficient of variation $of\ B1 +$ from the stock assessment data used to estimated B_{lim}. Since this stock has not been fished at F_{MSY} for at least 5 years, MSY $B_{trigger}$ is set at B_{pa}. Simulations were conducted with the MSE framework to estimate the MSY and PA reference points for fishing mortality (F), namely F_{lim}, F_{MSY} and F_{pa} (ICES, 2021d). A detailed analysis is presented in ICES (2021d).

ICES adopted new reference points for the stock based on data from the period 2006–2019 which is considered representative of a low productivity state. The recomputed values, using the management strategy evaluation framework, are presented in Table 8.7.1.

Table 8.7.1. Previous and updated Reference Points. The previous biological reference points were estimated during WKSARMP (ICES, 2019) based on the period 2006-2017 and the current were estimated during WKSARHCR (ICES, 2021d) based on the state of low productivity (2006–2019). Weights are in tonnes.

BRP	2006–2017	2006-2019	Technical basis
B_{lim}	196 334	196 334	B_{lim} = Hockey-stick change point
B_{pa}	252 523	252 523	$B_{pa} = B_{lim} * \exp(1.645 * \sigma)$, $\sigma = 0.17$ (ICES, 2021d)
F_{lim}	0.156	0.26	Stochastic long-term simulations (50% probability SSB < B_{lim}) (MSE)
$B_{trigger}$	252 523	252 523	$B_{trigger} = B_{pa}$
F_{pa}	0.032	0.092	$Fp_{.05}$; the F that leads to SSB ≥ B_{lim} with 95% probability (MSE).
F_{MSY}	0.224	0.22	Median F_{target} which maximizes yield without $B_{trigger}$ (MSE)
Adopted F_{MSY}	0.032	0.092	If $F_{pa} < F_{MSY}$ then $F_{MSY} = F_{pa}$

8.8 Management considerations

A new management and recovery plan for the Iberian sardine stock (divisions 8.c and 9.a) (Multiannual Management Plan for the Iberian Sardine 2021–2026) was developed by Spain and Portugal. In February 2021, ICES received a request from Portugal and Spain EU members to evaluate a generic harvest control rule (HCR) within that management plan. The new HCR is defined by three reference levels for fishing mortality, F = 0, F = 0.064 and F = 0.12 and, three reference levels for B1+, B_{low} = 112 943 t, defined as the lowest observed time series B1+ according to the 2018 assessment (ICES, 2018), MSY $B_{trigger}$ = 252 523 t, under a low productivity regime and MSY $B_{trigger}$ = 446 331 t, under a medium productivity regime (Figure 8.8.1.).

The proposed HCR was described as follows:

- i) If B1+ ≤ 112943 t, then F = 0
- ii) If 112943 t < B1+ ≤ 252 523 t, then F increases linearly from 0 to 0.064
- iii) If 252 523 t < B1+ ≤ 446 331 t, then F increases linearly from 0.064 to 0.12
- iv) If B1+ > 446 331 t, then F = 0.12

Conditions ii) to iv) are overridden if the forecast catch in any given year exceeds the maximum allowed catches of 30 to 50 kt.

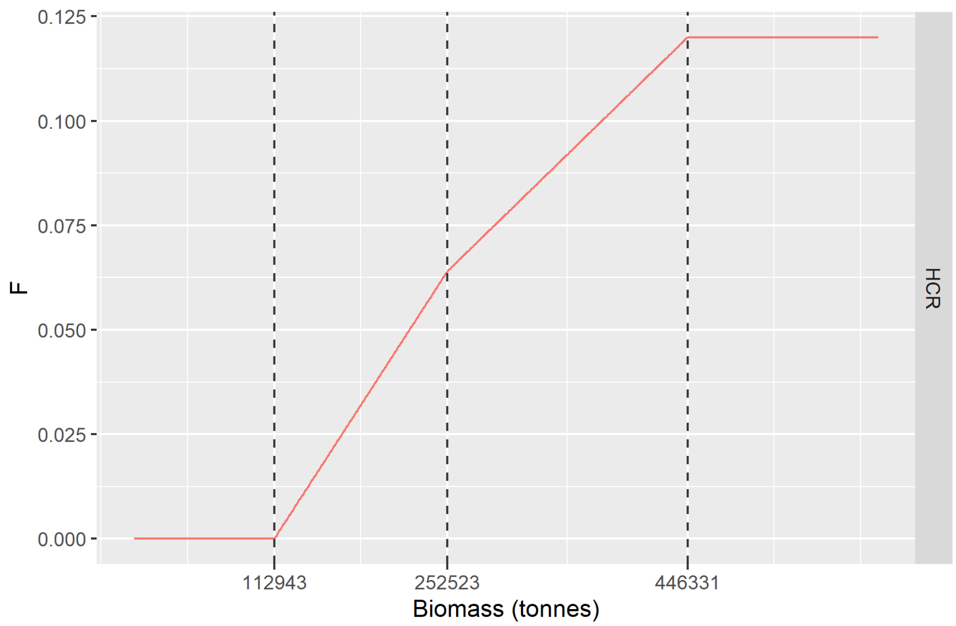

Figure 8.8.1. Proposed HCR. The biomass reference levels of biomass (B1+) reported correspond to $B_{loss(2018)}$ = 112 943 t, MSY $B_{trigger\_low}$ = B_{pa_low} = 252 523 t and MSY $B_{trigger\_medium}$ = B_{pa_medium} = 446 331 t.

ICES found that the generic harvest control rule was precautionary in a persistent low productivity regime with maximum allowed catches between 30 and 50 kt (ICES, 2021f). For 2021, the EU Commission requested ICES to provide advice based on the MSY approach.

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.

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.

2021 acoustic surveys (included in 2021 assessment) were not affected by the COVID disruption.

3. **Missing or deteriorated catch data:**

Sampling programs coordinated by the IEO, Spain (on-shore, observers on board and biological sampling) were suspended in most of 2020 due to administrative problems and to the COVID-19 disruption. Sampling by IPMA, Portugal was also affected by the COVID-19 pandemic: (i) market sampling in Portuguese ports of ICES 9a was suspended during the period March-June 2020 and resumed after that; (ii) on-board sampling in Portuguese waters of ICES 9a was suspended in March 2020 and was not resumed in that year.

Official catches were appropriately reported for both countries, but length distribution was missing in some of the subdivisions/quarters. Table 8.9.3.1 shows the number of length samples collected in 2020 for all subdivisions.

4. Missing or deteriorated commercial LPUE/CPUE data:

Not applicable.

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

The COVID pandemic also affected, but in a less extent, some of the biological samplings made by IEO in Spain and IPMA in Portugal. Table 8.9.5.1 shows the number of biological samples collected in 2020 for all subdivisions. For subdivisions were length distributions were available, there are missing age readings and estimation of mean weight for subdivisions 8cE in quarter 4, 9aCN in the second quarter and in all quarters of subdivision 9aCS.

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

The length distributions of the last 3 years (2017-2019, Figure 8.9.6.1) were analysed by subdivision, and it was found that the differences were notable between years. For example, the proportion at length in the year 2018 is very different from the two other years.

In the assessment model of the Iberian sardine, the sum of all subdivisions catch-at-age numbers is an input data. The proportions by age in the previous years (2017-2019) were analysed and for subdivisions where we lacked enough samples to extrapolate numbers at age for the catch, by quarter, we compared the proportion-at-age in those subdivisions to proportion-at-age in adjacent subdivisions (Figures 8.9.6.2 to 8.9.6.5):

- For 8cW, age composition is based on age composition of 8cE subdivision
- For 9aN, age composition is based on age composition of 9aCN subdivision
- For 9aS-Cádiz, age composition is based on age composition of 9aS-Algarve subdivision.

Differences at age in the last three years are shown in Tables 8.9.6.1 to 8.9.6.3. and Figures 8.9.6.6 to 8.9.6.8.

The differences in percentages are small when comparing the age percentages from the original data to the adjacent data approach (Figure 8.9.6.9).

<u>**Sensitivity analysis**</u>

In order to evaluate the effect on the assessment of the different possible catch assumptions, runs were made for past assessments without the vector for catch-at-age in the year previous to the terminal year (NoCatch) and with a modified vector for catch-at-age (OtherCatch and MeanCatch). Outputs of these assessments were compared to the 'real' assessment (Figures 8.9.6.10. to 8.9.6.12). In the OtherCatch run, the catch-at-age vector was modified according to the assumption that number of individuals at age in a subdivision lacking length sampling was equal to the number of individuals of an adjacent subdivision and weight-at-age were unchanged. In the MeanCatch run, the catch-at-age vector was modified with the assumption that number of individuals at age are the mean of the last 3 years catch-at-age vectors and weight-at-age are also the mean of the last 3 years. Percentual differences between the 'real assessment' and the other runs are shown in Tables 8.9.6.4 to 8.9.6.6. for the last 4 years of each time series.

Uncertainty, measured as the width of the confidence interval, is higher for the runs without any input data of age composition of catches in the last year where catch information is available. The highest difference observed in Recruitment and B1+ are from the NoCatch scenario: 98.1% for Recruitment, 42.6% for B1+ in the 2020 assessment (Figure 8.9.6.9 and 8.9.6.10, Table 8.9.6.4.).

Most often the run Othercatch estimates are closer to the 'real' assessment with the exception of the 2019 Assessment where the recruitment in the terminal year is estimated to be 19.4% lower and B1+ is estimated to be 5.6% lower (Figure 8.9.6.10 and Table 8.9.6.5.).

For Biomass 1+ differences are higher in the assessment of 2020 for scenario NoCatch in the interim year where B1+ is estimated to be 42.6% higher (Figure 8.9.6.9 and Table 8.9.6.4.).

Conclusion:

- It is always better to use catch data in the terminal year than to use not catch at all. The use of proportions at age based on the adjacent subdivision worked better in the simulations than the mean proportion of the last years (less differences versus the real assessment).

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

For catch data, when age-length keys (ALK) are not complete or not available, the group approved the use of the following assumptions:

Subdivision 9aCN Quarter 2: PELAGO ALK in 9aCN combined with ALK in 9aN Quarter 3 and Quarter 4: joint ALKs

Subdivision 9aCS Quarter 2: PELAGO ALK in 9aCS

Quarter 3: ALK were estimated with the Hoening *et al* (1993, 1994) method, which uses an undefined number of data sets with known and unknown age information.

Quarter 4: ALK were estimated with the Hoening *et al.* (1993, 1994) method.

Subdivision 9aS-Algarve: Quarter 2: observed ALK

Quarter 3: observed ALK

Quarter 4: observed ALK

In all the cases, the ALKs will be completed by hand to avoid gaps. The resulting age distributions in 9aCN will be propagated to the 9aN Spanish catches and the resulting age distributions in 9aS-Algarve in Quarter 2 will be propagated to Spanish catches in 9aS-Cadiz Quarter 1 and Quarter 2.

Also, the resulting age distribution from 8cE will be propagated to 8cW (all quarters).

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 References

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Table 8.2.2.1: Sardine in 8c and 9a: Quarterly distribution of sardine landings (t) in 2020 by ICES Subdivision. Above absolute values; below, relative numbers.

Subdivision	1st	2nd	3rd	4th	Total
8cE	134	447	152	164	896
8cW	0.5	1361	508	56	1925
9aN	9	1172	671	98	1950
9aCN		1170	3657	221	5049
9aCS		2197	5071	291	7560
9aS-Algarve		723	1977	107	2807
9aS-Cadiz	23	224	946	762	1955
Total	167	7295	12982	1699	22143

Subdivision	1st	2nd	3rd	4th	Total
8cE	0.61	2.02	0.68	0.74	4.05
8cW	0.00	6.15	2.29	0.25	8.70
9aN	0.04	5.29	3.03	0.44	8.81
9aCN	0.00	5.29	16.52	1.00	22.80
9aCS	0.00	9.92	22.90	1.31	34.14
9aS-Algarve	0.00	3.27	8.93	0.48	12.68
9aS-Cadiz	0.10	1.01	4.27	3.44	8.83
Total	0.75	32.95	58.63	7.67	100

Table 8.2.2.2. Sardine in 8c and 9a: Iberian Sardine Landings (tonnes) by subdivision for the period 1940-2020.

Year	Subdivision					
	8c	9a North	9a Central North	9a Central South	9a South Algarve	9a South 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	
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 (cont.). Sardine in 8c and 9a: Iberian Sardine Landings (tonnes) by subdivision for the period 1940-2020.

Year	Subdivision					
	8c	9aNorth	9a Central North	9a Central South	9a South Algarve	9a South 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
2020	2822	1950	5049	7560	2807	1955

Table 8.2.4.1: Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (t) by ICES subdivision in 2020.

Length	Subdivision							Total
	8c E	8c W	9a N	9a CN	9a CS	9a S Algarve	9a S Cadiz	
6.5			NA					
7			NA					
7.5			NA					
8			NA					
8.5			NA					
9			NA					
9.5			NA					
10			NA					
10.5			NA					
11			NA	170				170
11.5			NA	245				245
12	3		NA	716				719
12.5	32		NA	245			356	633
13	144		NA	94			1 572	1 810
13.5	398		NA	64			3 823	4 285
14	485		NA	1 356		224	2 720	4 785
14.5	884		NA	4 854		76	2 116	7 931
15	885		NA	17 831		287	1 408	20 411
15.5	814		NA	21 959	132	1 357	1 847	26 109
16	838	2	NA	25 365	1 194	2 853	2 166	32 418
16.5	1 484	5	NA	17 935	3 023	5 114	1 732	29 293
17	2 418	12	NA	17 847	7 113	11 513	1 588	40 491
17.5	3 138	18	NA	12 790	9 594	14 326	1 115	40 981
18	2 161	11	NA	4 827	10 902	12 250	911	31 061
18.5	1 383	14	NA	2 510	11 970	5 398	649	21 924
19	700	6	NA	721	12 810	2 220	187	16 645
19.5	390	2	NA	674	15 537	243		16 846
20	264	3	NA	189	16 195	23		16 674
20.5	221		NA	158	9 268	79		9 725
21	147		NA	56	7 078	311		7 592
21.5	80		NA	1	2 491			2 572
22	17		NA		1 870			1 886
22.5	14		NA	15	705			734
23	23		NA		554			576
23.5			NA		189			189
24			NA		41			41
24.5			NA		44			44
25			NA					
25.5			NA					
26			NA					
26.5			NA					
Total	16 923	73		130 623	110 709	56 274	22 189	336 792
Mean L	17.3	18.1	NA	16.4	19.4	17.7	15.4	17.6
sd	1.66	0.93	NA	1.14	1.41	0.88	1.63	1.86
Catch	896	1925	1950	5049	7560	2807	1955	22143

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 2020.

First Quarter								
Length	**8c E**	**8c W**	**9a N**	**9a CN**	**9a CS**	**9a S**	**9a S (Ca)**	**Total**
6.5		NA	NA				NA	
7		NA	NA				NA	
7.5		NA	NA				NA	
8		NA	NA				NA	
8.5		NA	NA				NA	
9		NA	NA				NA	
9.5		NA	NA				NA	
10		NA	NA				NA	
10.5		NA	NA				NA	
11		NA	NA				NA	
11.5		NA	NA				NA	
12	3	NA	NA				NA	3
12.5	32	NA	NA				NA	32
13	144	NA	NA				NA	144
13.5	398	NA	NA				NA	398
14	483	NA	NA				NA	483
14.5	881	NA	NA				NA	881
15	885	NA	NA				NA	885
15.5	764	NA	NA				NA	764
16	445	NA	NA				NA	445
16.5	256	NA	NA				NA	256
17	142	NA	NA				NA	142
17.5	114	NA	NA				NA	114
18	83	NA	NA				NA	83
18.5	91	NA	NA				NA	91
19	40	NA	NA				NA	40
19.5	43	NA	NA				NA	43
20	19	NA	NA				NA	19
20.5	8	NA	NA				NA	8
21	7	NA	NA				NA	7
21.5	1	NA	NA				NA	1
22		NA	NA				NA	
22.5		NA	NA				NA	
23		NA	NA				NA	
23.5		NA	NA				NA	
24		NA	NA				NA	
24.5		NA	NA				NA	
25		NA	NA				NA	
25.5		NA	NA				NA	
26		NA	NA				NA	
26.5		NA	NA				NA	
Total	4 842	NA	NA					4 842
Mean L	15.5	NA	NA					15.5
sd	1.37	NA	NA					1.37
Catch	134	. 5	9				23	144

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 2020.

Second Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
7		NA	NA				NA	
7.5		NA	NA				NA	
8		NA	NA				NA	
8.5		NA	NA				NA	
9		NA	NA				NA	
9.5		NA	NA				NA	
10		NA	NA				NA	
10.5		NA	NA				NA	
11		NA	NA				NA	
11.5		NA	NA				NA	
12		NA	NA				NA	
12.5		NA	NA				NA	
13		NA	NA				NA	
13.5		NA	NA				NA	
14		NA	NA	1 038			NA	1 038
14.5		NA	NA	3 047		29	NA	3 076
15		NA	NA	8 821		116	NA	8 937
15.5	41	NA	NA	8 395	132	202	NA	8 770
16	308	NA	NA	8 733	1 103	404	NA	10 548
16.5	1 027	NA	NA	2 783	2 468	173	NA	6 451
17	1 941	NA	NA	1 122	4 628	1 415	NA	9 106
17.5	2 622	NA	NA		4 023	3 611	NA	10 256
18	1 702	NA	NA		2 079	4 853	NA	8 634
18.5	881	NA	NA		1 132	1 906	NA	3 919
19	314	NA	NA		2 424	1 040	NA	3 778
19.5	107	NA	NA		4 504		NA	4 611
20	130	NA	NA		4 933		NA	5 063
20.5	141	NA	NA		3 013		NA	3 154
21	96	NA	NA		2 116	87	NA	2 299
21.5	57	NA	NA		618		NA	675
22	11	NA	NA		682		NA	693
22.5	11	NA	NA		324		NA	335
23	23	NA	NA		167		NA	189
23.5		NA	NA		73		NA	73
24		NA	NA		41		NA	41
24.5		NA	NA		44		NA	44
25		NA	NA				NA	
25.5		NA	NA				NA	
26		NA	NA				NA	
26.5		NA	NA				NA	
Total	9 412	NA	NA	33 940	34 503	13 836	NA	91 691
Mean L	17.9	NA	NA	15.7	19.1	18.	NA	17.6
sd	1.03	NA	NA	0.67	1.68	0.79	NA	1.89
Catch	447	1 361	1 172	1 170	2 197	723	224	7 295

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 2020.

Third Quarter								
Length	**8c E**	**8c W**	**9a N**	**9a CN**	**9a CS**	**9a S**	**9a S-C**	**Total**
6.5	NA	NA	NA				NA	
7	NA	NA	NA				NA	
7.5	NA	NA	NA				NA	
8	NA	NA	NA				NA	
8.5	NA	NA	NA				NA	
9	NA	NA	NA				NA	
9.5	NA	NA	NA				NA	
10	NA	NA	NA				NA	
10.5	NA	NA	NA				NA	
11	NA	NA	NA	170			NA	170
11.5	NA	NA	NA	245			NA	245
12	NA	NA	NA	716			NA	716
12.5	NA	NA	NA	245			NA	245
13	NA	NA	NA	94			NA	94
13.5	NA	NA	NA	64			NA	64
14	NA	NA	NA	232		224	NA	456
14.5	NA	NA	NA	1 678		47	NA	1 725
15	NA	NA	NA	7 523		94	NA	7 617
15.5	NA	NA	NA	12 104		826	NA	12 930
16	NA	NA	NA	14 594	91	2 004	NA	16 689
16.5	NA	NA	NA	14 627	555	4 593	NA	19 775
17	NA	NA	NA	16 433	2 458	9 730	NA	28 622
17.5	NA	NA	NA	12 687	5 527	10 387	NA	28 601
18	NA	NA	NA	4 827	8 635	7 281	NA	20 743
18.5	NA	NA	NA	2 510	10 734	3 395	NA	16 639
19	NA	NA	NA	721	10 044	1 122	NA	11 887
19.5	NA	NA	NA	674	10 378	243	NA	11 295
20	NA	NA	NA	189	10 370	23	NA	10 583
20.5	NA	NA	NA	158	5 412	79	NA	5 649
21	NA	NA	NA	56	4 532	224	NA	4 812
21.5	NA	NA	NA	1	1 702		NA	1 703
22	NA	NA	NA		1 138		NA	1 138
22.5	NA	NA	NA	15	353		NA	369
23	NA	NA	NA		337		NA	337
23.5	NA	NA	NA		116		NA	116
24	NA	NA	NA				NA	
24.5	NA	NA	NA				NA	
25	NA	NA	NA				NA	
25.5	NA	NA	NA				NA	
26	NA	NA	NA				NA	
26.5	NA	NA	NA				NA	
Total	NA	NA	NA	90 564	72 383	40 272	NA	203 218
Mean L	NA	NA	NA	16.7	19.5	17.6	NA	17.9
sd	NA	NA	NA	1.18	1.24	0.87	NA	1.68
Catch	152	508	671	3 657	5 071	1 977	946	12 982

Table 8.2.4.1d: Sardine in 8c and 9a: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2020.

Fourth Quarter								
Length	**8c E**	**8c W**	**9a N**	**9a CN**	**9a CS**	**9a S**	**9a S-C**	**Total**
6.5			NA					
7			NA					
7.5			NA					
8			NA					
8.5			NA					
9			NA					
9.5			NA					
10			NA					
10.5			NA					
11			NA					
11.5			NA					
12			NA					
12.5			NA				356	356
13			NA				1 572	1 572
13.5			NA				3 823	3 823
14	2		NA	86			2 720	2 808
14.5	3		NA	129			2 116	2 249
15			NA	1 487		77	1 408	2 972
15.5	9		NA	1 460		329	1 847	3 645
16	85	2	NA	2 037		445	2 166	4 735
16.5	200	5	NA	524		348	1 732	2 810
17	336	12	NA	292	27	368	1 588	2 622
17.5	401	18	NA	103	44	329	1 115	2 010
18	377	11	NA		188	116	911	1 602
18.5	412	14	NA		104	97	649	1 275
19	346	6	NA		342	58	187	939
19.5	239	2	NA		655			896
20	115	3	NA		892			1 010
20.5	72		NA		843			915
21	44		NA		429			474
21.5	22		NA		171			193
22	5		NA		50			55
22.5	2		NA		27			29
23			NA		50			50
23.5			NA					
24			NA					
24.5			NA					
25			NA					
25.5			NA					
26			NA					
Total	2 669	73*	NA	6 120	3 823	2 167	22 189	37 040
Mean L	18.4	18.1	NA	15.9	20.3	16.9	15.4	16.3
sd	1.22	.93	NA	.65	1.	.96	1.63	2.09
Catch	164	56	98	221	291	107	762	1 699

*** In 8cW, individuals correspond to 4.2 tonnes sampled**

Table 8.2.4.2: Sardine in 8c and 9a: Catch in numbers (thousands) at age by quarter and by subdivision in 2020.

							First Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0							3	
1	3 601	12	265				32	3 910
2	1 033	4	9				242	1 288
3	154	1					127	282
4	22						31	53
5	25							25
6	4							4
7	3							3
8								
9								
10								
11								
12								
Total	4 842	17	274				435	5 565
Catch (Tons)	134	. 5	9				23	167

							Second Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0						81	25	106
1	3 601	10 973	32 847	32 818	8 765	1 003	311	90 318
2	3 391	10 333	1 123	1 122	9 116	7 714	2 395	35 194
3	1 902	5 795			2 969	4 042	1 255	15 964
4	167	509			10 300	996	309	12 281
5	214	652			2 045			2 911
6	70	215			389			675
7	54	165			386			606
8	11	35			455			501
9					79			79
10								
11								
12								
Total	9 412	28 678	33 970	33 940	34 503	13 836	4 295	158 634
Catch (Tons)	447	1 361	1 172	1 170	2 197	723	224	4 928

							Third Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0	3	9	313	1 707	2 622	6 747	15 890	27 290
1	949	3 179	15 933	86 939	21 704	21 485	8 180	158 369
2	837	2 804	312	1 703	22 981	10 031	3 133	41 801
3	713	2 388	14	75	13 527	1 568	337	18 622
4	92	307	15	81	5 706	441	29	6 669
5	34	115	6	33	2 216			2 404
6	4	15	5	27	1 915			1 967
7					1 005			1 005
8					518			518
9					189			189
10								
11								
12								
Total	2 632	8 816	16 597	90 564	72 383	40 272	27 569	258 833
Catch (Tons)	152	508	671	3 657	5 071	1 977	946	12 982

							Fourth Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0	3	1	29	65	204	866	12 789	13 957
1	913	316	2 689	6 055	573	875	6 584	18 005
2	848	293			966	416	2 522	5 044
3	761	261			753		271	2 046
4	101	34			854	10	23	1 022
5	38	13			300			350
6	5	2						7
7					173			173
8								
9								
10								
11								
12								
Total	2 669	919	2 718	6 120	3 823	2 167	22 189	40 604
Catch (Tons)	164	56	98	221	291	107	762	1 699

							Whole Year	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-C**	**Total**
0	6	10	342	1 772	2 826	7 693	28 707	41 356
1	9 064	14 480	51 734	125 811	31 043	23 363	15 107	270 602
2	6 109	13 433	1 444	2 825	33 062	18 162	8 293	83 327
3	3 531	8 445	14	75	17 249	5 610	1 990	36 914
4	382	850	15	81	16 860	1 446	392	20 026
5	311	780	6	33	4 560			5 690
6	84	232	5	27	2 304			2 652
7	57	165			1 564			1 786
8	11	35			973			1 019
9					268			268
10								
11								
12								
Total	19 555	38 430	53 559	130 623	110 709	56 274	54 488	463 639
Catch (Tons)	896	1 925	1 950	5 049	7 560	2 807	1 955	22 143

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

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	869437	2296650	946698	295360	136661	41744	16468
1979	674489	1535560	956132	431466	189107	93185	36038
1980	856671	2037400	1561970	378785	156922	47302	30006
1981	1025960	1934840	1733730	679001	195304	104545	76466
1982	62000	795000	1869000	709000	353000	131000	129000
1983	1070000	577000	857000	803000	324000	141000	139000
1984	118000	3312000	487000	502000	301000	179000	117000
1985	268000	564000	2371000	469000	294000	201000	103000
1986	304000	755000	1027000	919000	333000	196000	167000
1987	1437000	543000	667000	569000	535000	154000	171000
1988	521000	990000	535000	439000	304000	292000	189000
1989	248000	566000	909000	389000	221000	2.00E+05	245000
1990	258000	602000	517000	707000	295000	151000	248000
1991	1580580	477368	436081	406886	265762	74726	105186
1992	498265	1001860	451367	340313	186234	110932	80579
1993	87808	566221	1081820	521458	257209	113871	120282
1994	120797	60194	542163	1094440	272466	112635	72091
1995	30512	189147	280715	829707	472880	70208	64485
1996	277053	101267	347690	514741	652711	197235	46607
1997	208570	548594	453324	391118	337282	225170	70268
1998	449115	366176	501585	352485	233672	178735	105884
1999	246016	475225	361509	339691	177170	105518	72541
2000	489836	354822	313972	255523	194156	97693	64373
2001	219973	1172300	256133	195897	126389	75145	49547
2002	106882	587354	753897	181381	112166	55650	40219
2003	198412	318695	446285	518289	114035	61276	51172
2004	589910	180522	263521	386715	377848	78396	55312
2005	169229	1005530	266213	206657	191013	116628	46087
2006	18347	250200	777315	128695	108244	121043	81149
2007	199364	82084	313453	535706	80348	82713	120821
2008	298405	219205	182636	370253	411611	65397	108832
2009	378304	353839	195618	125324	251973	197185	83887
2010	278311	516544	263334	136037	82831	129434	182722
2011	341535	452259	383353	122136	87976	40949	110734
2012	220164	193884	168105	122976	94143	48700	52645
2013	280544	232934	155842	87924	48492	26591	27635
2014	63949	189093	109802	54550	35237	19462	21688
2015	68371	98936	84313	47069	20960	13656	11242
2016	172202	215051	58288	40726	15422	9815	8424
2017	35329	198627	126003	39727	15971	8393	10853
2018	37222	49140	88410	33715	19257	9003	9140
2019		85035	49870	40297	13422	4307	3429
2020	41356	270602	83327	36914	20026	5690	5725

Table 8.2.4.4: Sardine 8c and 9a: Relative distribution of sardine catches. Upper panel relative contribution of each age 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%	0%	1%	1%	3%	14%	53%	9%
1	46%	38%	97%	96%	28%	42%	28%	58%
2	31%	35%	3%	2%	30%	32%	15%	18%
3	18%	22%	0%	0%	16%	10%	4%	8%
4	2%	2%	0%	0%	15%	3%	1%	4%
5	2%	2%	0%	0%	4%	0%	0%	1%
6+	1%	1%	0%	0%	5%	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%	0%	1%	4%	7%	19%	69%	100%
1	3%	5%	19%	46%	11%	9%	6%	100%
2	7%	16%	2%	3%	40%	22%	10%	100%
3	10%	23%	0%	0%	47%	15%	5%	100%
4	2%	4%	0%	0%	84%	7%	2%	100%
5	5%	14%	0%	1%	80%	0%	0%	100%
6+	3%	8%	0%	0%	89%	0%	0%	100%

Table 8.2.5.1: Sardine 8c and 9a: Sardine Mean length (cm) at age by quarter and by subdivision in 2020.

	First Quarter						
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							15.3
1	15.0	15.0	15.7				17.0
2	16.3	16.3	17.3				18.0
3	18.7	18.7					18.3
4	19.7	19.7					18.6
5	20.3	20.3					
6	21.0	21.0					
7	20.9	20.9					
8	22.8	22.8					
9							
10							
11							
12							

	Second Quarter						
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							15.3
1	17.5	17.5	15.7				17.0
2	17.6	17.6	17.3				18.0
3	18.4	18.4					18.3
4	19.7	19.7					18.6
5	20.7	20.7					
6	21.5	21.5					
7	21.4	21.4					
8	22.9	22.9					
9							
10							
11							
12							

	Third Quarter						
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	14.4	14.4	12.5				14.4
1	17.4	17.4	16.7				16.4
2	18.5	18.5	19.3				17.6
3	19.2	19.2	20.8				17.9
4	19.7	19.7	20.9				18.2
5	20.6	20.6	21.0				
6	19.8	19.8	22.1				
7							
8							
9							
10							
11							
12							

	Fourth Quarter						
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	14.4	14.4	14.3				14.4
1	17.4	17.4	16.0				16.4
2	18.6	18.6					17.6
3	19.2	19.2					17.9
4	19.7	19.7					18.2
5	20.6	20.6					
6	19.8	19.8					
7							
8							
9							
10							
11							
12							

	Whole Year						
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	14.4	14.4	12.6				14.4
1	16.5	17.5	16.0				16.4
2	17.6	17.8	17.7				17.7
3	18.8	18.7	20.8				18.2
4	19.7	19.7	20.9				18.5
5	20.7	20.7	21.0				
6	21.2	21.3	22.1				
7	21.4	21.4					
8	22.9	22.9					
9							
10							
11							
12							

Table 8.2.5.2: Sardine 8c and 9a: Sardine Mean weight (kg) at age by quarter and by subdivision in 2020.

						First Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0							0.0
1	0.025	0.025	0.034				0.046
2	0.033	0.033	0.046				0.052
3	0.052	0.052					0.054
4	0.063	0.063					0.056
5	0.069	0.069					
6	0.077	0.077					
7	0.076	0.076					
8	0.103	0.103					
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	0.044	0.044	0.034				0.046
2	0.044	0.044	0.046				0.052
3	0.052	0.052					0.054
4	0.066	0.066					0.056
5	0.078	0.078					
6	0.089	0.089					
7	0.088	0.088					
8	0.110	0.110					
9							
10							
11							
12							

						Third Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	0.026	0.026	0.018				0.027
1	0.048	0.048	0.040				0.041
2	0.059	0.059	0.060				0.052
3	0.066	0.066	0.074				0.055
4	0.071	0.071	0.074				0.058
5	0.083	0.083	0.076				
6	0.071	0.071	0.087				
7							
8							
9							
10							
11							
12							

						Fourth Quarter	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	0.026	0.026	0.026				0.027
1	0.050	0.050	0.036				0.041
2	0.062	0.062					0.052
3	0.070	0.070					0.055
4	0.076	0.076					0.058
5	0.088	0.088					
6	0.076	0.076					
7							
8							
9							
10							
11							
12							

						Whole Year	
Age	**8c-E**	**8c-W**	**9a-N**	**9a-CN**	**9a-CS**	**9a-S**	**9a-S-C**
0	0.026	0.026	0.018				0.027
1	0.037	0.045	0.036				0.041
2	0.047	0.048	0.049				0.052
3	0.059	0.057	0.074				0.054
4	0.070	0.068	0.074				0.056
5	0.079	0.079	0.076				
6	0.087	0.088	0.087				
7	0.087	0.088					
8	0.110	0.110					
9							
10							
11							
12							

Table 8.3.1. DEPM parameters derived from 2020 sardine DEPM surveys with their CV (%) in brackets by institution and stratum (in 2020, only 9a South and 9a West estimates were based on the survey; cf. note below). Surveyed and positive areas (km2), Mortality Z (hour-1), Daily egg production P0 (eggs/m2/day), Total egg production P0 tot (eggs/day) (x1012), Females mean weight (g), Batch fecundity (number of eggs spawned per mature females per batch), Sex ratio (fraction of population that are mature females by weight), Spawning fraction (fraction of mature females spawning).

Institute	IPMA	IPMA	TOTAL	Total (Iberian Península) (*)
Area	9a South	9a West	(9a S + 9a W)	
Survey area (Km2)	18689	29560	48249	
Positive area (Km2)	7844	9127	16971	
Z (hour-1)(CV%)	-0.030 (7.0)	-0.023(5.7)		
P0 (eggs/m2/day)(CV%)	450.85 (23.7)	243.95 (20.4)		
P0 tot (eggs/day) (x1012) (CV%)	3.54 (23.7)	2.23 (20.4)	5.77 (17)	
Female Weight (g) (CV%)	38.80 (14.7)	45.40 (16.2)		
Batch Fecundity (CV%)	14176 (15.3)	16637 (17.0)		
Sex Ratio (CV%)	0.568 (8.3)	0.587 (7.3)		
Spawning Fraction (CV%)	0.050 (22.0)	0.072 (23.8)		
Daily Fecundity (eggs/day.g female)	10.38	15.49		
Spawning Biomass (tons) (CV%)	341164 (39.4)	143984 (39.8)	485148 (30.2)	630692 (*)

(*) Eggs and adult parameters for the ICES subdivision 9a North and division 8c 9a are not available in 2020 due to the cancelation of SAREVA 0320 DEPM survey because of the COVID-19 pandemic. The total Iberian Peninsula SSB was estimated raising the Portuguese SSB index (9a South and 9a West).

Table 8.3.2.1. Sardine in 8c and 9a: sardine abundance in number (millions of fish) and biomass (tons) by age groups and ICES subdivision in PELAGO2021. 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)	0	15066	157819	9286	1394	3121	1187	142	0	0	0	188016
%Biomass	0	8	84	5	1	2	1	0	0	0	0	100
Abundance (N in 10^3)	0	545162	4518507	228170	20101	43196	14285	1840	0	0	0	5371261
%Abundance	0.0	10.1	84.1	4.2	0.4	0.8	0.3	0.0	0.0	0.0	0.0	100
Mean Weight (gr)	NA	22.6	40.5	57.7	70.5	73.5	85.4	78.0	NA	NA	NA	
Mean Length (cm)	NA	14.6	17.7	19.8	21.3	21.6	22.7	22.0	NA	NA	NA	
AREA 9aCS												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	0	13873	16099	20600	15145	30118	8467	6704	2122	542	0	113670
%Biomass	0.0	12.2	14.2	18.1	13.3	26.5	7.4	5.9	1.9	0.5	0.0	100
Abundance (N in 10^3)	0	423611	461262	378026	249167	458021	117161	81218	24841	6676	0	2199982
%Abundance	0.0	19.3	21.0	17.2	11.3	20.8	5.3	3.7	1.1	0.3	0.0	100
Mean Weight (gr)	NA	29.6	36.4	53.0	60.1	68.7	76.5	84.9	86.0	83.8	NA	
Mean Length (cm)	NA	15.7	16.9	19.2	20.0	21.0	22.1	22.9	23.2	23.4	NA	
AREA 9aS-ALG												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	0	19196	15006	20951	14059	12943	1032	428	0	47	0	83662
%Biomass	0.0	22.9	17.9	25.0	16.8	15.5	1.2	0.5	0.0	0.1	0.0	100
Abundance (N in 10^3)	0	730601	421458	437869	266074	230794	15565	5726	0	641	0	2108728
%Abundance	0.0	34.6	20.0	20.8	12.6	10.9	0.7	0.3	0.0	0.03	0.0	100
Mean Weight (gr)	NA	25.0	35.1	49.3	58.5	62.4	66.8	76.2	NA	67.0	NA	
Mean Length (cm)	NA	15.0	16.8	18.8	19.9	20.5	21.4	21.9	NA	21.6	NA	
AREA 9aS-CAD												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	0	22887	4651	2571	775	284	0	0	0	0	0	31167
%Biomass	0.0	73.4	14.9	8.2	2.5	0.9	0.0	0.0	0.0	0.0	0.0	100
Abundance (N in 10^3)	0	1016779	129702	54149	15354	5224	0	0	0	0	0	1221208
%Abundance	0.0	83.3	10.6	4.4	1.3	0.4	0.0	0.0	0.0	0.0	0.0	100
Mean Weight (gr)	NA	21.1	37.8	48.5	54.2	59.9	NA	NA	NA	NA	NA	
Mean Length (cm)	NA	14.2	17.4	18.8	19.4	20.1	NA	NA	NA	NA	NA	
TOTAL PELAGO21												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	0	71022	193575	53408	31373	46466	10686	7275	2122	589	0	416515
%Biomass	0.0	17.1	46.5	12.8	7.5	11.2	2.6	1.7	0.5	0.1	0.0	100
Abundance (N in 10^3)	0	2716152	5530929	1098213	550696	737235	147012	88784	24841	7317	0	10901179
%Abundance	0.0	24.9	50.7	10.1	5.1	6.8	1.3	0.8	0.2	0.1	0.0	100
Mean Weight (gr)	23.4	38.4	51.7	60.5	67.2	77.9	83.3	86.0	80.4	96.0		
Mean Length (cm)	14.7	17.4	19.1	20.1	20.9	22.2	22.7	23.2	23.0	24.1		

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 PELACUS0321. MW (mean weight) in grams and ML (mean length) in cm.

AREA 8cE									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (ton)	11908	15455	2541	4862	4884	2355	917		42922
%Biomass	28	36	6	11	11	5	2		100
Abundance (N in 10^3)	729447	325235	41250	59017	55070	23967	9965		1243951
%Abundance	58.6	26.1	3.3	4.7	4.4	1.9	0.8		100
Mean Weight (gr)	13.9	45.2	58.1	78.9	85.1	94.7	88.7		
Mean Length (cm)	12.5	18.2	19.7	21.7	22.2	23.0	22.5		
AREA 8cW									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (ton)	91	5147	1139	1374	1134	284	183		9352
%Biomass	1.0	55.0	12.2	14.7	12.1	3.0	2.0		100
Abundance (N in 10^3)	2634	99719	17987	17664	13950	3017	2099		157069.5
%Abundance	1.7	63.5	11.5	11.2	8.9	1.9	1.3		100
Mean Weight (gr)	32.2	49.2	60.1	74.5	78.0	90.8	84.0		
Mean Length (cm)	16.3	18.7	19.9	21.3	21.6	22.7	22.1		
AREA 9aN									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (ton)	3348	185986	35041	21438	44729	3355		939	294836
%Biomass	1.1	63.1	11.9	7.3	15.2	1.1		0.3	100
Abundance (N in 10^3)	95208	3770177	632882	264337	531290	37984		7349	5339226
%Abundance	1.8	70.6	11.9	5.0	10.0	0.7		0.1	100
Mean Weight (gr)	34.7	49.0	54.6	80.4	83.8	88.3		127.7	
Mean Length (cm)	16.7	18.6	19.3	21.8	22.1	22.5		25.3	
TOTAL PELACUS21									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (ton)	15347	206587	38721	27675	50747	5995	1100	939	347110
%Biomass	4.4	59.5	11.2	8.0	14.6	1.7	0.3	0.3	100
Abundance (N in 10^3)	827288	4195131	692119	341018	600310	64968	12064	7349	6740246
%Abundance	12.3	62.2	10.3	5.1	8.9	1.0	0.2	0.1	100
Mean Weight (gr)	15.6	46.9	52.9	77.6	81.1	88.9	87.8	123.8	
Mean Length (cm)	13.0	18.4	19.1	21.6	21.9	22.5	22.4	25.0	

Table 8.3.3. Sardine in 8c and 9a: sardine abundance in biomass and number by age groups and ICES subdivision in IBERAS 2021. Mean weight in grams and mean length in cm.

	AGE 0	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10
9aN											
Biomass (mt)	290	6716	47704	16364	22060	11529		1876			106540
%	0.27	6.30	44.78	15.36	20.71	10.82		1.76			
No Fish (thousands)	10290	131681	873167	202047	277766	128540		18319			1641809
%	0.63	8.02	53.18	12.31	16.92	7.83		1.12			
M. weight	26.54	48.37	51.99	76.83	75.59	85.51		98.68			31.70
M. length	14.72	17.69	18.08	20.38	20.28	21.06		22.00			18.96
9aCN											
Biomass (mt)	17237	5391	127455	584	2378	3127		0			156172
%	11.04	3.45	81.61	0.37	1.52	2.00					
No Fish (thousands)	656732	115881	2357958	13111	29288	40087		0			3213056
%	20.44	3.61	73.39	0.41	0.91	1.25					
M. weight	26.05	45.02	53.70	44.57	80.83	77.62					48.25
M. length	14.64	17.30	18.26	17.25	20.70	20.44					17.53
9aCS											
Biomass (mt)	5986	8034	2520	881	1298	1811	529	2647	560	675	24941
%	24.00	32.21	10.10	3.53	5.21	7.26	2.12	10.61	2.24	2.71	
No Fish (thousands)	278732	253840	50581	14952	19595	23818	5546	23341	5795	6213	682413
%	40.85	37.20	7.41	2.19	2.87	3.49	0.81	3.42	0.85	0.91	
M. weight	19.62	29.56	46.88	55.85	62.43	72.04	91.57	108.95	92.98	104.73	20.00
M. length	13.42	15.21	17.52	18.48	19.12	19.98	21.50	22.68	21.60	22.40	15.43

Table 8.4.1a. Sardine in 8c and 9a: Mean weights-at-age (kg) in the catch. Weights-at-age in 1978-1990 are fixed.

Year	Age						
	0	1	2	3	4	5	6+
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	0.050	0.059	0.074	0.084	0.094	0.097
2020	0.031	0.042	0.057	0.065	0.075	0.084	0.095

Table 8.4.1b. Sardine in 8c and 9a: Mean weights-at-age (Kg) in the stock. Weights-at-age in 1978-1998 are fixed (see Stock Annex).

Year	Age						
	0	1	2	3	4	5	6+
1978	0	0.027	0.041	0.050	0.059	0.060	0.063
1979	0	0.027	0.041	0.050	0.059	0.060	0.063
1980	0	0.027	0.041	0.050	0.059	0.060	0.063
1981	0	0.027	0.041	0.050	0.059	0.060	0.063
1982	0	0.027	0.041	0.050	0.059	0.060	0.063
1983	0	0.027	0.041	0.050	0.059	0.060	0.063
1984	0	0.027	0.041	0.050	0.059	0.060	0.063
1985	0	0.027	0.041	0.050	0.059	0.060	0.063
1986	0	0.027	0.041	0.050	0.059	0.060	0.063
1987	0	0.027	0.041	0.050	0.059	0.060	0.063
1988	0	0.027	0.041	0.050	0.059	0.060	0.063
1989	0	0.027	0.041	0.050	0.059	0.060	0.063
1990	0	0.027	0.041	0.050	0.059	0.060	0.063
1991	0	0.027	0.041	0.050	0.059	0.060	0.063
1992	0	0.027	0.041	0.050	0.059	0.060	0.063
1993	0	0.027	0.041	0.050	0.059	0.060	0.063
1994	0	0.027	0.041	0.050	0.059	0.060	0.063
1995	0	0.027	0.041	0.050	0.059	0.060	0.063
1996	0	0.027	0.041	0.050	0.059	0.060	0.063
1997	0	0.027	0.041	0.050	0.059	0.060	0.063
1998	0	0.027	0.041	0.050	0.059	0.060	0.063
1999	0	0.030	0.043	0.050	0.054	0.059	0.062
2000	0	0.027	0.041	0.050	0.059	0.060	0.063
2001	0	0.024	0.039	0.051	0.064	0.061	0.064
2002	0	0.022	0.037	0.052	0.069	0.062	0.066
2003	0	0.021	0.041	0.054	0.068	0.065	0.072
2004	0	0.020	0.045	0.056	0.067	0.068	0.079
2005	0	0.019	0.049	0.058	0.066	0.072	0.086
2006	0	0.024	0.052	0.060	0.067	0.072	0.084
2007	0	0.029	0.054	0.062	0.069	0.072	0.081
2008	0	0.033	0.057	0.064	0.070	0.072	0.079
2009	0	0.030	0.054	0.063	0.070	0.069	0.075
2010	0	0.027	0.051	0.062	0.070	0.067	0.072
2011	0	0.024	0.048	0.061	0.070	0.064	0.068
2012	0	0.027	0.048	0.062	0.068	0.068	0.073
2013	0	0.030	0.049	0.063	0.067	0.073	0.077
2014	0	0.032	0.049	0.065	0.066	0.077	0.081
2015	0	0.030	0.048	0.063	0.066	0.073	0.077
2016	0	0.029	0.046	0.062	0.065	0.070	0.072
2017	0	0.027	0.045	0.060	0.065	0.066	0.068
2018	0	0.027	0.044	0.056	0.063	0.066	0.071
2019	0	0.027	0.043	0.053	0.060	0.067	0.074
2020	0	0.027	0.042	0.050	0.058	0.068	0.078

Table 8.4.1.1. Parameters and asymptotic standard deviations estimated in the 2021 assessment model.

Label	Value	Parm_StDev	Phase	Min	Max	Init
SR_LN(R0)	16.806	0.035	1	1	20	16.00
Early_InitAge_4	0.092	0.539	2	-5	5	0.00
Early_InitAge_3	0.159	0.444	2	-5	5	0.00
Early_InitAge_2	0.361	0.288	2	-5	5	0.00
Early_InitAge_1	0.821	0.197	2	-5	5	0.00
Main_RecrDev_1978	0.986	0.163	2	-5	5	0.00
Main_RecrDev_1979	1.099	0.157	2	-5	5	0.00
Main_RecrDev_1980	1.198	0.147	2	-5	5	0.00
Main_RecrDev_1981	0.679	0.173	2	-5	5	0.00
Main_RecrDev_1982	0.017	0.239	2	-5	5	0.00
Main_RecrDev_1983	1.548	0.111	2	-5	5	0.00
Main_RecrDev_1984	0.276	0.186	2	-5	5	0.00
Main_RecrDev_1985	0.147	0.180	2	-5	5	0.00
Main_RecrDev_1986	0.000	0.192	2	-5	5	0.00
Main_RecrDev_1987	0.832	0.126	2	-5	5	0.00
Main_RecrDev_1988	0.215	0.160	2	-5	5	0.00
Main_RecrDev_1989	0.184	0.158	2	-5	5	0.00
Main_RecrDev_1990	0.247	0.155	2	-5	5	0.00
Main_RecrDev_1991	1.347	0.089	2	-5	5	0.00
Main_RecrDev_1992	0.900	0.101	2	-5	5	0.00
Main_RecrDev_1993	0.052	0.143	2	-5	5	0.00
Main_RecrDev_1994	-0.073	0.136	2	-5	5	0.00
Main_RecrDev_1995	-0.297	0.137	2	-5	5	0.00
Main_RecrDev_1996	0.084	0.111	2	-5	5	0.00
Main_RecrDev_1997	-0.345	0.132	2	-5	5	0.00
Main_RecrDev_1998	-0.016	0.115	2	-5	5	0.00
Main_RecrDev_1999	-0.283	0.134	2	-5	5	0.00
Main_RecrDev_2000	0.904	0.088	2	-5	5	0.00
Main_RecrDev_2001	0.323	0.110	2	-5	5	0.00
Main_RecrDev_2002	-0.238	0.144	2	-5	5	0.00
Main_RecrDev_2003	-0.459	0.159	2	-5	5	0.00
Main_RecrDev_2004	0.995	0.078	2	-5	5	0.00
Main_RecrDev_2005	-0.066	0.111	2	-5	5	0.00
Main_RecrDev_2006	-1.277	0.170	2	-5	5	0.00
Main_RecrDev_2007	-0.882	0.134	2	-5	5	0.00
Main_RecrDev_2008	-0.590	0.113	2	-5	5	0.00
Main_RecrDev_2009	-0.407	0.101	2	-5	5	0.00
Main_RecrDev_2010	-0.925	0.124	2	-5	5	0.00
Main_RecrDev_2011	-1.025	0.129	2	-5	5	0.00
Main_RecrDev_2012	-0.831	0.117	2	-5	5	0.00
Main_RecrDev_2013	-0.698	0.113	2	-5	5	0.00
Main_RecrDev_2014	-1.004	0.135	2	-5	5	0.00
Main_RecrDev_2015	-0.381	0.115	2	-5	5	0.00
Main_RecrDev_2016	-0.217	0.125	2	-5	5	0.00
Main_RecrDev_2017	-1.142	0.167	2	-5	5	0.00
Main_RecrDev_2018	-0.355	0.148	2	-5	5	0.00
Main_RecrDev_2019	0.660	0.144	2	-5	5	0.00

Label	Value	Parm_StDev	Phase	Min	Max	Init
Main_RecrDev_2020	-0.521	0.249	2	-5	5	0.00
Main_RecrDev_2021	-0.661	0.430	2	-5	5	0.00
InitF_seas_1_flt_1purse_seine	0.422	0.062	1	-1	2	0.30
LnQ_base_Acoustic_survey(2)	0.300	0.089	1	-3	3	0.75
Q_extraSD_Acoustic_survey(2)	0.047	0.052	1	0	1	0.30
LnQ_base_DEPM_survey(3)	0.228	0.126	1	-3	3	0.26
Q_extraSD_DEPM_survey(3)	0.071	0.083	1	0	1	0.30
LnQ_base_Rec_survey(4)	-14.666	6.648	1	-30	3	0.00
Q_power_Rec_survey(4)	0.898	0.436	1	0	3	1.00
Q_extraSD_Rec_survey(4)	0.715	0.184	1	0	3	1.00
AgeSel_P2_purse_seine(1)	1.639	0.153	2	-3	3	0.90
AgeSel_P3_purse_seine(1)	0.743	0.137	2	-4	4	0.40
AgeSel_P4_purse_seine(1)	-0.242	0.169	2	-4	4	0.10
AgeSel_P7_purse_seine(1)	-0.630	0.447	2	-4	4	-0.50
AgeSel_P2_purse_seine(1)_BLK1delta_1988	-0.331	0.183	2	-4	4	0.90
AgeSel_P2_purse_seine(1)_BLK1delta_2006	0.083	0.139	2	-4	4	0.90
AgeSel_P3_purse_seine(1)_BLK1delta_1988	-0.005	0.167	2	-4	4	0.40
AgeSel_P3_purse_seine(1)_BLK1delta_2006	-0.214	0.135	2	-4	4	0.40
AgeSel_P4_purse_seine(1)_BLK1delta_1988	0.886	0.191	2	-4	4	0.10
AgeSel_P4_purse_seine(1)_BLK1delta_2006	-0.572	0.139	2	-4	4	0.10
AgeSel_P7_purse_seine(1)_BLK1delta_1988	-0.162	0.475	2	-4	4	-0.50
AgeSel_P7_purse_seine(1)_BLK1delta_2006	0.633	0.376	2	-4	4	-0.50

Table 8.4.1.2. Sardine in 8c and 9a: Fishing mortality-at-age estimated in the assessment. RefF is equal to $F_{bar(2–5)}$, 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	0.031	0.157	0.330	0.259	0.259	0.259	0.138	0.277
1979	0.025	0.130	0.273	0.215	0.215	0.215	0.114	0.229
1980	0.026	0.132	0.278	0.218	0.218	0.218	0.116	0.233
1981	0.025	0.130	0.273	0.215	0.215	0.215	0.114	0.229
1982	0.025	0.129	0.271	0.213	0.213	0.213	0.113	0.227
1983	0.026	0.132	0.277	0.217	0.217	0.217	0.116	0.232
1984	0.026	0.133	0.280	0.220	0.220	0.220	0.117	0.235
1985	0.024	0.124	0.262	0.205	0.205	0.205	0.109	0.219
1986	0.031	0.161	0.338	0.266	0.266	0.266	0.141	0.284
1987	0.036	0.188	0.394	0.309	0.309	0.309	0.165	0.331
1988	0.031	0.115	0.240	0.457	0.457	0.457	0.207	0.403
1989	0.030	0.111	0.232	0.442	0.442	0.442	0.200	0.390
1990	0.033	0.121	0.253	0.481	0.481	0.481	0.218	0.424
1991	0.030	0.111	0.232	0.443	0.443	0.443	0.201	0.390
1992	0.022	0.082	0.171	0.325	0.325	0.325	0.147	0.287
1993	0.021	0.079	0.164	0.313	0.313	0.313	0.142	0.276
1994	0.018	0.066	0.138	0.263	0.263	0.263	0.119	0.232
1995	0.018	0.066	0.138	0.263	0.263	0.263	0.119	0.231
1996	0.024	0.089	0.186	0.355	0.355	0.355	0.161	0.313
1997	0.033	0.120	0.251	0.479	0.479	0.479	0.217	0.422
1998	0.037	0.136	0.285	0.542	0.542	0.542	0.246	0.478
1999	0.034	0.125	0.262	0.498	0.498	0.498	0.226	0.439
2000	0.030	0.112	0.234	0.445	0.445	0.445	0.202	0.393
2001	0.029	0.106	0.222	0.422	0.422	0.422	0.191	0.372
2002	0.024	0.089	0.186	0.353	0.353	0.353	0.160	0.311
2003	0.021	0.079	0.166	0.316	0.316	0.316	0.143	0.278
2004	0.024	0.088	0.184	0.351	0.351	0.351	0.159	0.309
2005	0.024	0.087	0.182	0.348	0.348	0.348	0.157	0.306
2006	0.025	0.101	0.171	0.184	0.184	0.184	0.157	0.181
2007	0.030	0.122	0.206	0.221	0.221	0.221	0.189	0.217
2008	0.048	0.194	0.327	0.352	0.352	0.352	0.300	0.346
2009	0.055	0.221	0.372	0.400	0.400	0.400	0.341	0.393
2010	0.068	0.275	0.464	0.498	0.498	0.498	0.425	0.490
2011	0.083	0.332	0.560	0.602	0.602	0.602	0.514	0.592
2012	0.067	0.268	0.452	0.486	0.486	0.486	0.415	0.478
2013	0.064	0.256	0.433	0.465	0.465	0.465	0.397	0.457
2014	0.041	0.165	0.279	0.300	0.300	0.300	0.256	0.295
2015	0.025	0.102	0.172	0.184	0.184	0.184	0.157	0.181
2016	0.025	0.100	0.169	0.182	0.182	0.182	0.155	0.178
2017	0.021	0.083	0.141	0.151	0.151	0.151	0.129	0.149
2018	0.011	0.045	0.076	0.082	0.082	0.082	0.070	0.081
2019	0.008	0.032	0.053	0.057	0.057	0.057	0.049	0.056
2020	0.010	0.039	0.067	0.072	0.072	0.072	0.061	0.070

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 2021 are also shown.

Year	Age						
	0	1	2	3	4	5	6+
1978	39319700	12539500	3708790	1309170	621151	315363	407647
1979	45303200	14313600	5822900	1666300	677221	334428	429344
1980	51093900	16578700	6829040	2769230	901317	381264	468276
1981	30856000	18689100	7890830	3231430	1492000	505427	518635
1982	15833600	11291600	8916270	3752380	1747800	839915	623320
1983	71641200	5795500	5392980	4249810	2033240	985701	882574
1984	20693800	26208400	2760320	2555550	2292270	1141450	1129750
1985	18011000	7568330	12465400	1304220	1375270	1283930	1375570
1986	15218400	6598260	3631020	5997970	711970	781397	1632220
1987	34025000	5535800	3052150	1618140	3082930	380884	1451130
1988	18484500	12313200	2493580	1286340	796063	1578580	1090640
1989	17675800	6725340	5965090	1226150	546117	351762	1348480
1990	18533100	6437420	3269930	2955520	528142	244829	960666
1991	54912800	6731770	3099410	1587290	1224320	227710	667528
1992	37336800	19998500	3272810	1535430	683495	548711	499732
1993	16246300	13706500	10013700	1724380	743481	344467	592479
1994	14139800	5969030	6884140	5309840	845198	379286	550829
1995	11061300	5212760	3035870	3747490	2736040	453286	560502
1996	15710200	4077980	2651530	1653020	1931870	1468020	607006
1997	10000200	5755660	2026780	1375470	777050	945196	1100780
1998	13322700	3633020	2772950	985176	571253	335891	1056150
1999	10135800	4819140	1722510	1303510	383896	231686	737404
2000	31833900	3677330	2310300	828661	530810	162709	526408
2001	19024900	11591200	1786530	1142780	355797	237212	385831
2002	10943800	6938160	5664090	894493	502146	162721	340954
2003	8777800	4009850	3449590	2940500	421104	246045	291485
2004	36646000	3224420	2012550	1826500	1437260	214228	309868
2005	13021100	13429800	1604300	1046370	862318	706246	298293
2006	4078970	4772860	6686980	835430	495494	425001	536625

Year	Age						
	0	1	2	3	4	5	6+
2007	5891440	1492780	2343640	3522800	466016	287674	582366
2008	7541330	2145010	717994	1192280	1892650	260589	512617
2009	8495560	2696910	960005	323448	562077	928667	404829
2010	4846870	3018140	1175380	413510	145308	262816	647534
2011	3949680	1698870	1246100	462089	168396	61590	419872
2012	4250580	1364790	662354	444731	169596	64327	206142
2013	4666120	1492380	567324	263404	183358	72776	126763
2014	3495210	1642910	627431	229967	110854	80316	94079
2015	6302990	1258840	756528	296569	114163	57277	94791
2016	8254470	2306490	617902	398298	165318	66236	92378
2017	3561200	3021750	1133870	326153	222641	96181	96373
2018	7660310	1309080	1510450	615575	187911	133508	119757
2019	22047800	2842840	679865	874699	380144	120779	167760
2020	8498900	8209850	1496550	402820	553614	250420	196359
2021	7860940	3158530	4288170	875050	251351	359542	298400

Table 8.4.1.4. Sardine in 8c and 9a: Summary table of the WGHANSA 2021 assessment. Coefficient of variation (CV) 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. Catches for 2021 are an assumption based on the Member States agreement.

Year	Biomass 1+	SSB	CV SSB	Recruits	CV Recruits	F (2-5)	F Apical	CV F Apical	Landings
1978	637337	583470	0.170	39319700	0.178	0.277	0.330	0.200	145609
1979	795591	732514	0.169	45303200	0.169	0.229	0.273	0.190	157241
1980	971631	898488	0.160	51093900	0.156	0.233	0.278	0.177	194802
1981	1140730	1058080	0.149	30856000	0.180	0.229	0.273	0.166	216517
1982	1050850	996762	0.149	15833600	0.246	0.228	0.271	0.155	206946
1983	824787	796212	0.159	71641200	0.108	0.232	0.277	0.150	183837
1984	1223480	1115890	0.111	20693800	0.187	0.235	0.280	0.145	206005
1985	1025470	982736	0.107	18011000	0.179	0.220	0.262	0.112	208439
1986	818643	788619	0.107	15218400	0.191	0.283	0.338	0.142	187363
1987	651679	626484	0.110	34025000	0.122	0.330	0.394	0.145	177696
1988	709402	657656	0.096	18484500	0.160	0.403	0.457	0.124	161531
1989	625741	592875	0.097	17675800	0.159	0.390	0.442	0.122	140961
1990	562026	533006	0.098	18533100	0.157	0.424	0.481	0.120	149429
1991	516150	486123	0.104	54912800	0.088	0.390	0.443	0.123	132587
1992	855649	772382	0.081	37336800	0.100	0.287	0.325	0.113	130250
1993	968715	903875	0.071	16246300	0.143	0.276	0.313	0.107	142495
1994	816231	785471	0.072	14139800	0.136	0.232	0.263	0.092	136582
1995	676525	652638	0.072	11061300	0.138	0.232	0.263	0.086	125280
1996	541772	522808	0.075	15710200	0.110	0.313	0.355	0.090	116736
1997	479181	454132	0.075	10000200	0.133	0.422	0.479	0.092	115814
1998	381436	364131	0.081	13322700	0.114	0.478	0.542	0.100	108924
1999	363937	352576	0.082	10135800	0.136	0.439	0.498	0.105	94091
2000	309687	292668	0.089	31833900	0.085	0.392	0.445	0.107	85786
2001	468080	396746	0.075	19024900	0.110	0.372	0.422	0.104	101957
2002	475964	414795	0.075	10943800	0.143	0.311	0.353	0.105	99673
2003	450042	414513	0.078	8777800	0.159	0.278	0.316	0.096	97831
2004	392681	364873	0.083	36646000	0.071	0.309	0.351	0.094	98020
2005	527882	418840	0.070	13021100	0.107	0.307	0.348	0.090	97345
2006	621272	569715	0.061	4078970	0.171	0.181	0.184	0.098	87023
2007	488300	476999	0.062	5891440	0.131	0.217	0.221	0.075	96469
2008	379762	372609	0.064	7541330	0.108	0.346	0.352	0.076	101464
2009	286910	280557	0.066	8495560	0.094	0.393	0.400	0.088	87740
2010	241475	238456	0.063	4846870	0.121	0.489	0.498	0.099	89571
2011	173054	171355	0.073	3949680	0.128	0.592	0.602	0.110	80403
2012	127171	125806	0.092	4250580	0.124	0.478	0.486	0.123	54857
2013	116523	115031	0.107	4666120	0.130	0.457	0.465	0.145	45818

Year	Biomass 1+	SSB	CV SSB	Recruits	CV Recruits	F (2-5)	F Apical	CV F Apical	Landings
2014	119386	119386	0.125	3495210	0.161	0.295	0.300	0.161	27937
2015	111777	111021	0.142	6302990	0.147	0.181	0.184	0.168	20595
2016	142039	142039	0.141	8254470	0.164	0.179	0.182	0.170	22704
2017	179554	178420	0.150	3561200	0.199	0.148	0.151	0.178	21911
2018	169419	167909	0.161	7660310	0.182	0.080	0.082	0.176	15062
2019	195665	189979	0.159	22047800	0.172	0.056	0.057	0.163	13759
2020	369116	369116	0.151	8498900	0.262	0.071	0.072	0.162	22143
2021	394227	386780	0.152	7860940	0.445	NA	NA	NA	40545*

Table 8.6.1. Sardine in 8c and 9a: Input data for short-term catch predictions. Number-at-age for 2021 and recruitment for 2022. Input values for stock weight, catch weight, natural mortality (M) and fishing mortality (F) at-age. Input units are thousands and kg.

Year = 2021						
Age	Numbers	Stock weights	Catch weights	Maturity	M	F
0	7860940	0.000	0.030	0.000	0.98	0.015
1	3158530	0.028	0.046	0.988	0.61	0.060
2	4288170	0.045	0.059	0.989	0.47	0.102
3	875050	0.058	0.073	1.000	0.40	0.109
4	251351	0.063	0.082	1.000	0.36	0.109
5	359542	0.068	0.091	1.000	0.35	0.109
6	298400	0.073	0.097	1.000	0.32	0.093
Recruitment in 2022 = 8333147 In 2022, stock weights, catch weights, maturity and mortality are the same as in 2021.						

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

B1+ 2022 = 369 328 tonnes; Catch 2021 = 40 545 tonnes ; F 2021 = 0.107					
F (2022)	Catch (2022)	Biomass 1+ (2023)	Catch2023	% Biomass 1+ change[1]	% Catch change[2]
0.050	23188	358805	22704	-3	5
0.070	32138	352577	30916	-5	45
0.090	40910	346484	38669	-6	85
0.110	49507	340524	45987	-8	124
0.130	57932	334694	52891	-9	162
0.150	66190	328991	59403	-11	199
0.170	74285	323411	65543	-12	235
0.190	82220	317952	71330	-14	271
0.210	89999	312611	76783	-15	306
0.230	97625	307386	81919	-17	341
0.250	105101	302273	86754	-18	375
0.270	112432	297270	91304	-20	408
0.290	119619	292374	95584	-21	440
0.310	126667	287584	99608	-22	472
0.330	133579	282896	103390	-23	503
0.350	140357	278308	106942	-25	534
0.370	147005	273818	110277	-26	564
0.390	153525	269424	113405	-27	593
0.410	159920	265123	116339	-28	622
0.430	166193	260914	119088	-29	651
0.450	172347	256793	121663	-30	678
0.470	178384	252760	124072	-32	706
0.490	184306	248811	126325	-33	732
0.510	190118	244946	128431	-34	759
0.530	195820	241162	130396	-35	784
0.550	201415	237457	132230	-36	810
0.570	206906	233830	133939	-37	834
0.590	212295	230278	135530	-38	859
0.610	217583	226801	137009	-39	883
0.630	222774	223396	138384	-40	906
0.650	227870	220061	139659	-40	929
0.670	232872	216796	140841	-41	952
0.690	237782	213598	141935	-42	974
0.710	242603	210465	142945	-43	996
0.730	247336	207398	143877	-44	1017

B1+ 2022 = 369 328 tonnes; Catch 2021 = 40 545 tonnes ; F 2021 = 0.107					
F (2022)	Catch (2022)	Biomass 1+ (2023)	Catch2023	% Biomass 1+ change[1]	% Catch change[2]
0.750	251984	204393	144735	-45	1038
0.770	256548	201450	145523	-45	1059
0.790	261030	198567	146246	-46	1079
0.810	265431	195743	146908	-47	1099
0.830	269755	192976	147511	-48	1118
0.850	274001	190265	148060	-48	1137
0.870	278172	187609	148558	-49	1156
0.890	282270	185007	149008	-50	1175
0.910	286295	182457	149413	-51	1193
0.930	290250	179958	149776	-51	1211
0.950	294137	177510	150099	-52	1228
0.970	297955	175110	150385	-53	1246
0.990	301708	172758	150637	-53	1263
0.471	178738	252523	124210	-32	707
0.806	264509	196334	146773	-47	1095
0.092	41777	345882	39420	-6	89
0.107	48382	341303	45046	-8	119
0.260	108784	299758	89064	-19	391
0.098	44262	344159	41555	-7	100
0.065	30000	354063	30000	-4	35
0.076	35000	350588	35000	-5	58
0.088	40000	347115	40000	-6	81

[1]Biomass 1+ in 2023 relative to Biomass 1+ in 2022 (369 328 tonnes).

[2]Advised catches in 2022 compared to 2020 catches (22 143 tonnes)

Table 8.9.3.1. - Catch (in tonnes), number of length samples and individuals measured in 2020 by subdivision.

Subdivision	Variable	Quarter				Total
		1	2	3	4	
8cE	Catch	135 (2.0%)	447 (6.6%)	152 (2.3%)	164 (2.4%)	896 (13.3%)
	Nº samples	16	6	0	18	40
	Nº ind	2297	442	0	1393	4132
8cW	Catch	1 (0.0%)	1361 (20.2%)	508 (7.5%)	56 (0.8%)	1925 (28.6%)
	Nº samples	0	0	0	1	1
	Nº ind	0	0	0	69	69
9aN	Catch	9 (0.1%)	1172 (17.4%)	671 (10.0%)	98 (1.5%)	1950 (29.0%)
	Nº samples	0	0	0	0	0
	Nº ind	0	0	0	0	0
9aCN	Catch	0	1170 (7.6%)	3657 (23.7%)	221 (1.4%)	5048 (32.3%)
	Nº samples	1	6	37	2	46
	Nº ind	10	316	2780	92	3198
9aCS	Catch	0	2197 (14.2%)	5071 (32.9%)	291 (1.9%)	7559 (49%)
	Nº samples	0	10	16	3	29
	Nº ind	0	738	970	167	1875
9aS-Alg	Catch	0	723 (4.7%)	1997 (12.9%)	107 (0.7%)	2827 (18.3%)
	Nº samples	0	3	5	1	9
	Nº ind	0	334	594	112	1040
9aS-Cadiz	Catch	23 (0.3%)	224 (3.3%)	947 (14.1%)	762 (11.3%)	1955 (29.1%)
	Nº samples	0	0	0	7	7
	Nº ind	0	0	0	770	770

Table 8.9.5.1 - Catch (in tonnes), number of biological samples, number of individuals measured and age readings in 2020 by subdivision.

Subdivision	Variable	Quarter				Total
		1	2	3	4	
8cE	Catch	135 (2.0%)	447 (6.6%)	152 (2.3%)	164 (2.4%)	896 (13.3%)
	Nº samples	2	2	1	0	5
	Nº ind	222	150	80	0	352
	Nº aged	222	150	80	0	352
8cW	Catch	1 (0.0%)	1361 (20.3%)	508 (7.6%)	56 (0.8%)	1925 (28.7%)
	Nº samples	0	1	2	1	3
	Nº ind	0	100	140	100	230
	Nº aged	0	100	140	100	230
9aN	Catch	9 (0.1%)	1172 (17.4%)	671 (10.0%)	98 (1.5%)	1950 (29.0%)
	Nº samples	0	2	3	0	4
	Nº ind	0	200	301	0	501
	Nº aged	0	200	301	0	501
9aCN	Catch	0	1170 (7.6%)	3657 (23.7%)	221 (1.4%)	5048 (32.3%)
	Nº samples	4	0	3	1	8
	Nº ind	207	0	158	39	404
	Nº aged	185	0	156	39	308
9aCS	Catch	0	2197 (14.2%)	5071 (32.9%)	291 (1.9%)	7559 (49%)
	Nº samples	0	0	0	0	0
	Nº ind	0	0	0	0	0
	Nº aged	0	0	0	0	0
9aSA	Catch	0	723 (4.7%)	1997 (12.9%)	107 (0.7%)	2827 (18.3%)
	Nº samples	0	2	3	1	6
	Nº ind	0	105	191	75	371
	Nº aged	0	103	191	74	368
9aSC	Catch	23 (0.3%)	224 (3.3%)	938 (14.0%)	762 (11.3%)	1947 (29.0%)
	Nº samples	0	0	2	1	3
	Nº ind	0	0	734	651	1385
	Nº aged	0	0	734	651	1385

Table 8.9.6.1 - Number at age from the original subdivision (Original) , based on the adjacent subdivision (Based-adj), difference (Dif), percentaje of the orignal (%original) age related to the total and pertentage of the ages based on the adjacent subdivision (%adjacent) and difference in the proportion (dif. Prop) for year 2017.

2017	Original	Based_adj	Dif	%original	%adjacent	dif.prop
age0	35328.81	35981.40	1.85	0.08	0.09	-0.01
age1	198626.90	163713.20	-17.58	0.46	0.40	0.05
age2	126003.35	116088.23	-7.87	0.29	0.29	0.00
age3	39726.95	41744.26	5.08	0.09	0.10	-0.01
age4	15971.28	21905.51	37.16	0.04	0.05	-0.02
age5	8392.76	11323.65	34.92	0.02	0.03	-0.01
age6+	10852.82	15612.91	43.86	0.02	0.04	-0.01
total	434902.87	406369.16	-6.56			

Table 8.9.6.2 - Number at age from the original subdivision (Original) , based on the adjacent subdivision (Based-adj), difference (Dif), percentaje of the orignal (%original) age related to the total and pertentage of the ages based on the adjacent subdivision (%adjacent) and difference in the proportion (dif. Prop) for year 2018.

2018	Original	Based_adj	Dif	%original	%adjacent	dif.prop
age0	37222.17	38524.32	3.50	0.15	0.16	0.00
age1	49089.99	42256.29	-13.92	0.20	0.17	0.03
age2	87002.20	90391.13	3.90	0.36	0.37	-0.01
age3	33470.92	33513.31	0.13	0.14	0.14	0.00
age4	19049.78	21880.34	14.86	0.08	0.09	-0.01
age5	8942.98	10359.65	15.84	0.04	0.04	-0.01
age6+	9137.19	9503.01	4.00	0.04	0.04	0.00
total	243915.23	246428.05	1.03			

Table 8.9.6.3 - Number at age from the original subdivision (Original) , based on the adjacent subdivision (Based-adj), difference (Dif), percentaje of the orignal (%original) age related to the total and pertentage of the ages based on the adjacent subdivision (%adjacent) and difference in the proportion (dif. Prop) for year 2019.

2019	Original	Based_adj	Dif	%original	%adjacent	dif.prop
age0	53515.30	43475.16	-18.76	0.21	0.17	0.04
age1	80914.12	82929.33	2.49	0.32	0.33	-0.01
age2	43304.82	53756.28	24.13	0.17	0.22	-0.04
age3	48181.49	47008.57	-2.43	0.19	0.19	0.00
age4	15737.17	14146.50	-10.11	0.06	0.06	0.01
age5	3537.61	3701.12	4.62	0.01	0.01	0.00
age6+	4684.47	4714.34	0.64	0.02	0.02	0.00
total	249874.98	249731.30	-0.06			

Table 8.9.6.4. - Assessment of 2020: Percentual differences between the runs MeanCatch, NoCatch and OtherCatch when compared to the 'real' assessment.

Run	Indicator	\`2017\`	\`2018\`	\`2019\`	\`2020\`
MeanCatch	Biomass	9.4	3.2	-4.7	-6.3
NoCatch		-7	-11.1	-18.1	42.6
OtherCatch		0.3	1.9	2.1	-3.2
MeanCatch	Fishing mortality	-7.7	-1.3	8.9	NA
NoCatch		6.9	12.8	-9.1	NA
OtherCatch		-0.8	-1.7	0.1	NA
MeanCatch	Recruitment	-21.8	-16	-6.2	NA
NoCatch		-22.7	-27.9	98.1	NA
OtherCatch		7.9	1.8	-8.1	NA

Table 8.9.6.5. - Assessment of 2019: Percentual differences between the runs No Catch and OtherCatch when compared to the 'real' assessment.

Run	Indicator	\`2016\`	\`2017\`	\`2018\`	\`2019\`
MeanCatch		14	2.6	-0.4	-4.5
NoCatch	Biomass	1.9	2.7	-1.4	-0.9
OtherCatch		3.1	5.7	2.7	-5.6
MeanCatch		-11.4	-0.1	9.6	NA
NoCatch	Fishing mortality	-2.5	2.4	0.9	NA
OtherCatch		-4.7	-1.1	-0.2	NA
MeanCatch		-14.8	-7.6	-9.2	NA
NoCatch	Recruitment	3.1	-20.5	1.3	NA
OtherCatch		8.1	-13.5	-19.4	NA

Table 8.9.6.6. - Assessment of 2018: Percentual differences between the runs No Catch and OtherCatch when compared to the 'real' assessment.

Run	Indicator	\`2015\`	\`2016\`	\`2017\`	\`2018\`
MeanCatch		19.3	3.2	-11.4	-0.2
NoCatch	Biomass	3.3	0.5	-4.4	-0.3
OtherCatch		2.9	1.8	-1.3	-1
MeanCatch		-10.4	-1.1	-1.6	NA
NoCatch	Fishing mortality	-1.6	1.1	3.3	NA
OtherCatch		-2.5	-1.2	0.6	NA
MeanCatch		-18.2	-28.1	55.8	NA
NoCatch	Recruitment	-3.2	-10.3	22.4	NA
OtherCatch		0.1	-5.5	2.1	NA

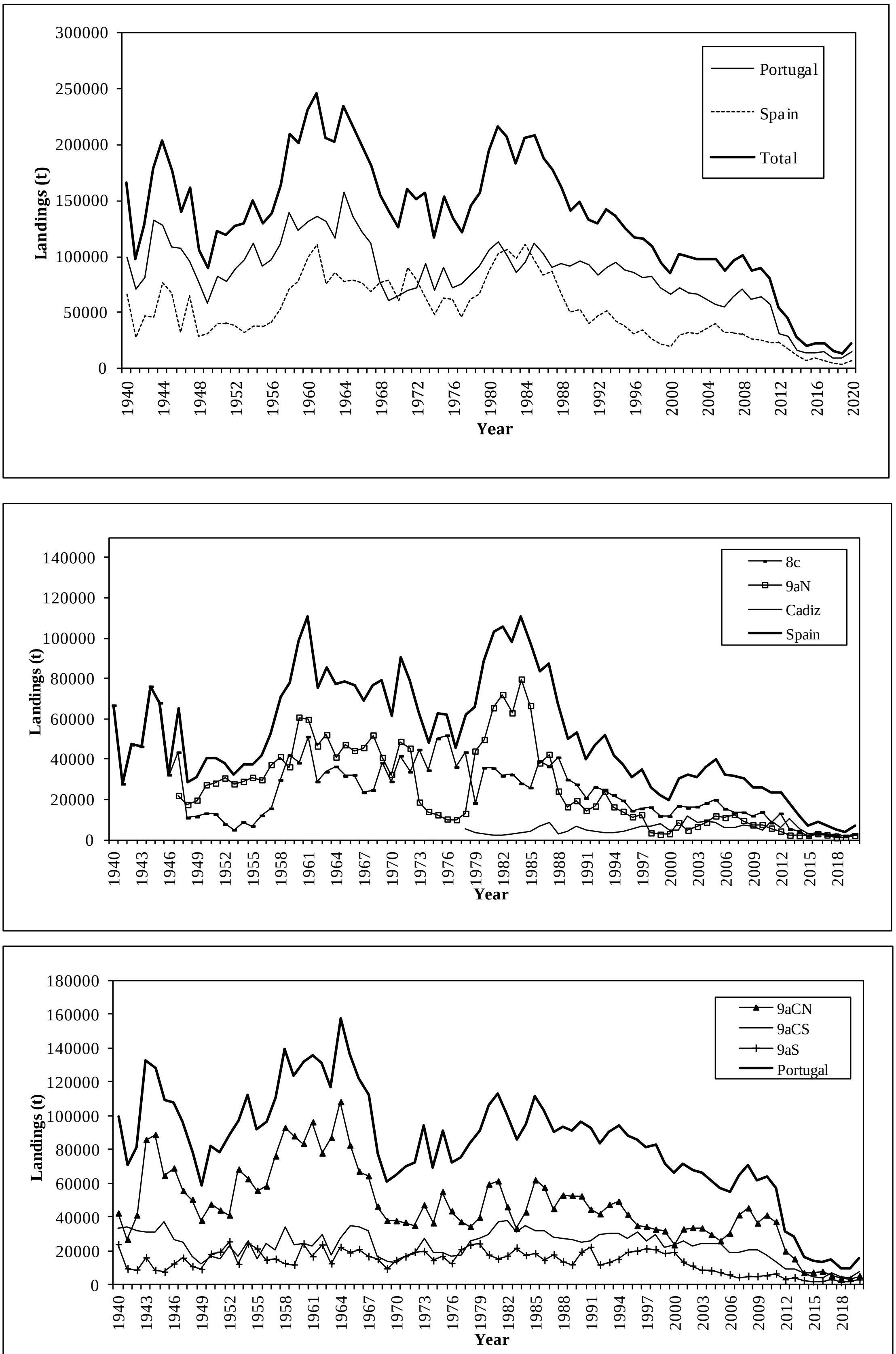

Figure 8.2.2.1: Sardine in 8c and 9a: WG estimates of annual landings of sardine, by country (upper panel) and by ICES subdivision and country.

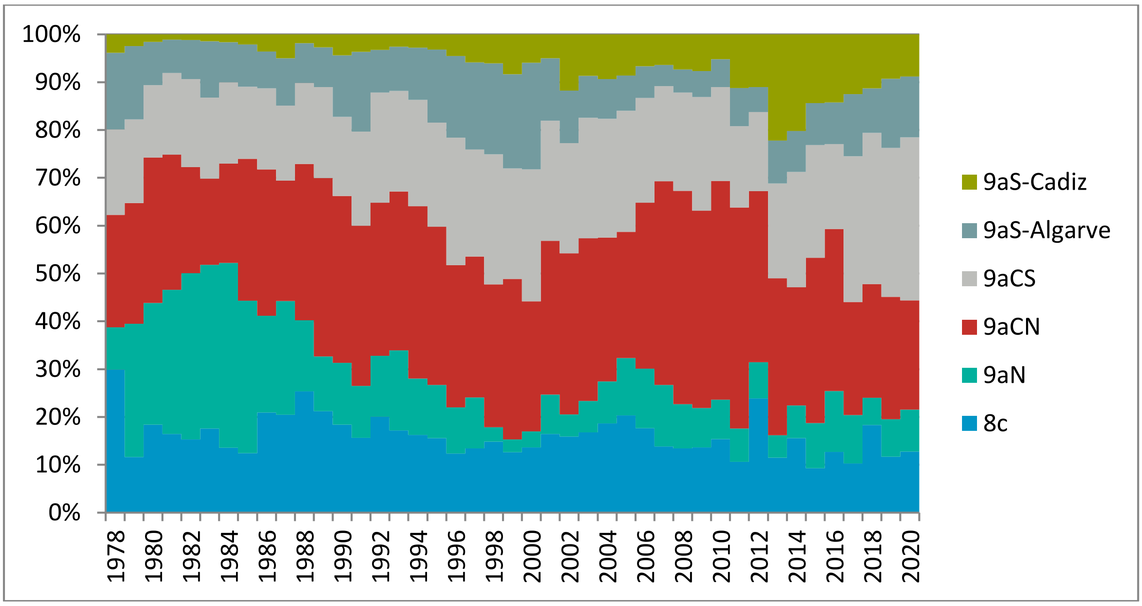

Figure 8.2.2.2: Sardine in 8c and 9a: Historical relative contribution of the different subdivisions to the total catches (1978-2020).

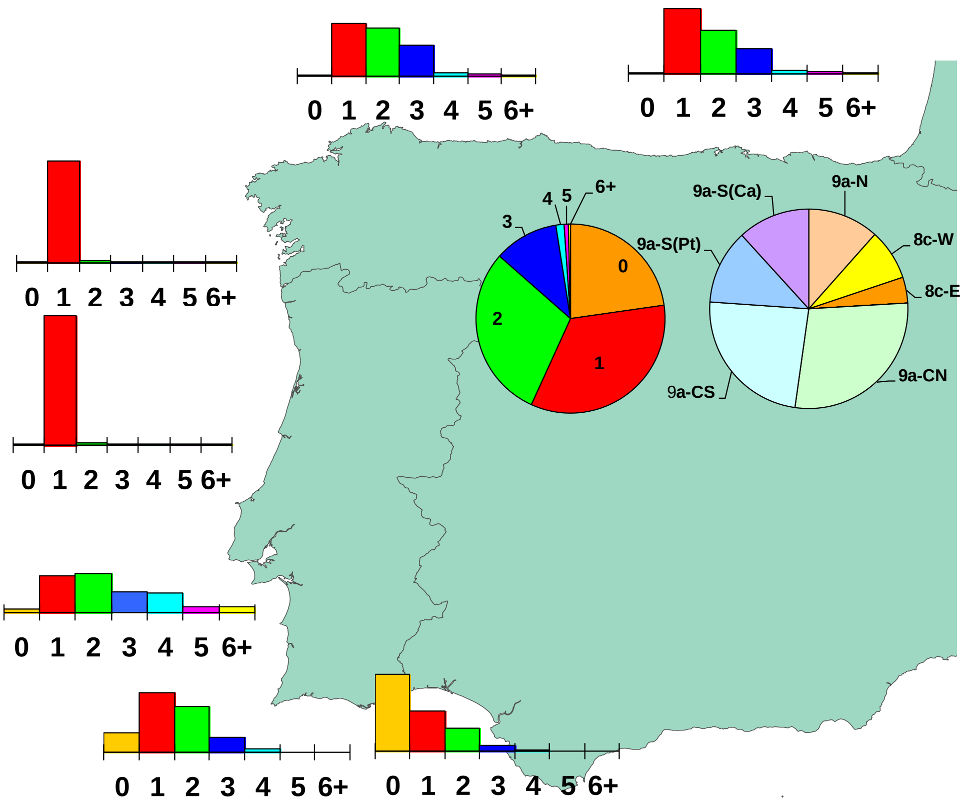

Figure 8.2.4.1.: Sardine in 8c and 9a: Relative contribution of each age-class by subdivisions as well as their relative contribution to the 2020 catches (pie-chart).

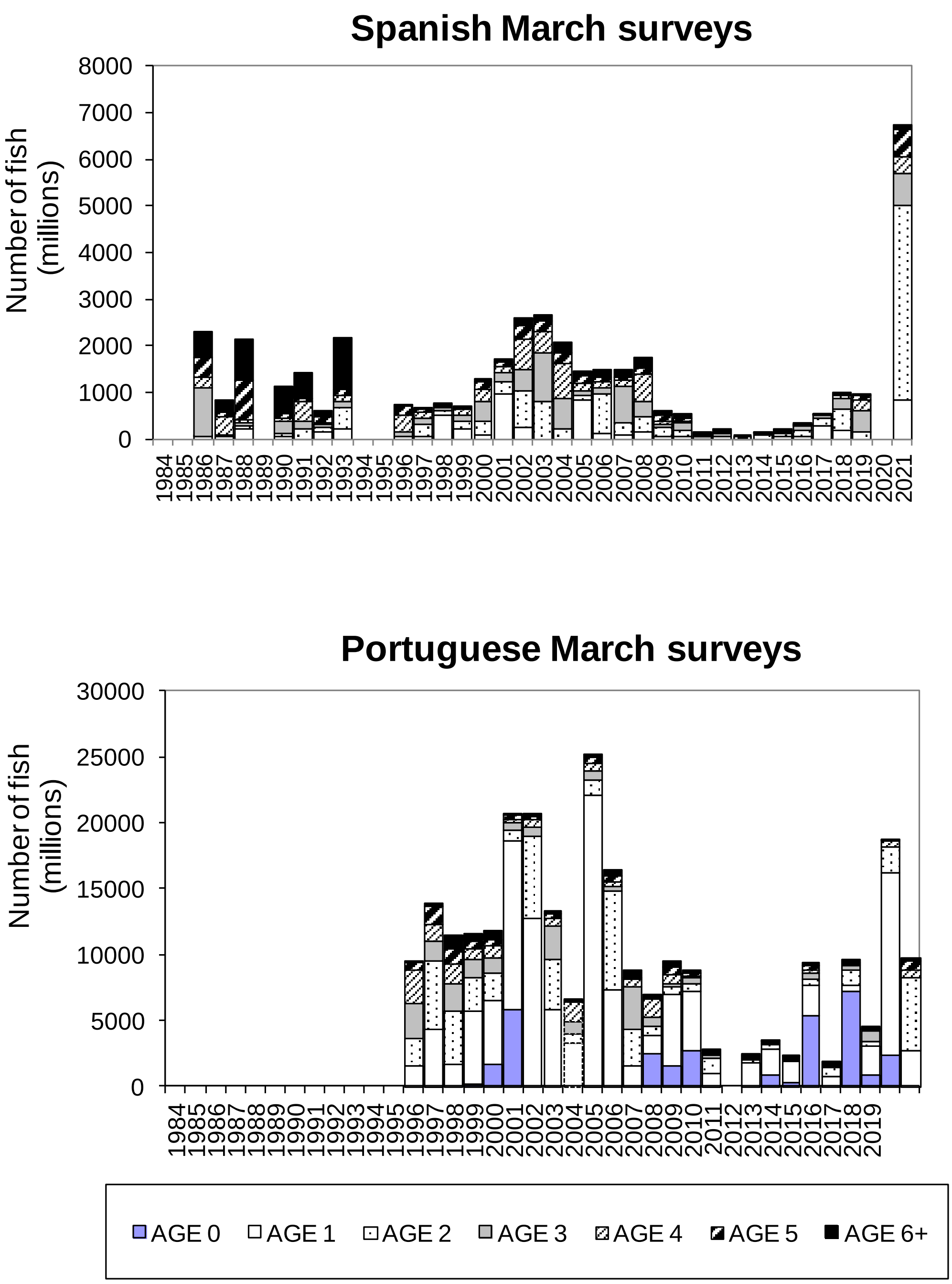

Figure 8.3.1: Sardine in 8c and 9a: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area 8c and 9a-N (top panel) and the Portuguese March surveys covers 9aCN, 9a-CS, 9aS-Algarve and 9aS-Cadiz subdivisions (bottom panel). 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 and for Spanish survey in 2020 (years without survey).

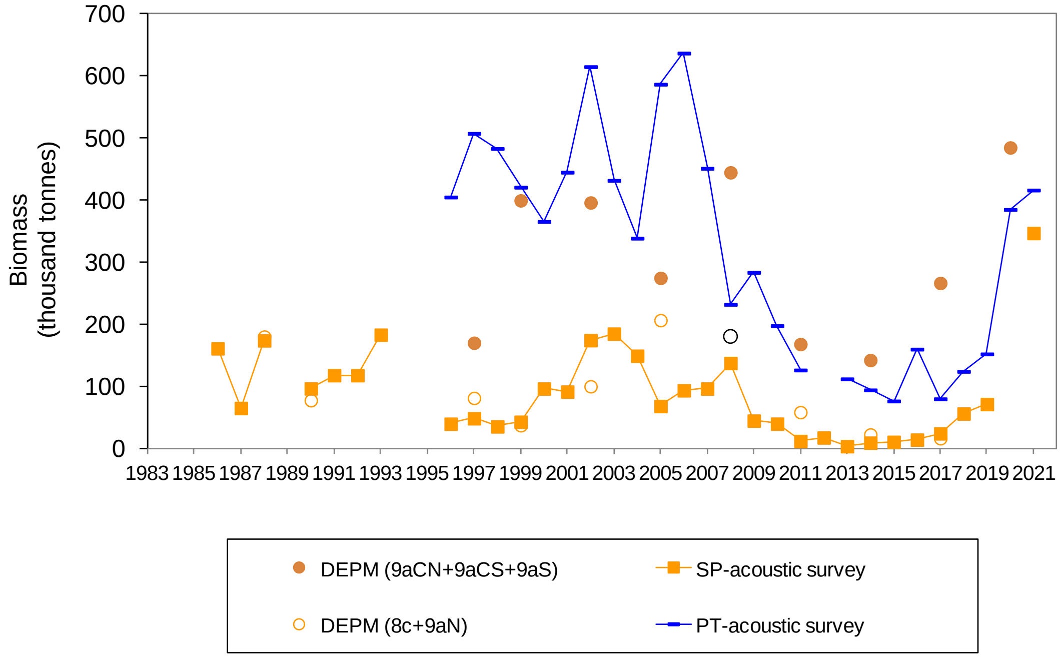

Figure 8.3.2: Sardine in 8c and 9a: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

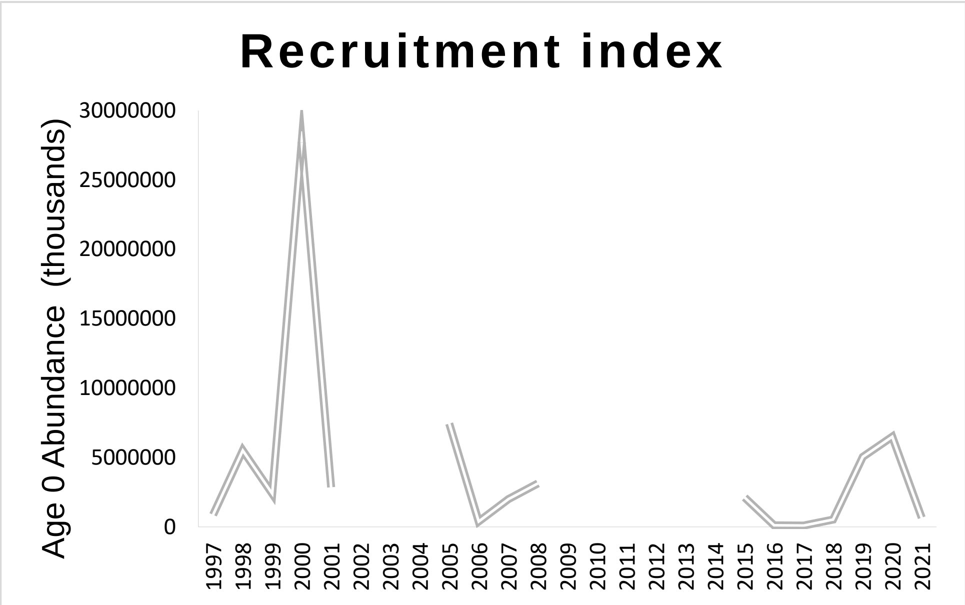

Figure 8.3.3: Sardine in 8c and 9a. Recruitment index. Age 0 Individuals (thousands) estimated in SAR-PT-AUT, JUVESAR and IBERAS autumn acoustic survey time series 1997-2021 (thousand tonnes) in 9aCN subdivision.

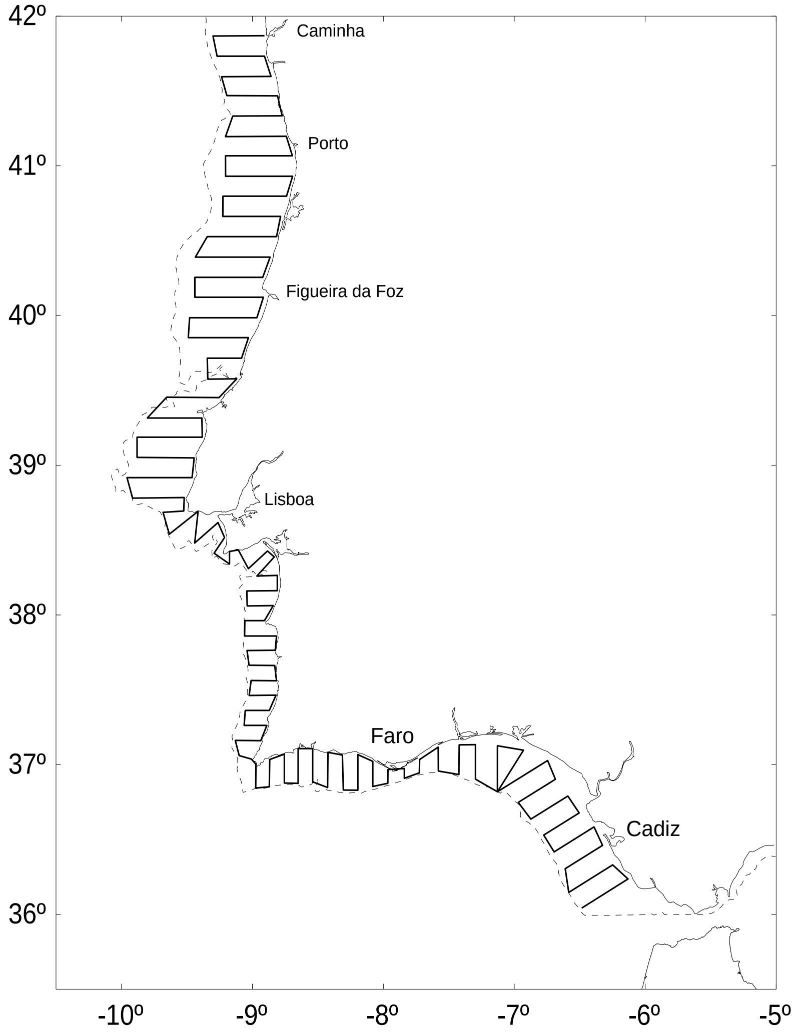

Figure 8.3.2.1.1. Sardine in 8c and 9a: acoustic transects during PELAGO 2021 survey.

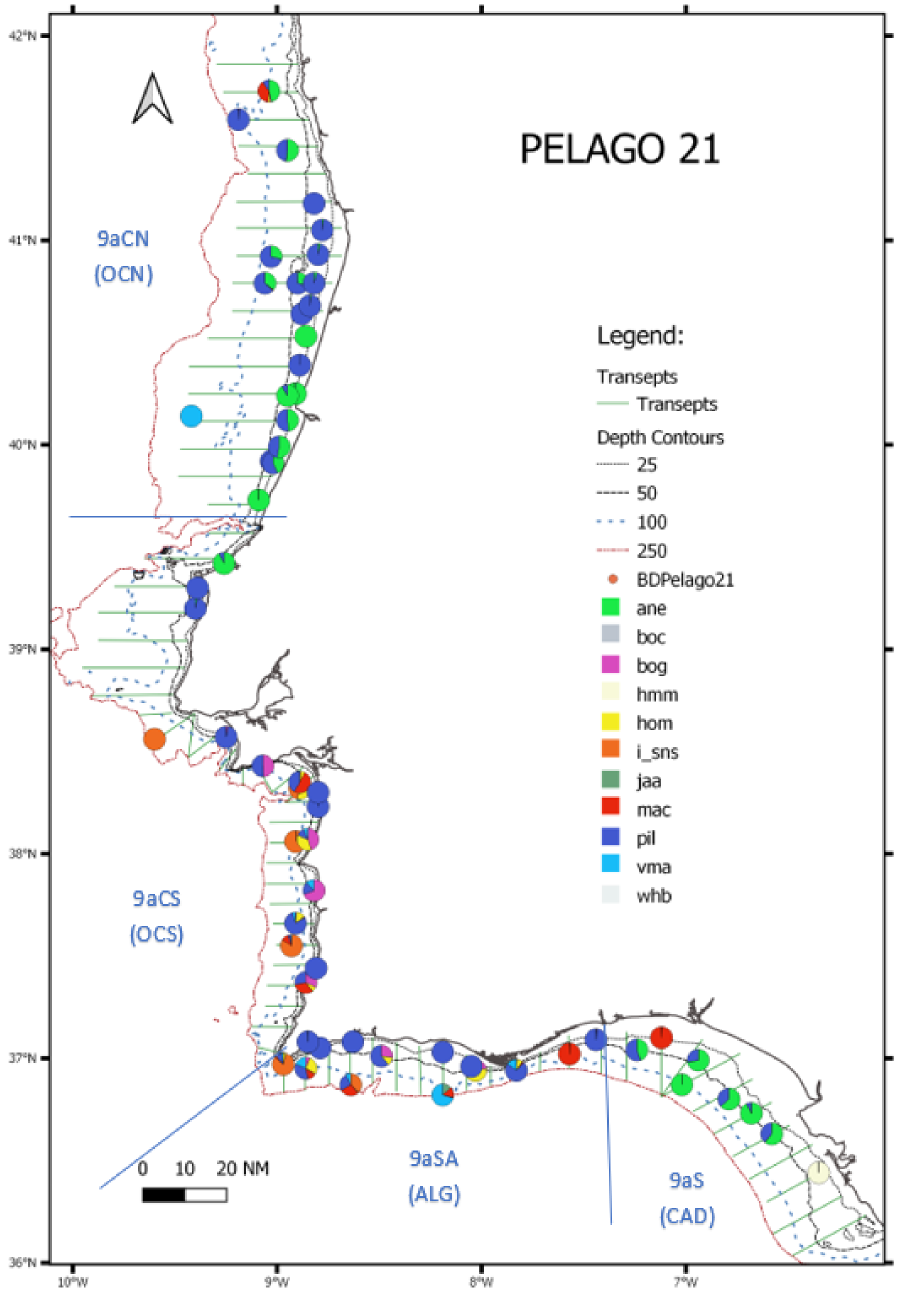

Figure 8.3.2.1.2: Sardine in 8c and 9a: Fishing haul operations during PELAGO 2021 survey.

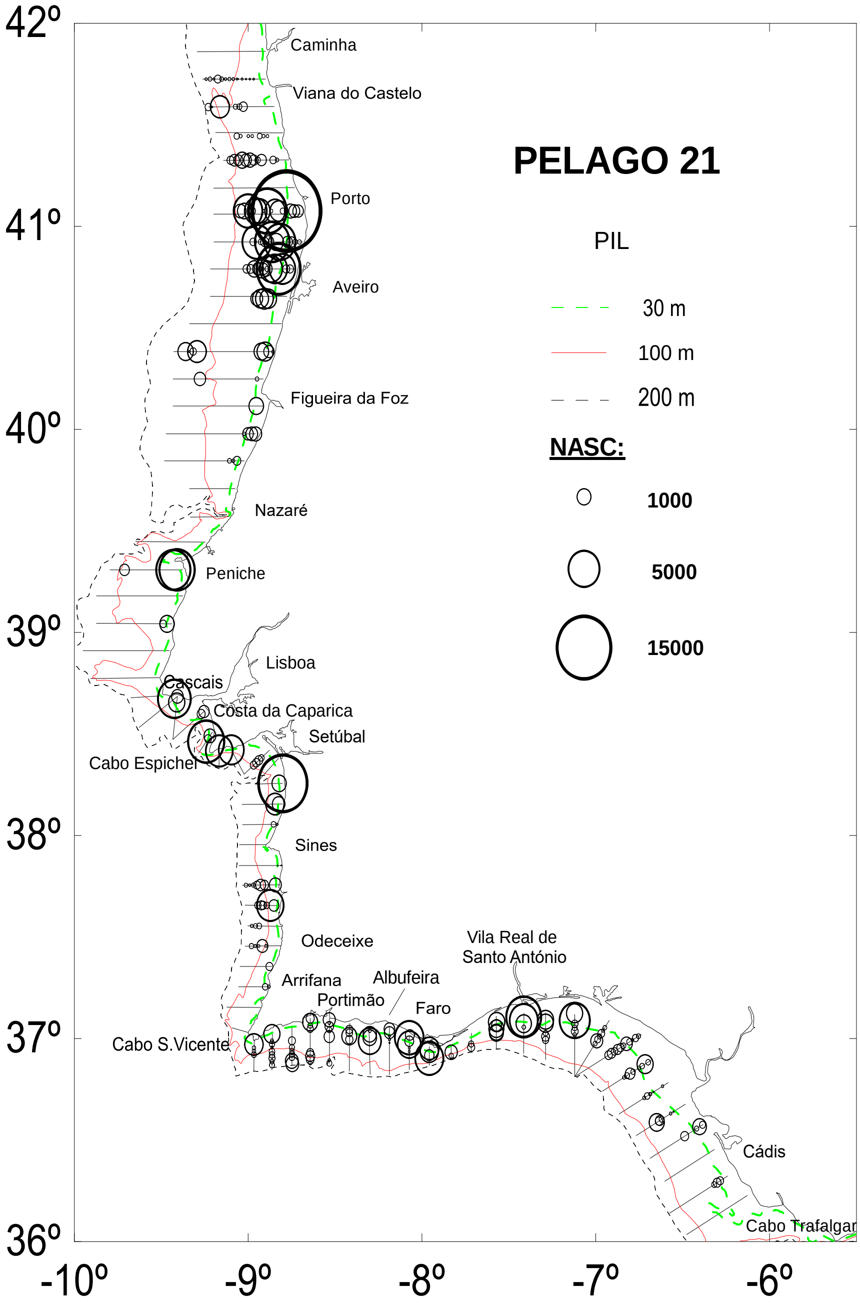

Figure 8.3.2.1.3: Sardine in 8c and 9a: Acoustic energy during PELAGO2021.

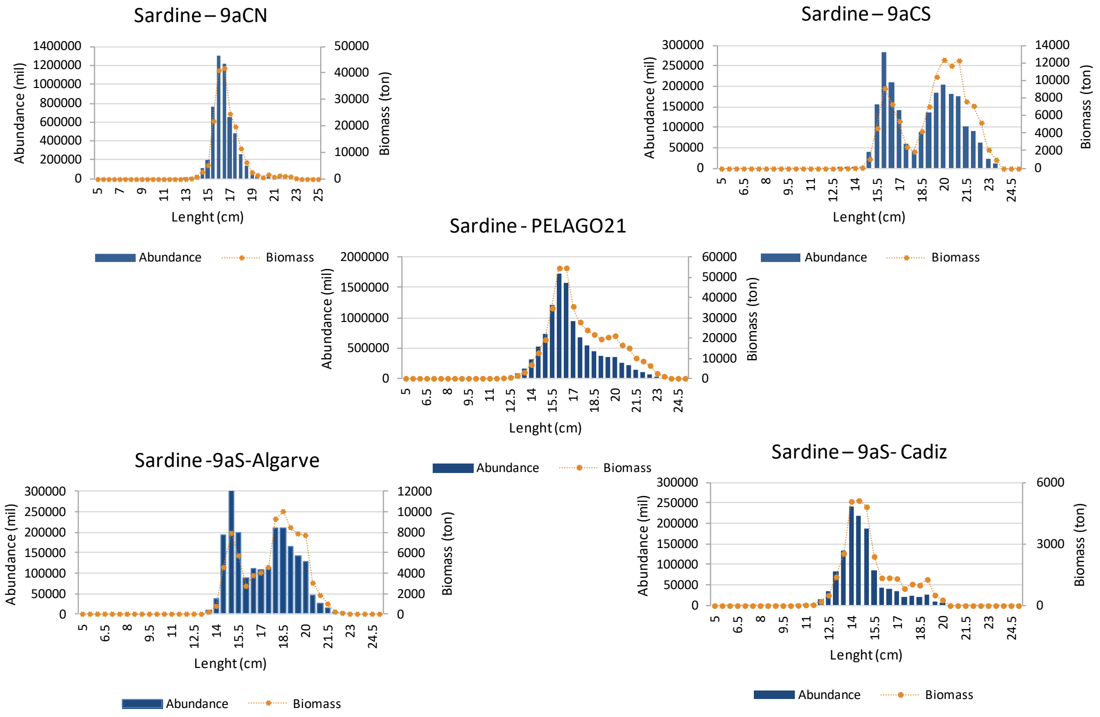

Figure 8.3.2.1.4: Sardine in 8c and 9a: Size composition during PELAGO2021.

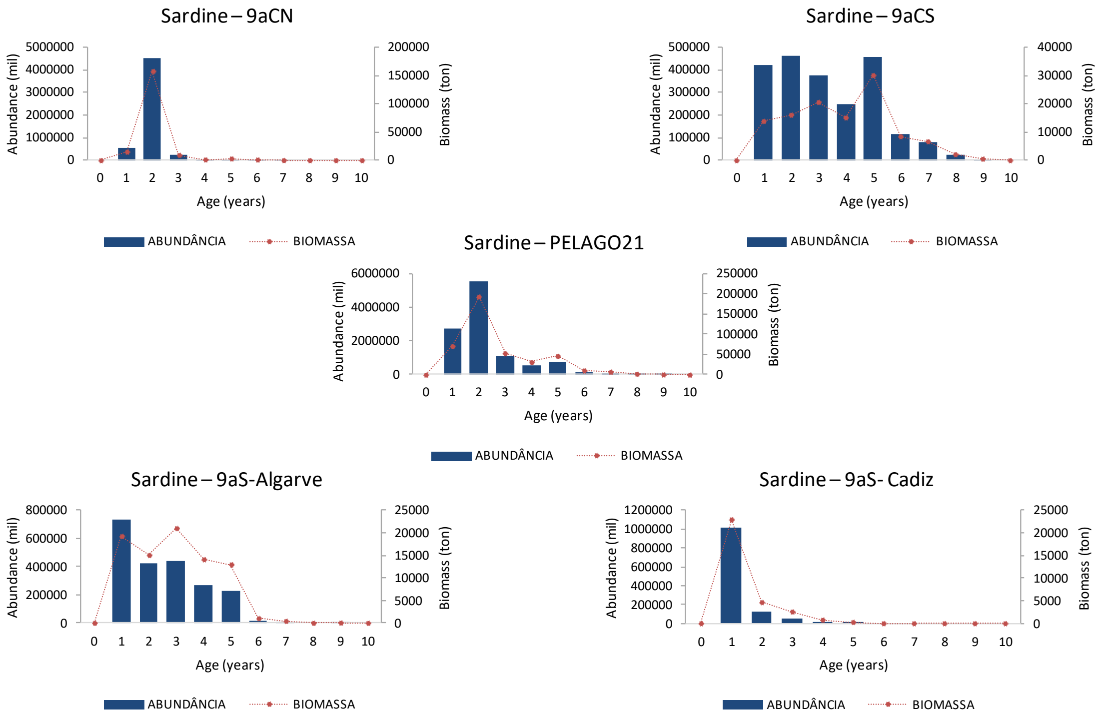

Figure 8.3.2.1.5: Sardine in 8c and 9a: Age composition during PELAGO2021.

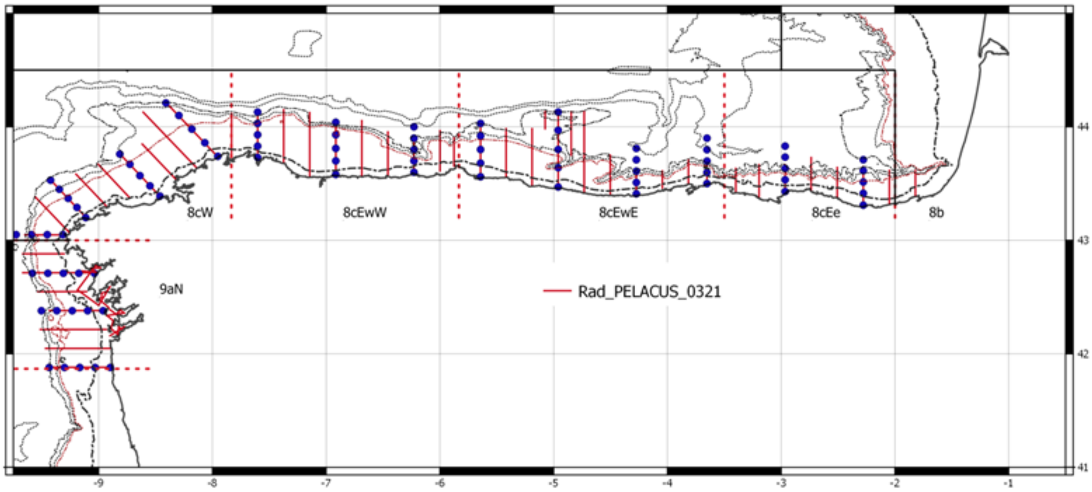

Figure 8.3.2.2.1 Sardine in 8c and 9a: Survey track of PELACUS0321 survey.

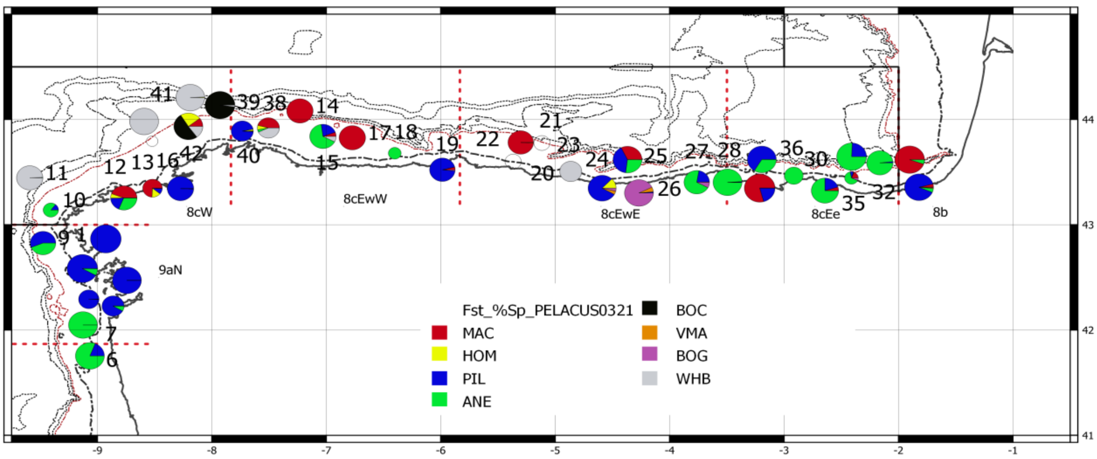

Figure 8.3.2.2.2. Sardine in 8c and 9a: Fishing stations and catch composition (% in number of fish caught). WHB-blue whiting; MAC-mackerel; HOM-horse mackerel;PIL-sardine; BOG-bogue; BOC-boarfish; MAV-müller's pearlside; ANE-anchovy; VMA-chub mackerel; and HKE-hake.

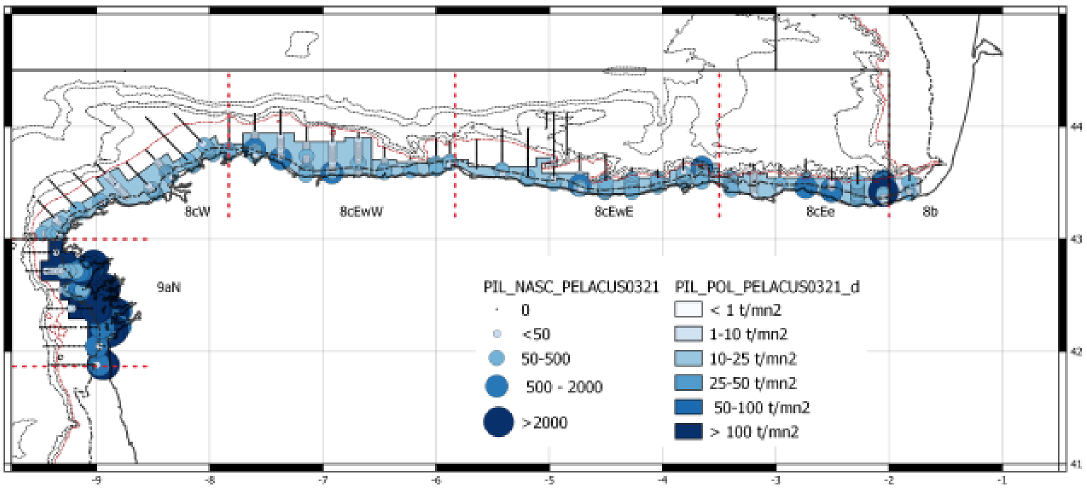

Figure 8.3.2.2.3. Sardine in 8c and 9a: Sardine spatial distribution in PELACUS0321 survey.

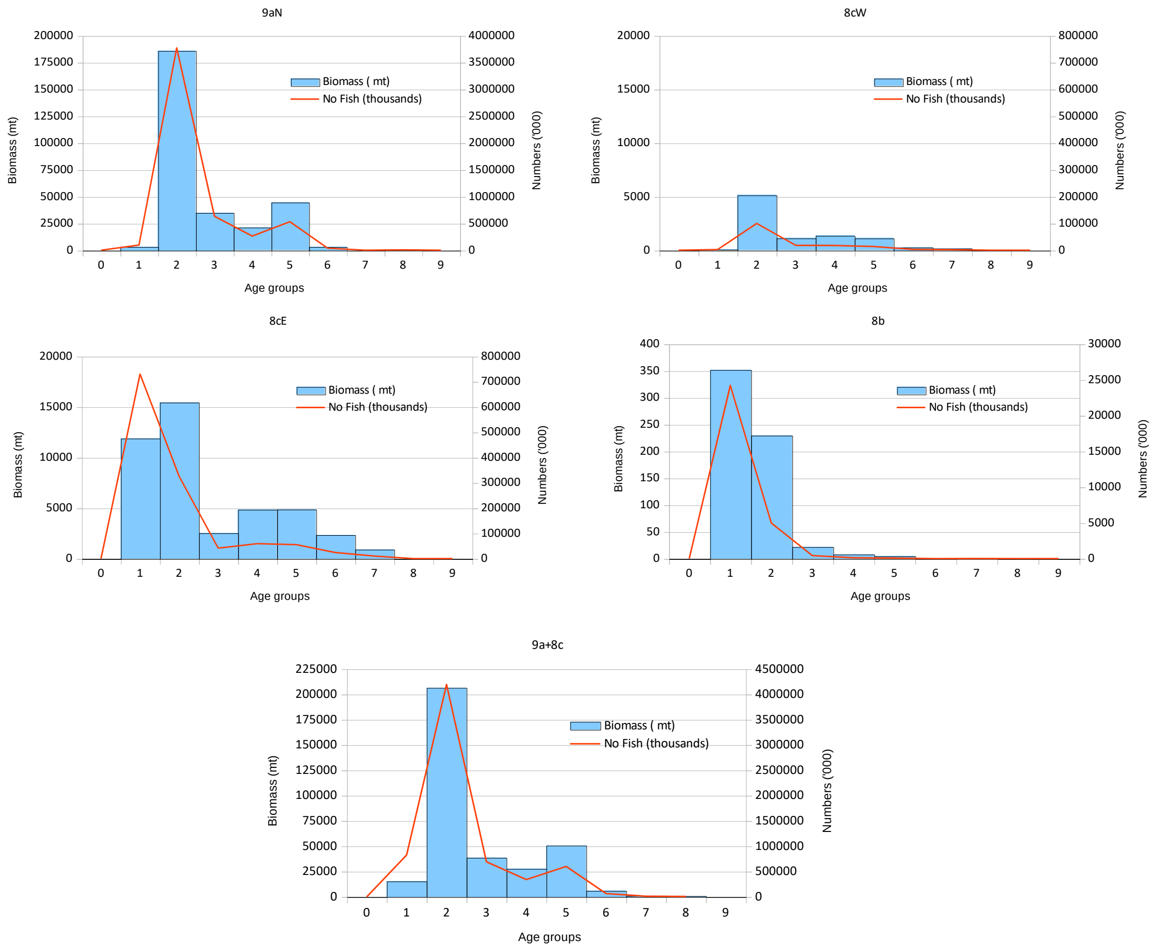

Figure 8.3.2.2.4. Sardine abundance by age group estimated in PELACUS 0321.

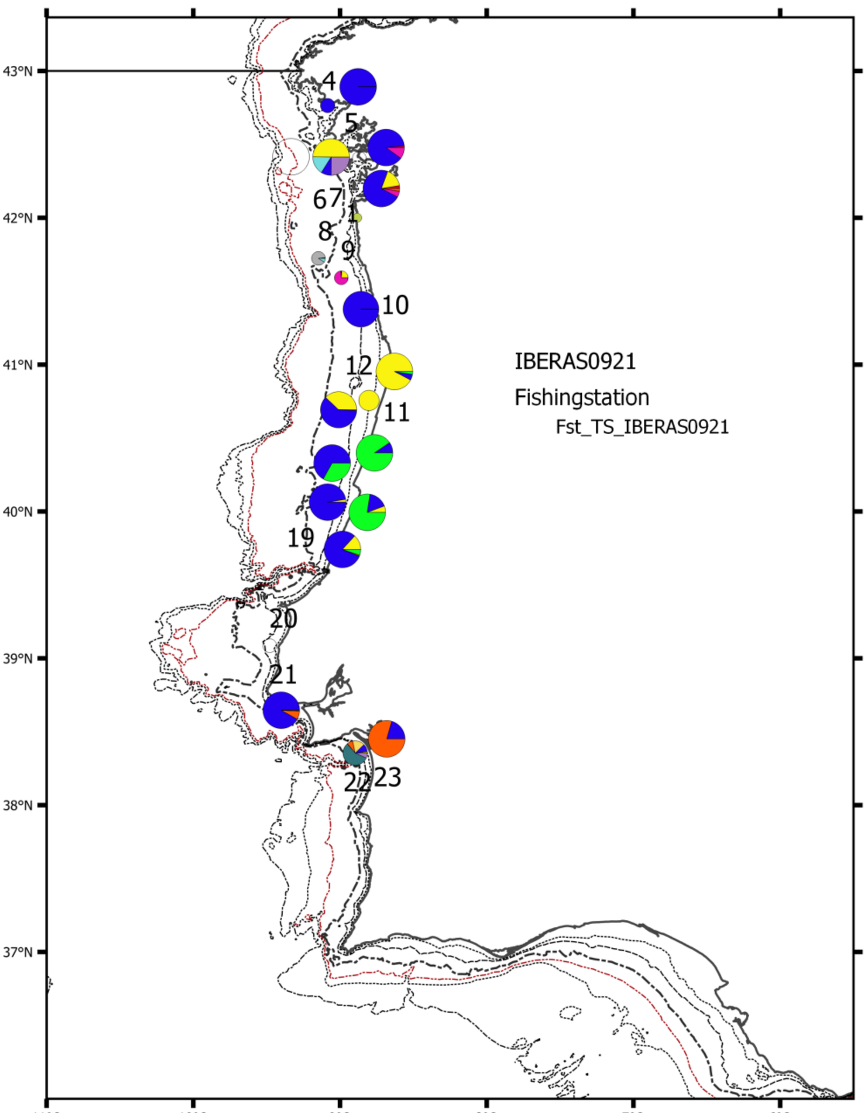

Figure 8.3.3.1. Sardine in 8c and 9a: Fishing stations and catch composition (% in number of fish caught) in IBERAS2021 survey. WHB-blue whiting; MAC-mackerel; HOM-horse mackerel;PIL-sardine; BOG-bogue; BOC-boarfish; MAV-müller's pearlside; ANE-anchovy; VMA-chub mackerel; and HKE-hake.

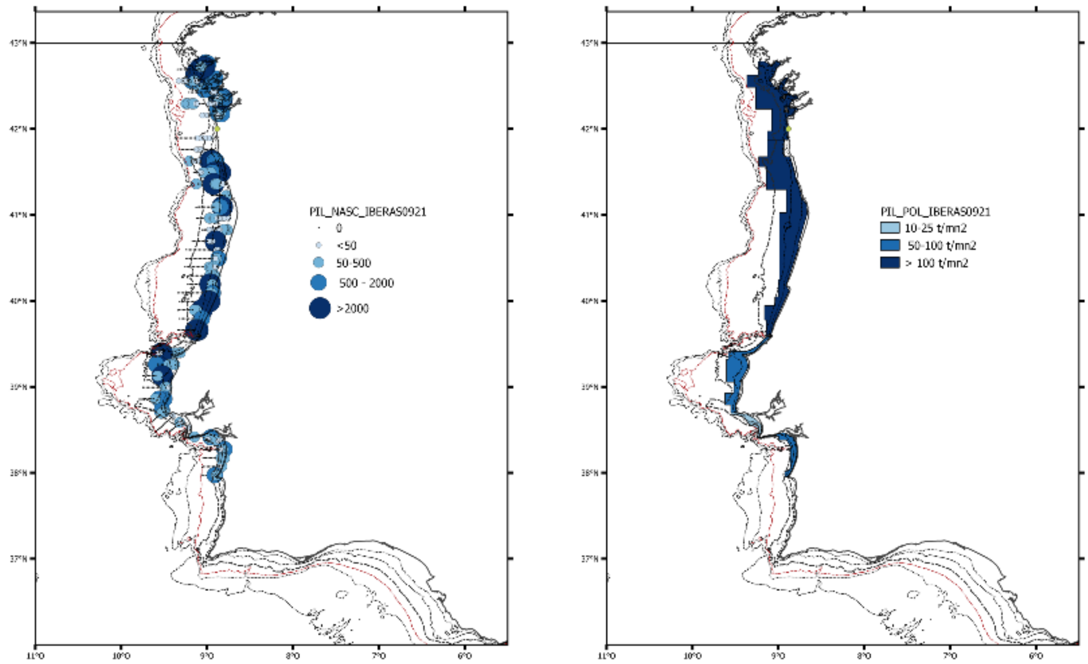

Figure 8.3.3.2. Sardine in 8c and 9a: Sardine spatial distribution in IBERAS2021 survey, a)allocated NASC b)conversion to biomass.

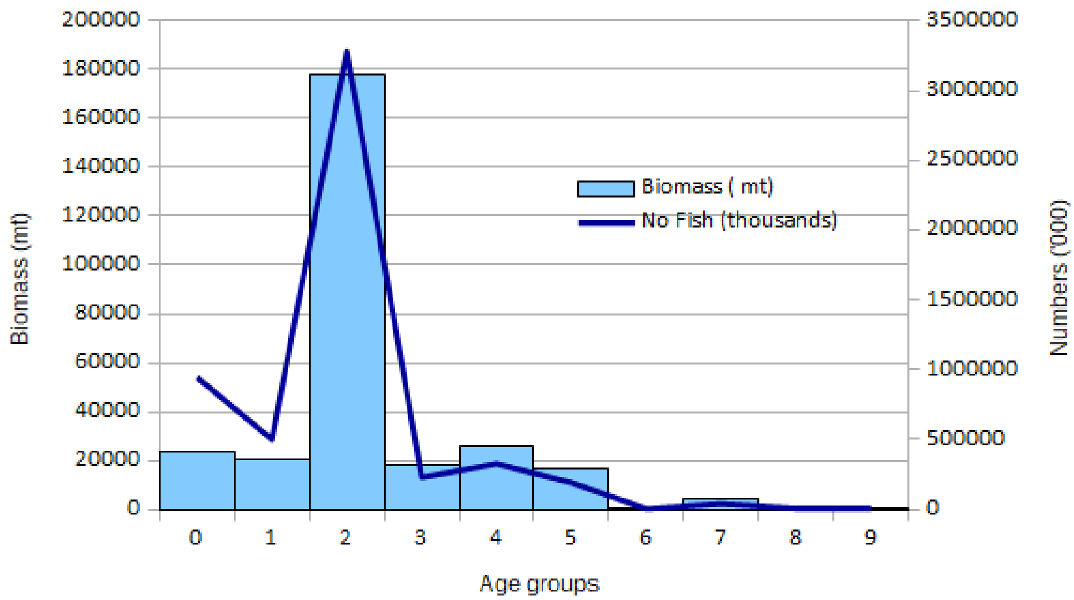

Figure 8.3.3.3. Sardine in 8c and 9a: Sardine abundance and biomass by age group estimated in IBERAS2021 survey.

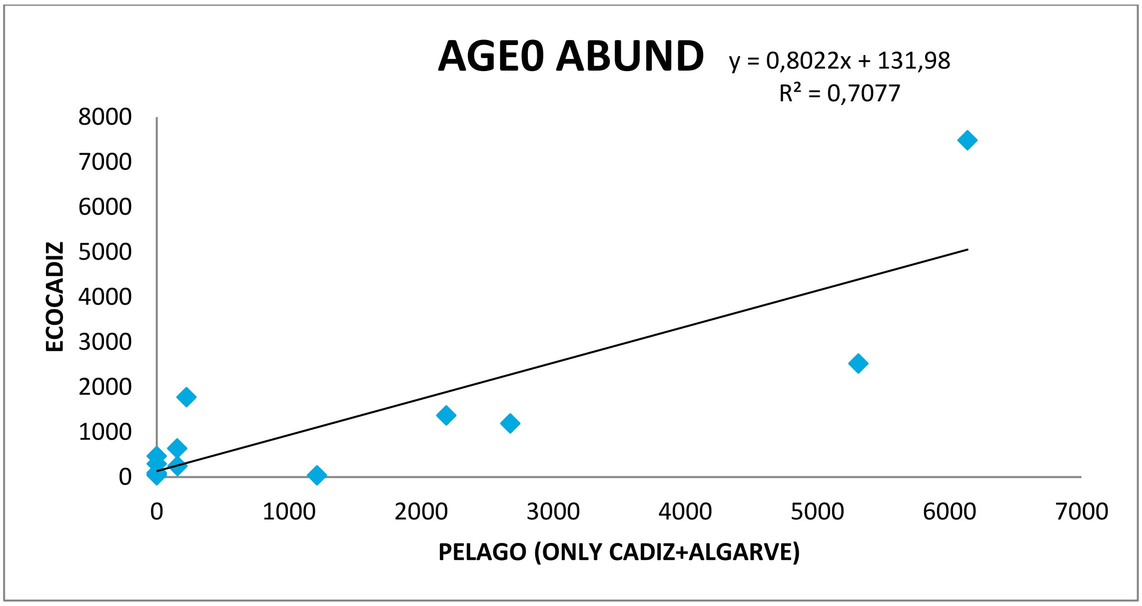

Figure 8.3.4.1 Sardine in 8c and 9a: Relationship between age-0 abundance in PELAGO survey and age-0 abundance in ECOCADIZ survey in the same year.

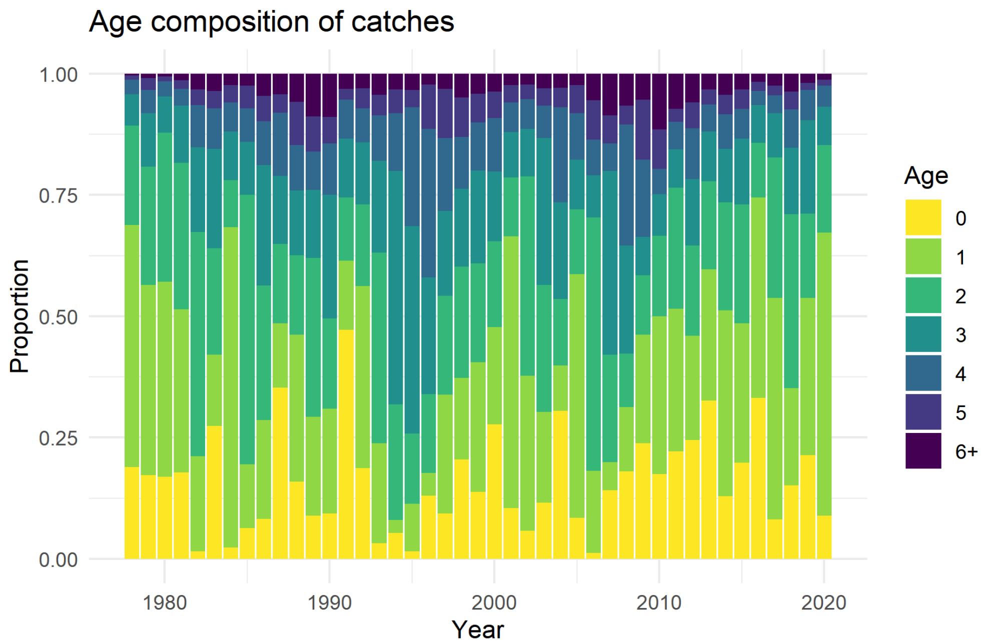

Figure 8.3.8.1. Sardine in 8c and 9a: Catches-at-age for 1978–2020.

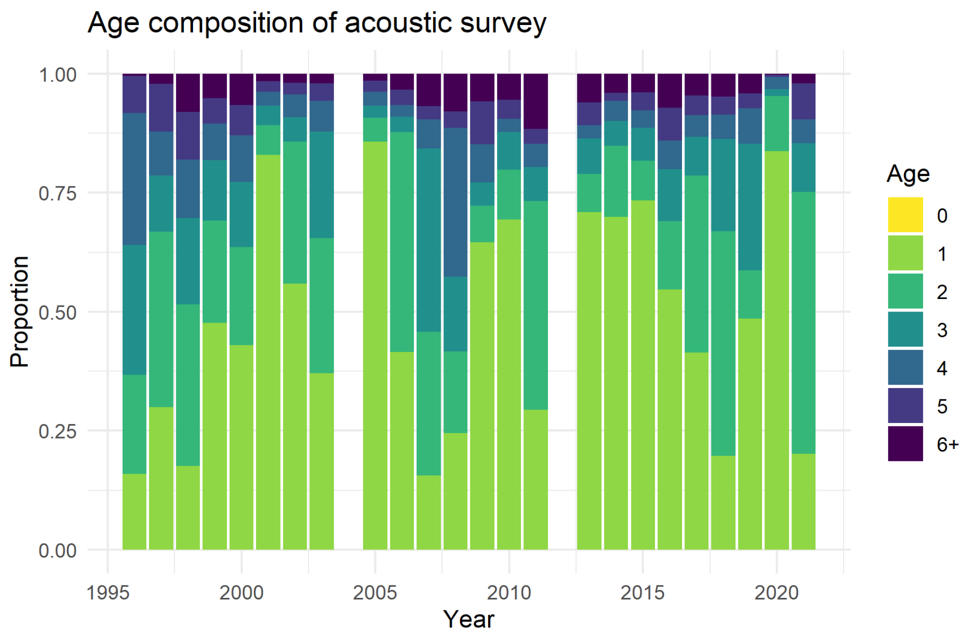

Figure 8.3.8.2. Sardine in 8c and 9a: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996–2021.

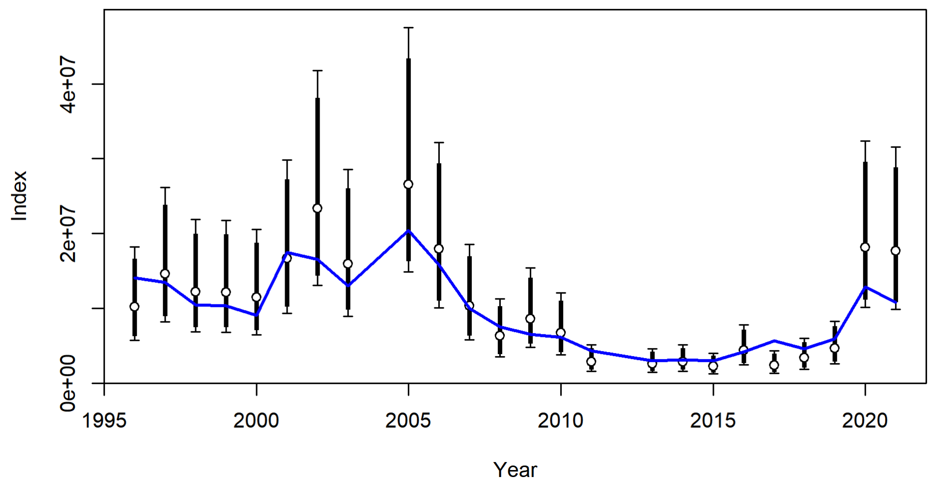

Figure 8.4.1.1. Sardine in 8c and 9a: Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

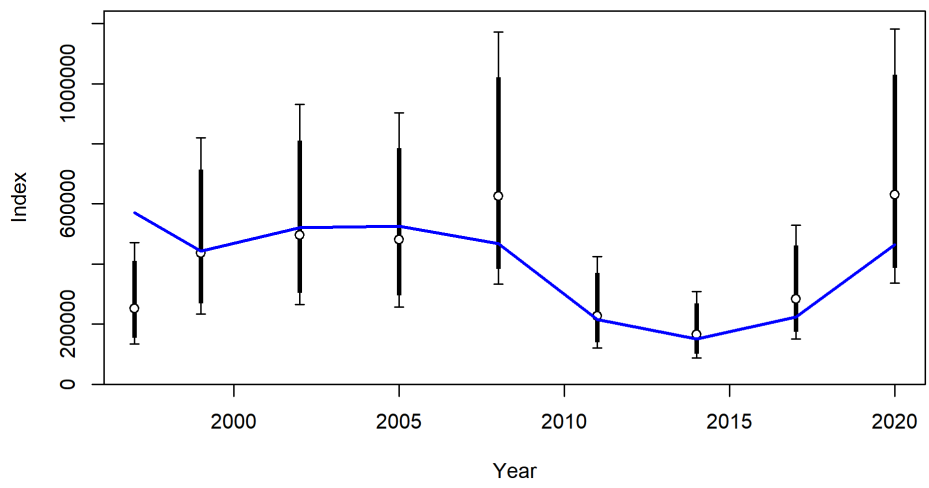

Figure 8.4.1.2. Sardine in 8c and 9a: Model fit to the DEPM survey series. The index is SSB (in thousand tonnes).Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

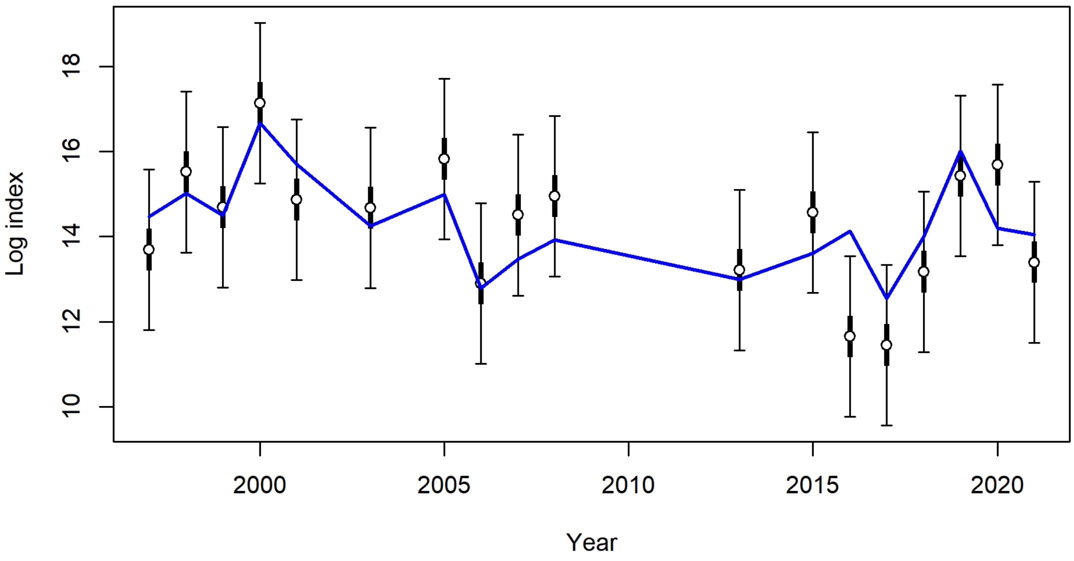

Figure 8.4.1.3. Sardine in 8c and 9a: Model fit to the log autumn acoustic survey series data on log scale. The index is age 0 abundance in subarea 9aCN (in thousand individuals). Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

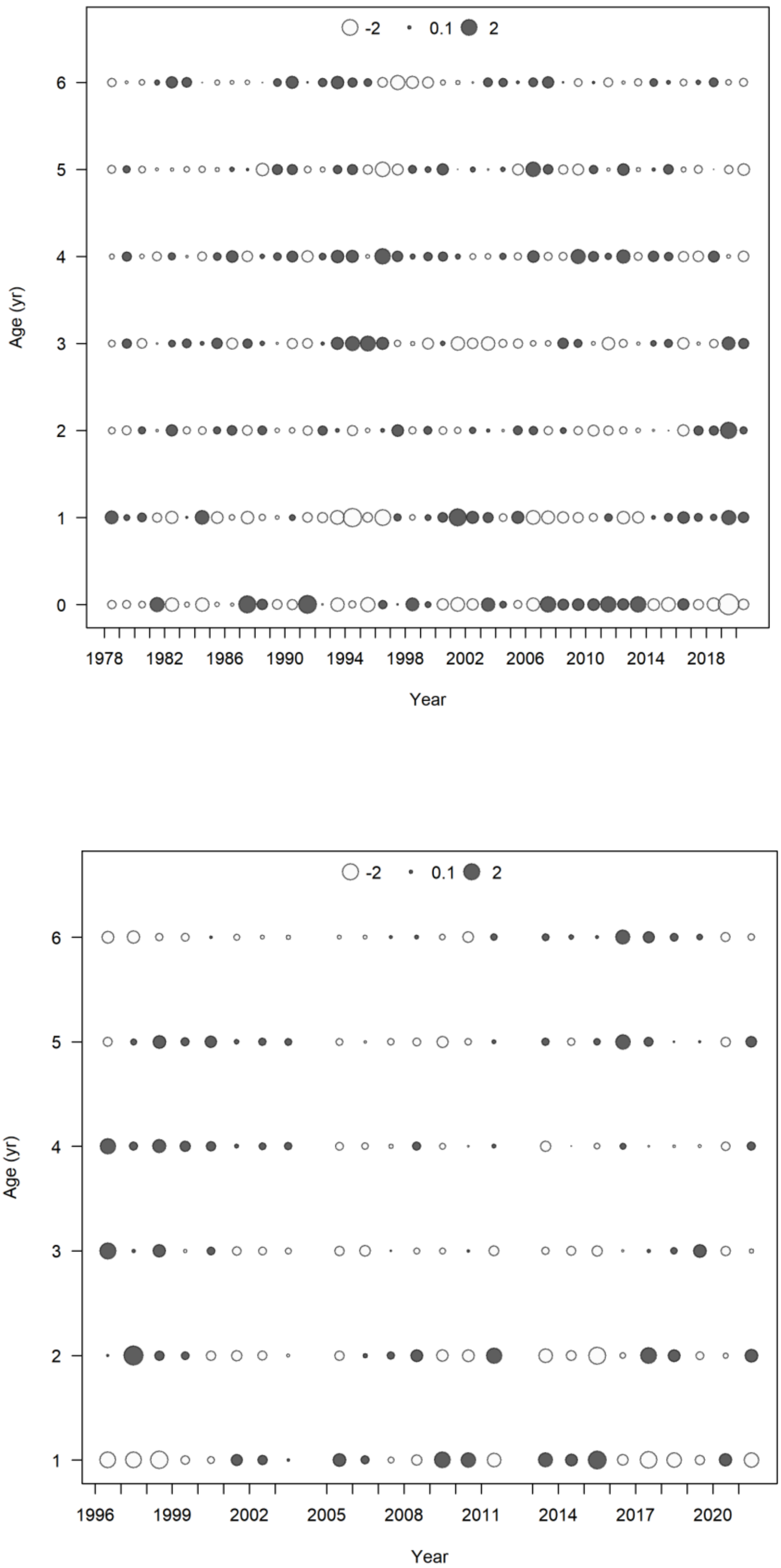

Figure 8.4.1.4. Sardine in 8c and 9a: Model residuals from the fit to the catch-at-age composition (top) and the acoustic survey age composition (bottom).

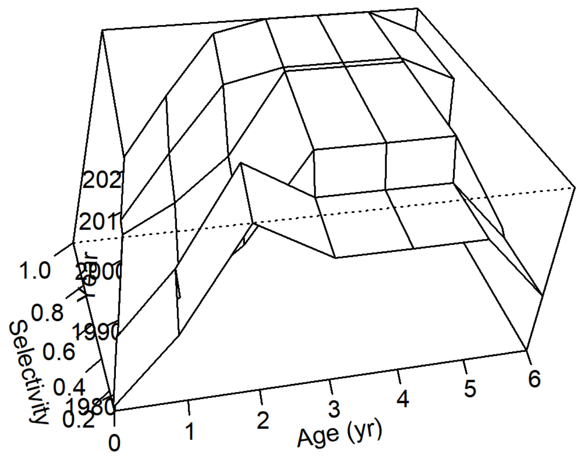

Figure 8.4.1.5. Sardine in 8c and 9a: Selectivity-at-age in the fishery showing the three blocks of fixed selectivity, 1978–1987, 1988–2005 and 2006–2021.

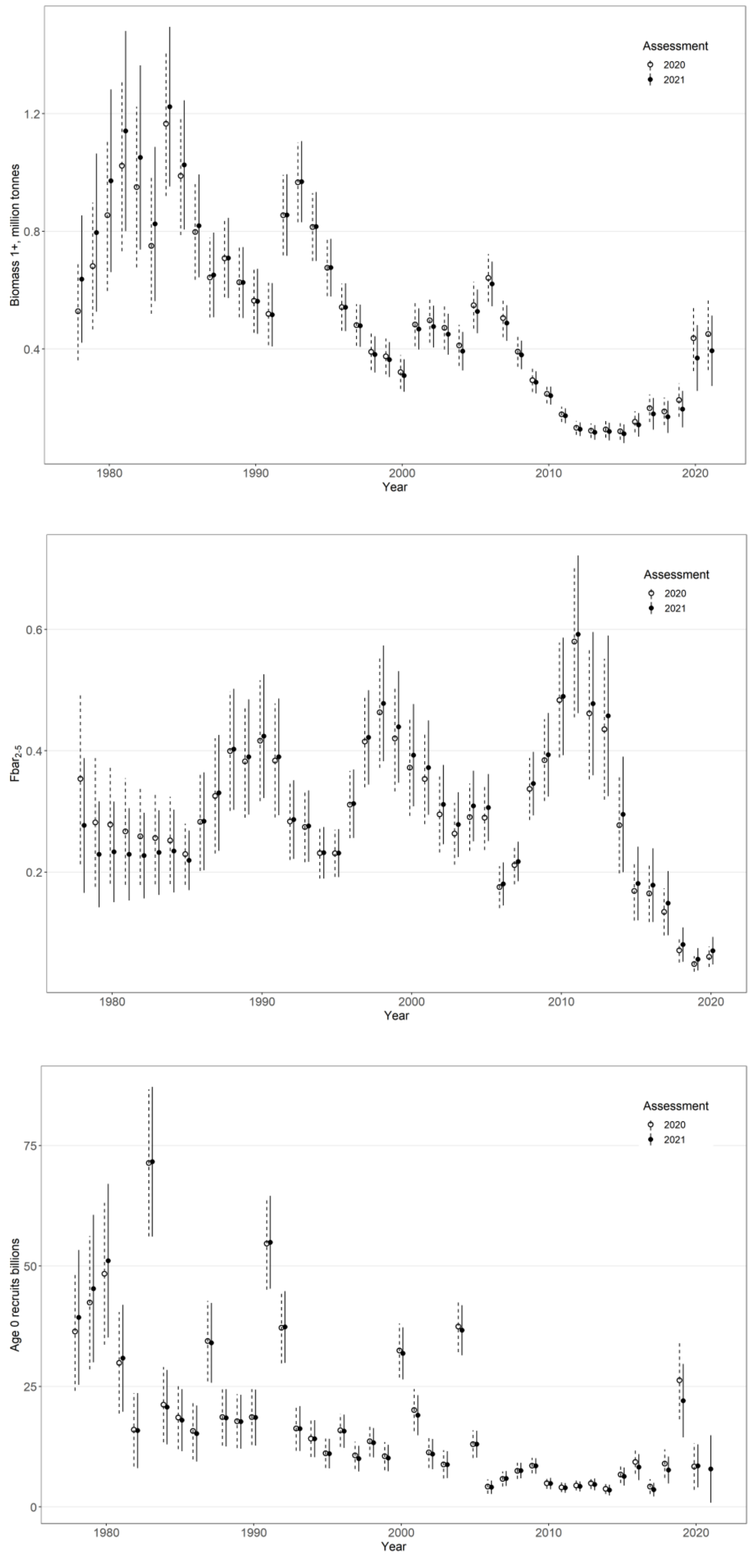

Figure 8.4.1.5. Sardine in 8c and 9a: Historical B1+ (top), $F_{bar(2–5)}$ (middle) and recruitment (bottom) trajectories in the period 1978–2021 (B1+ and recruitment is estimated up to 2021). The updated assessment of 2020 is shown for comparison (open dots and dashed lines).

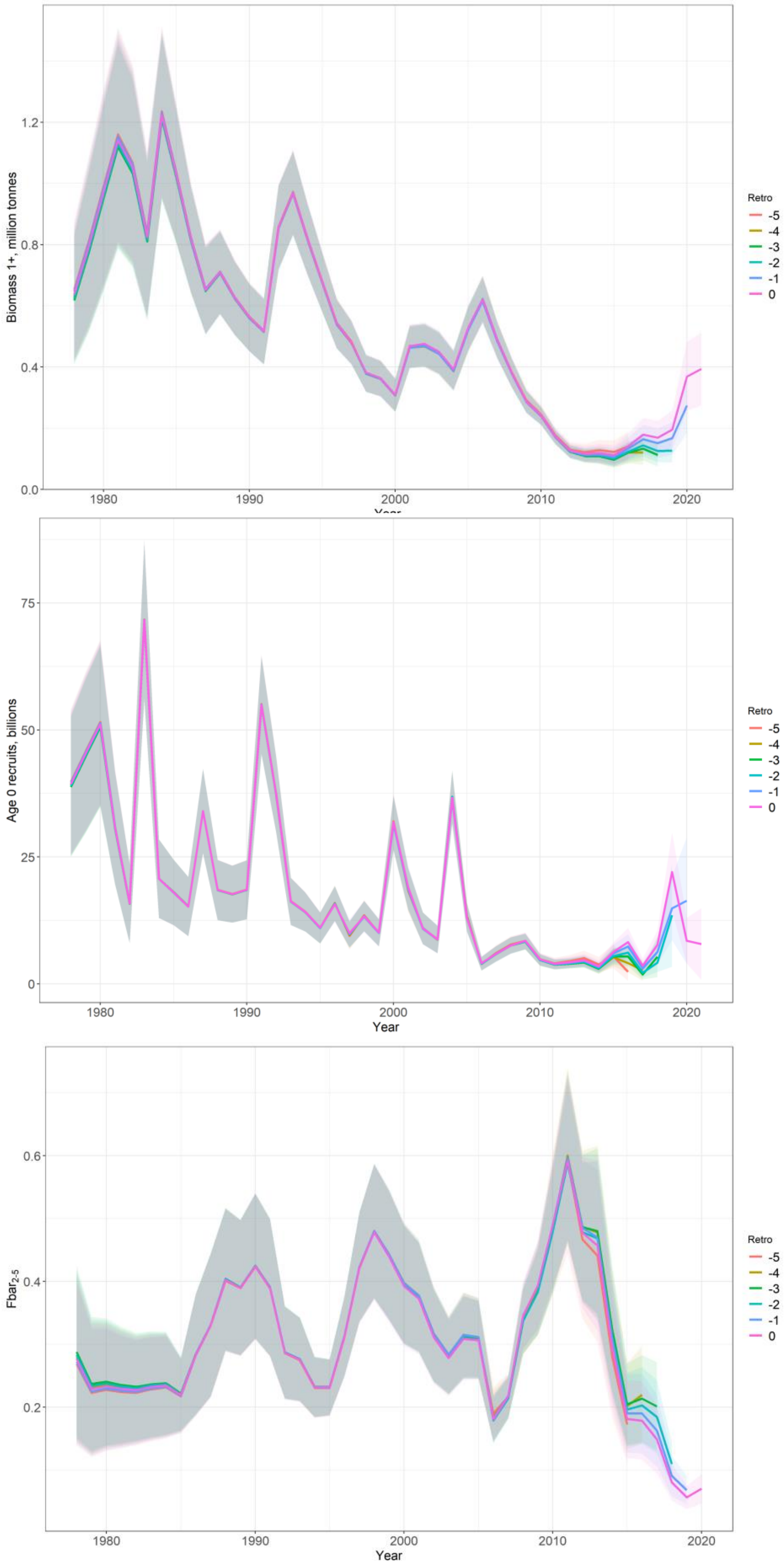

Figure 8.5.1. Sardine in 8c and 9a: Retrospective error for Biomass 1+ (top), recruitment (middle) and $F_{bar\ 2\text{-}5}$ (bottom) in the assessment.

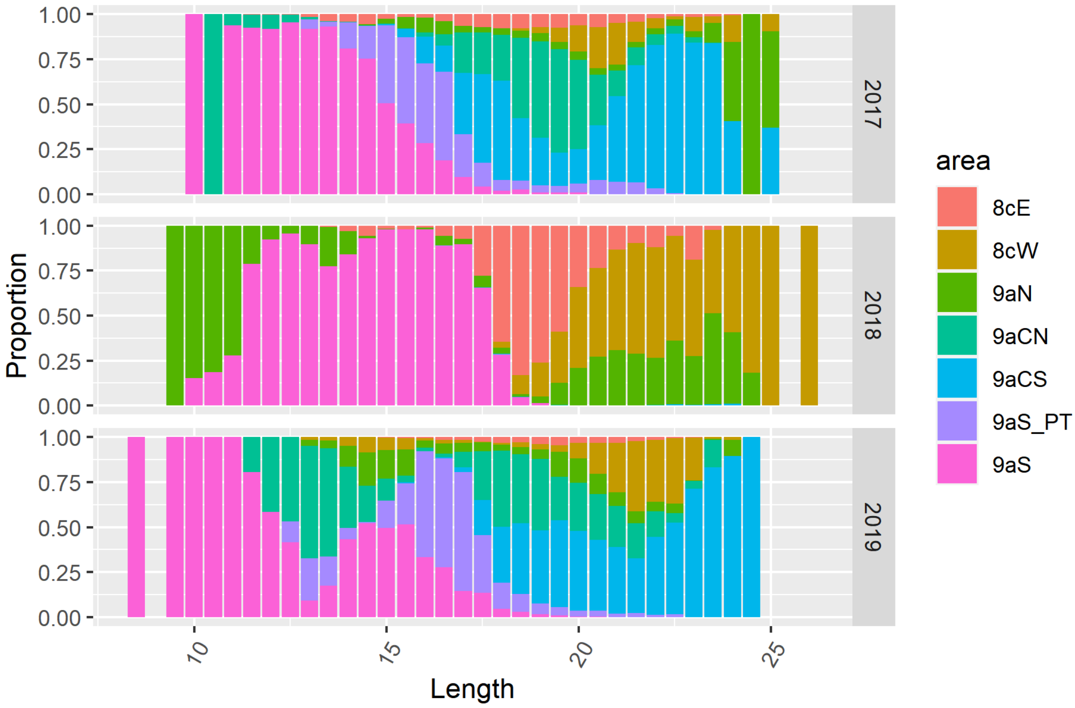

Figure 8.9.6.1 Proportion at length by subdivision (colours) and years (2017-2019).

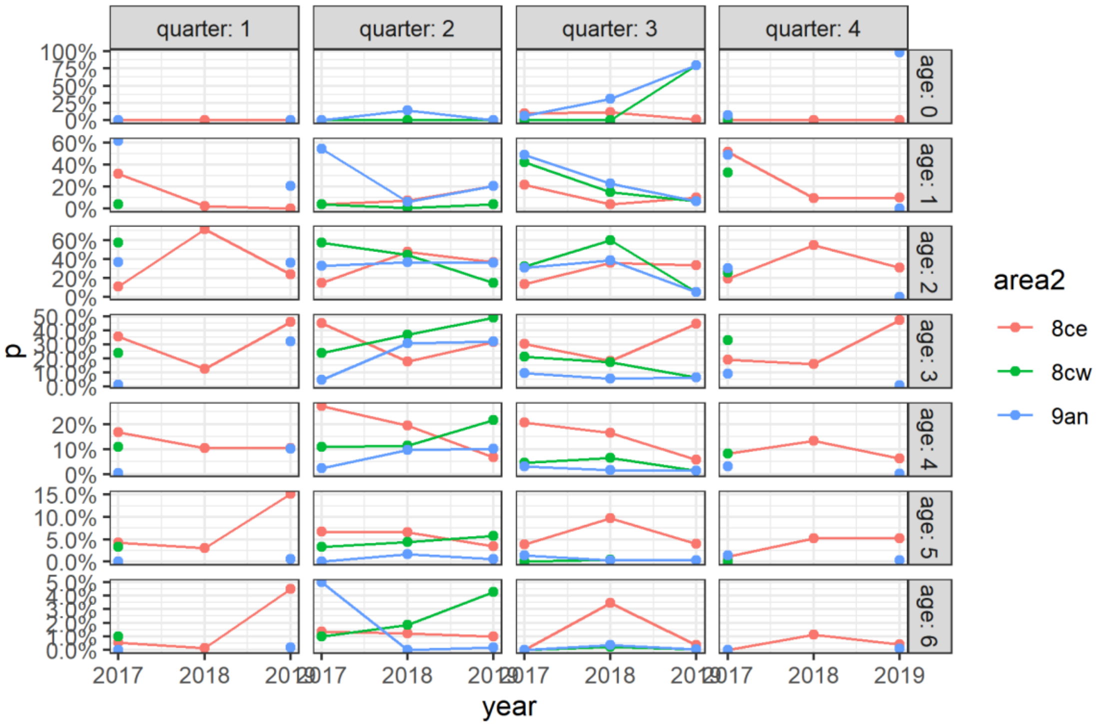

Figure 8.9.6.2 Proportion at age (rows) by quarter (columns) in years (2017-2019) in subdivision 8cW and adjacent subdivisions 8cE and 9aN.

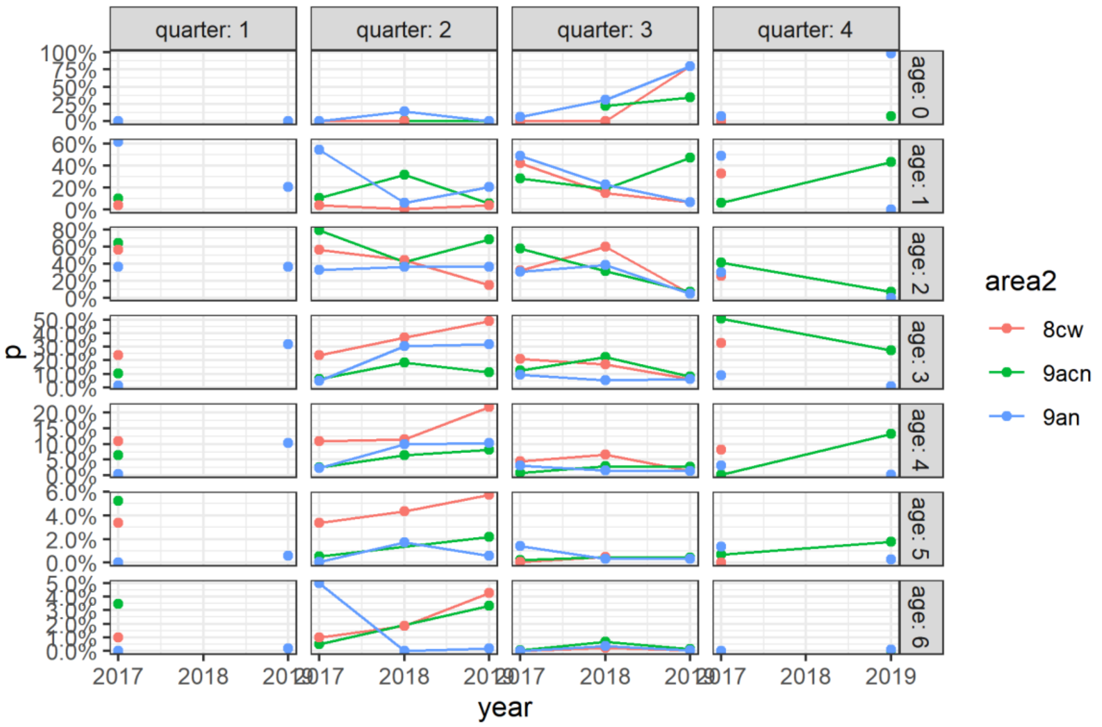

Figure 8.9.6.3 Proportion at age (rows) by quarter (columns) in years (2017-2019) in subdivision 9aN and adjacent subdivisions 8cW and 9aCN.

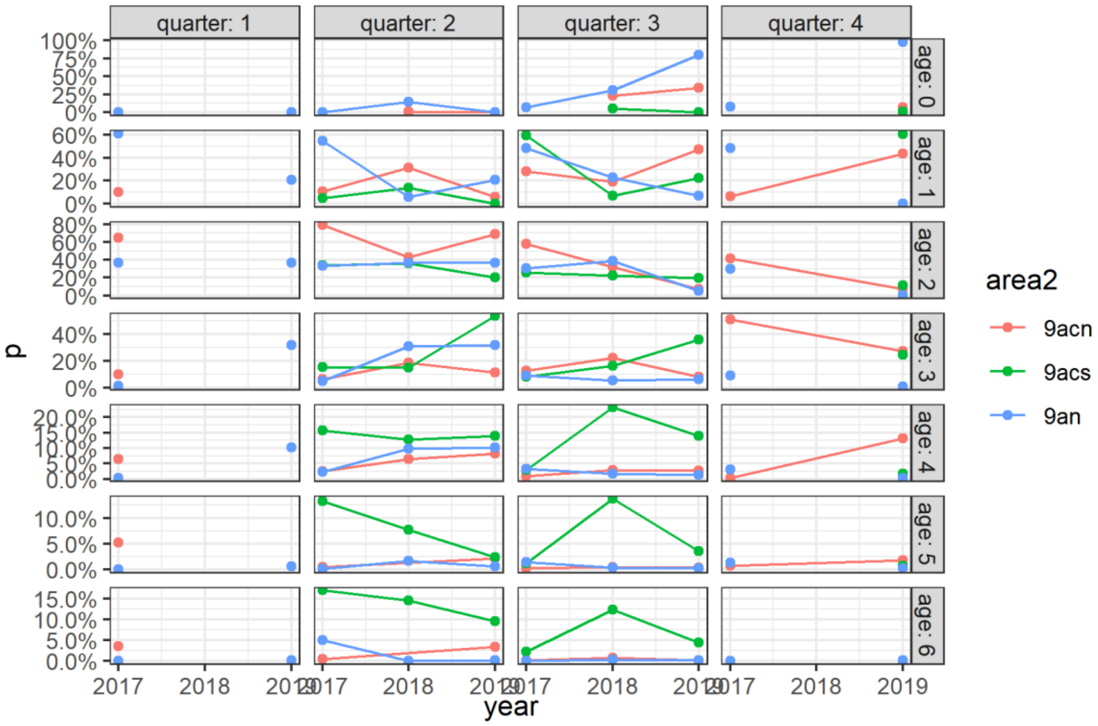

Figure 8.9.6.4 Proportion at age (rows) by quarter (columns) in years (2017-2019) in subdivision 9aCN and adjacent sub-divisions 9aN and 9aCS.

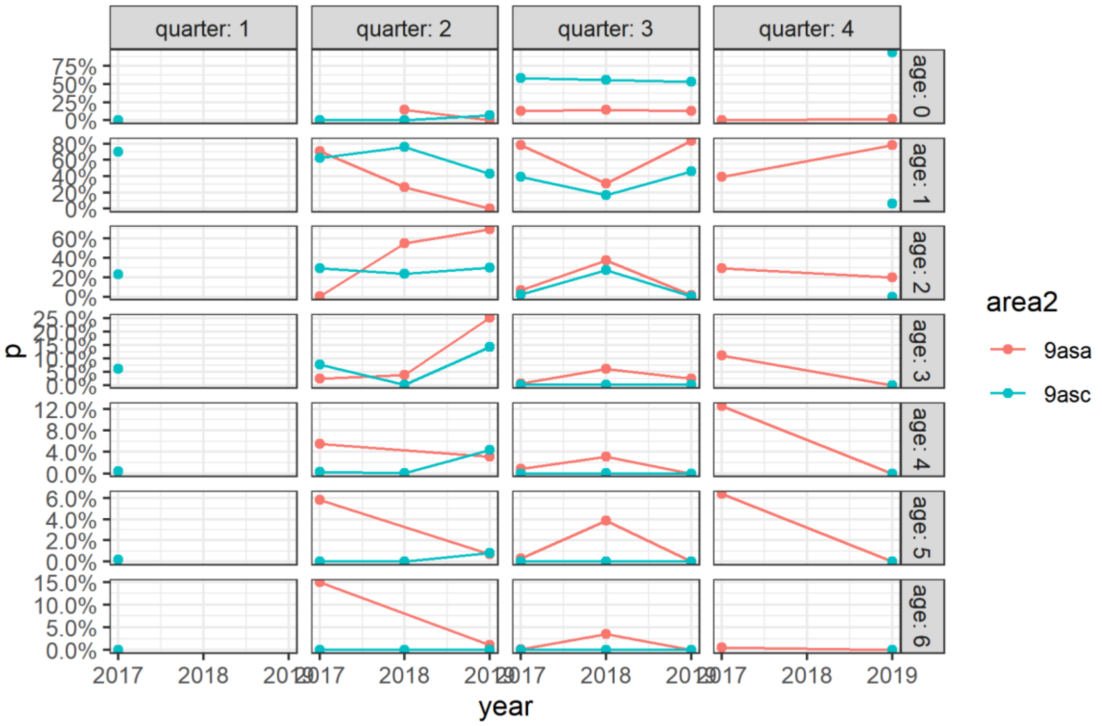

Figure 8.9.6.5. Proportion at age (rows) by quarter (columns) in years (2017-2019) in subdivision 9aS-Cádiz and adjacent subdivision 9aS-Algarve.

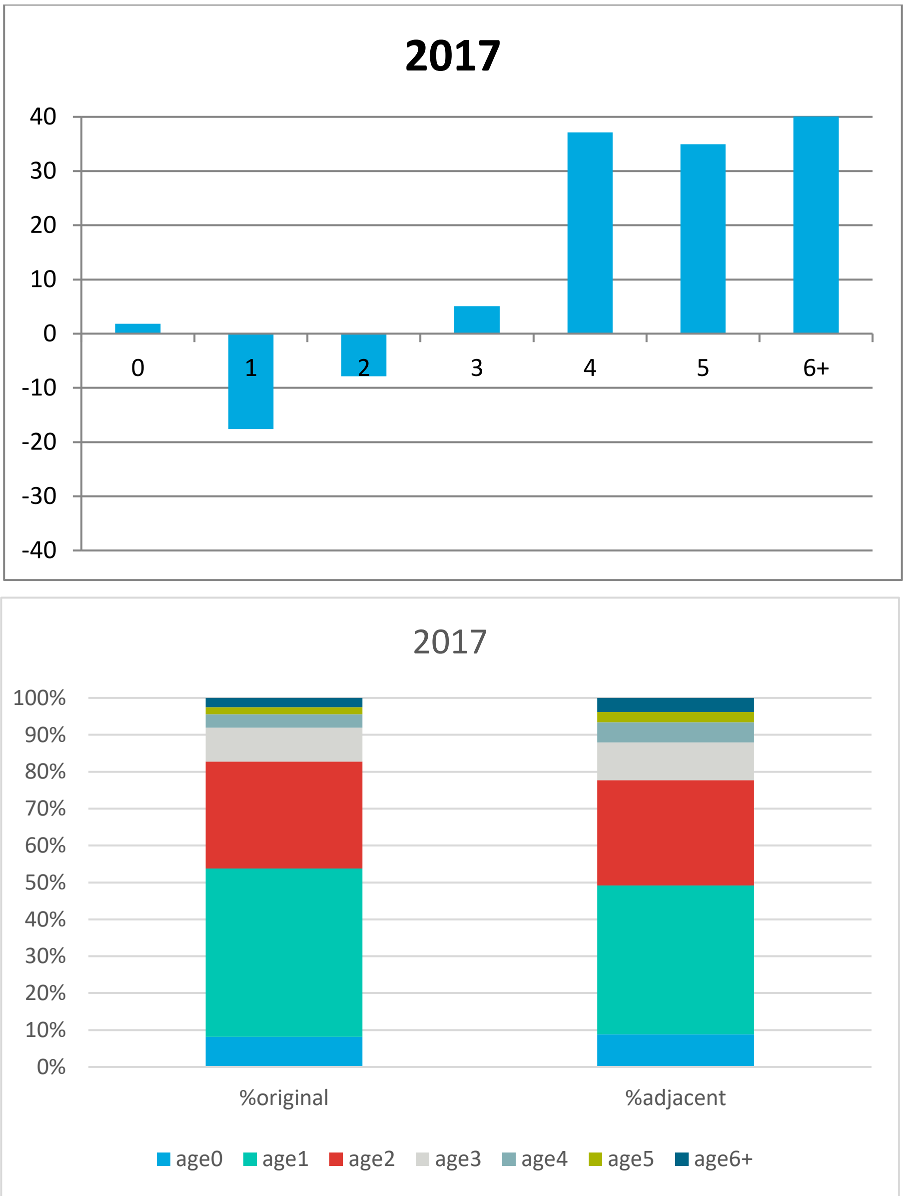

Figure 8.9.6.6. Difference at age for year 2017 (top panel in numbers, bottom panel in proportions).

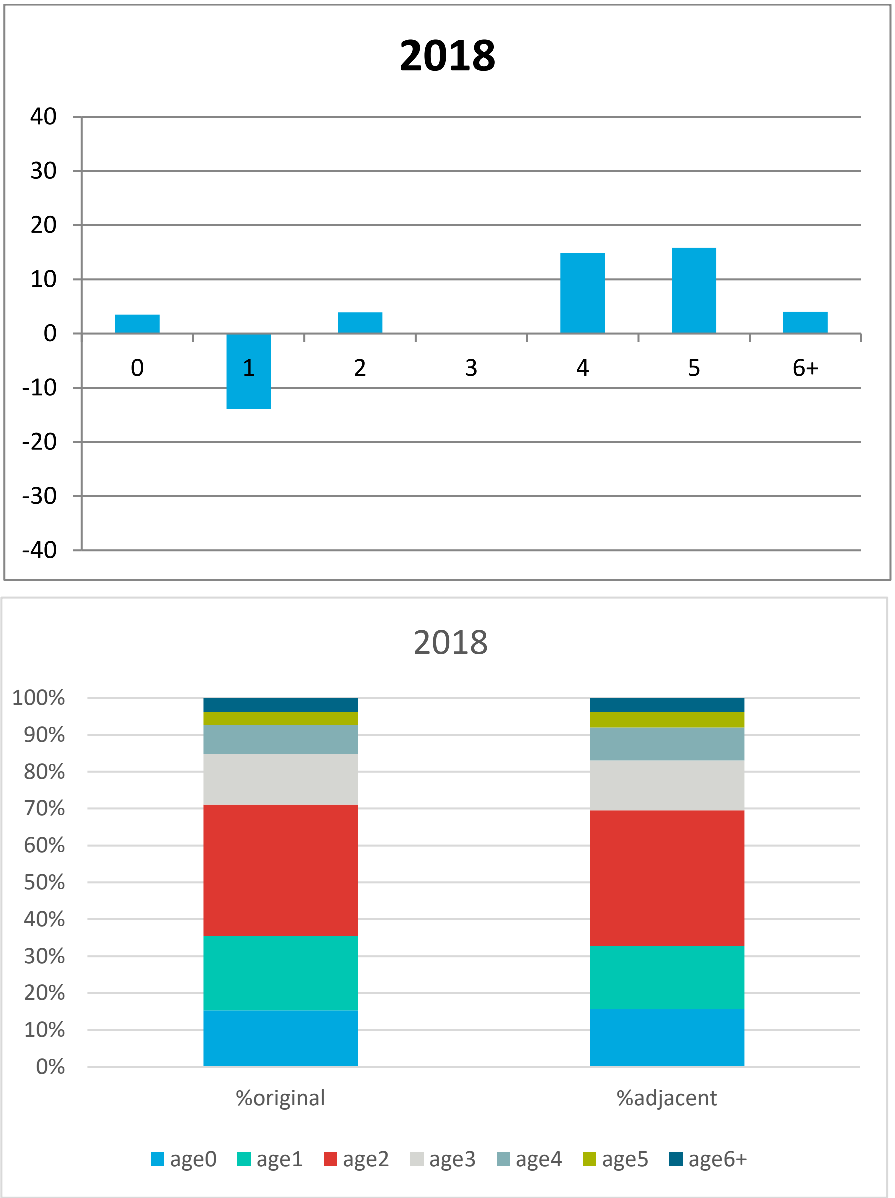

Figure 8.9.6.7. Difference at age for year 2018 (top panel in numbers, bottom panel in proportions).

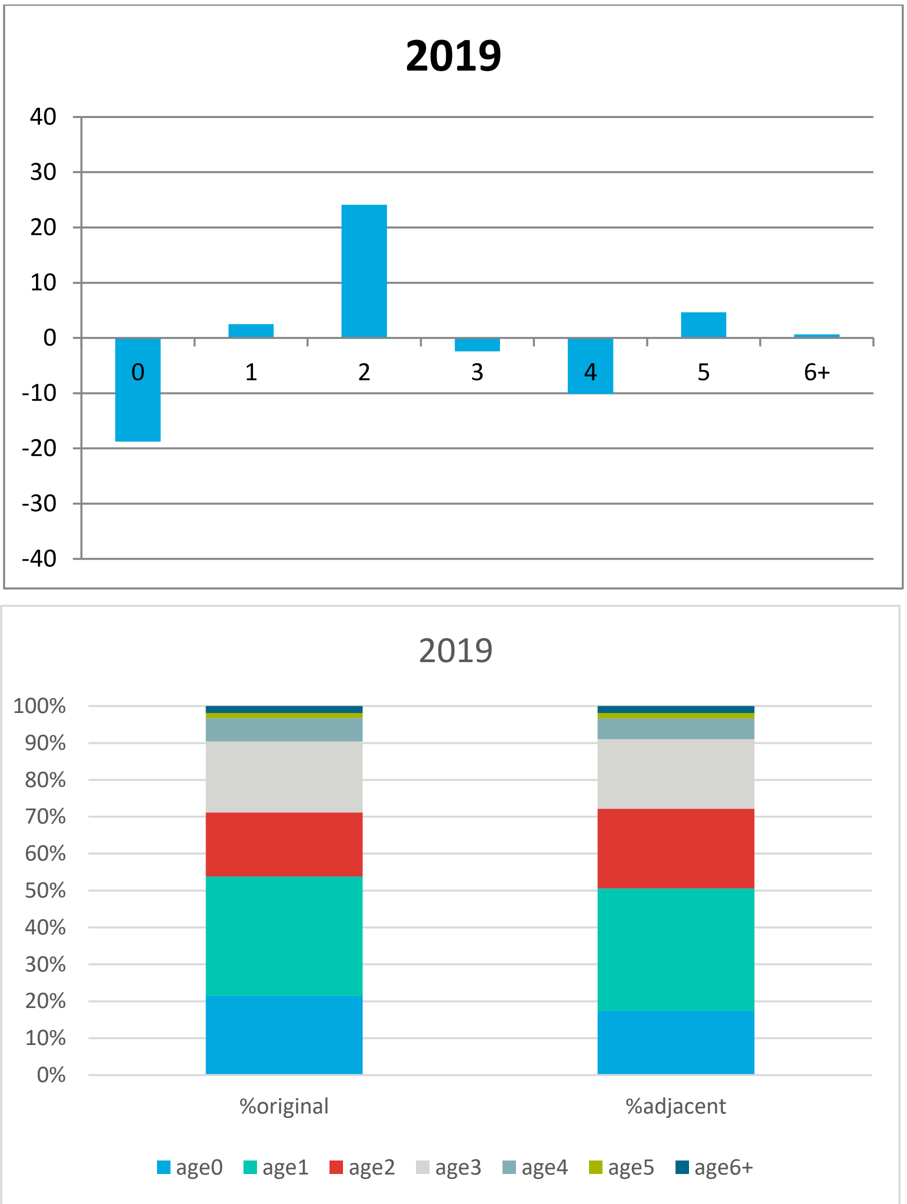

Figure 8.9.6.8. Difference at age for year 2019 (top panel in numbers, bottom panel in proportions).

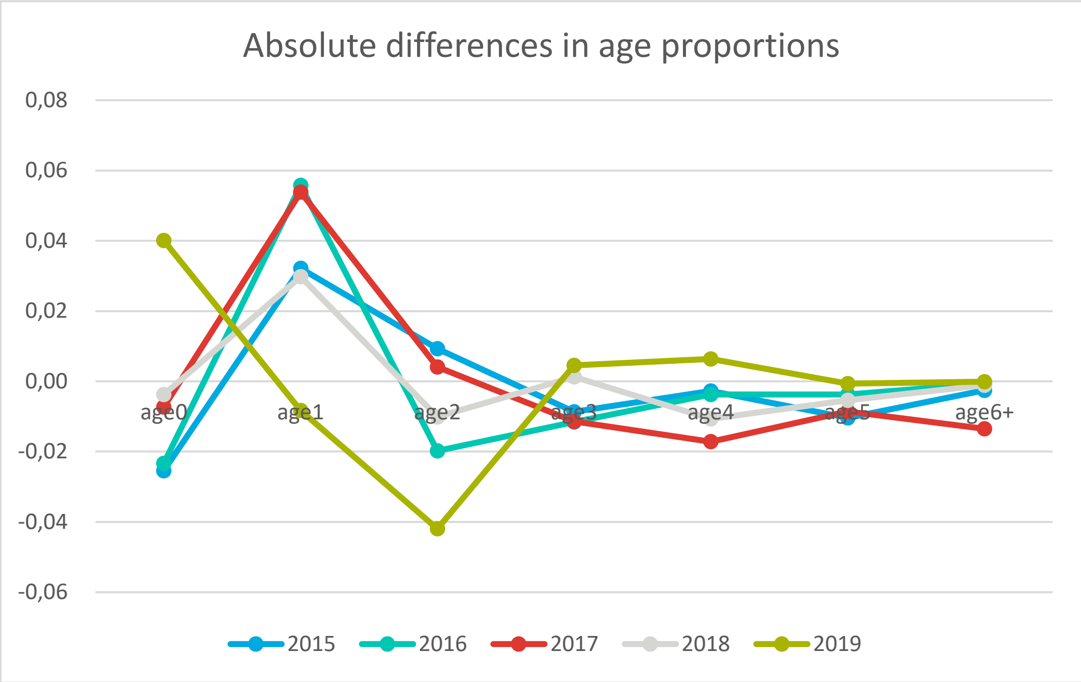

Figure 8.9.6.9. Absolute differences in age proportions.

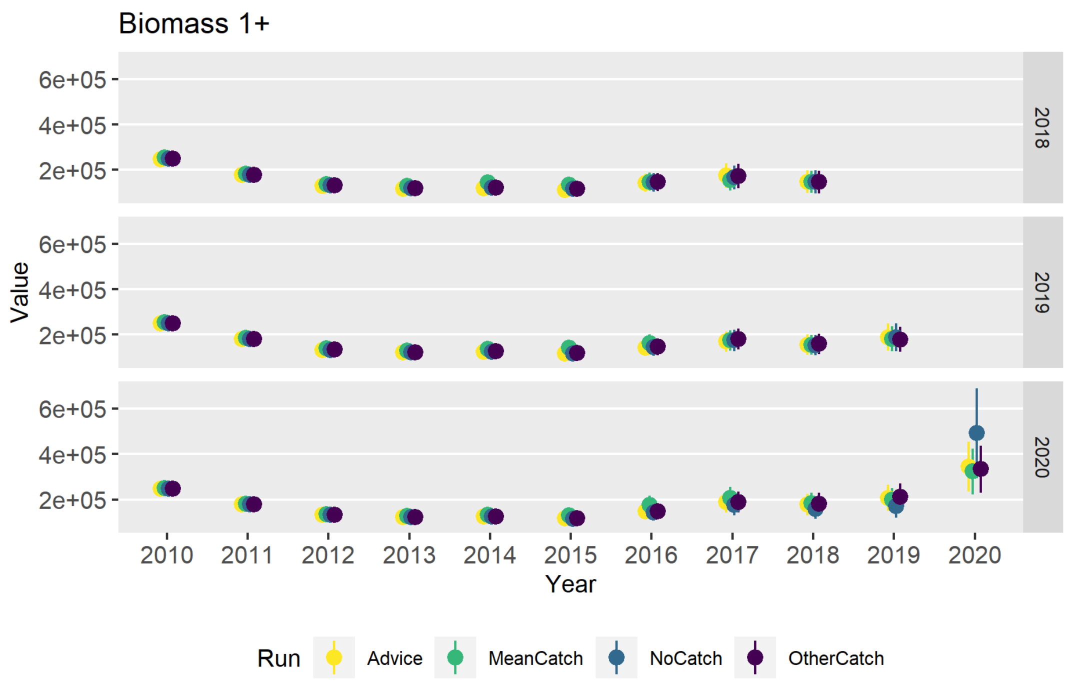

Figure 8.9.6.10. Point estimates and 95% confidence intervals of Biomass of age 1 and older for 4 runs (Advice, MeanCatch, NoCatch and OtherCatch) for three different assessments (2018, 2019, 2020).

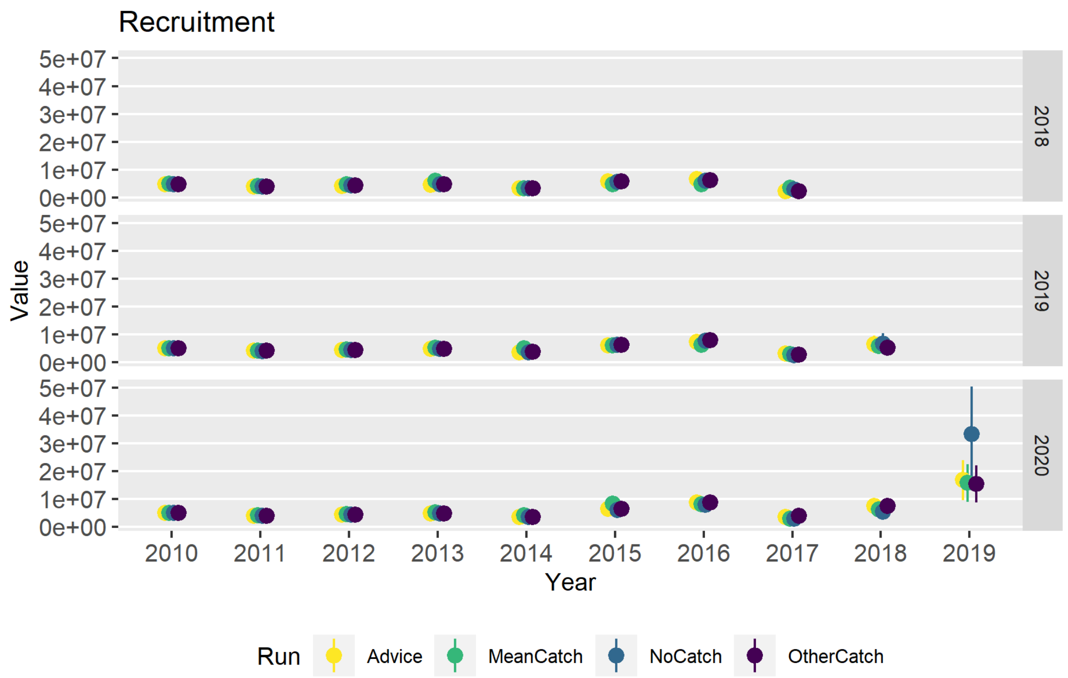

Figure 8.9.6.11. Point estimates and 95% confidence intervals of Recruitment and older for 4 runs (Advice, MeanCatch, NoCatch and OtherCatch) for three different assessments (2018, 2019, 2020).

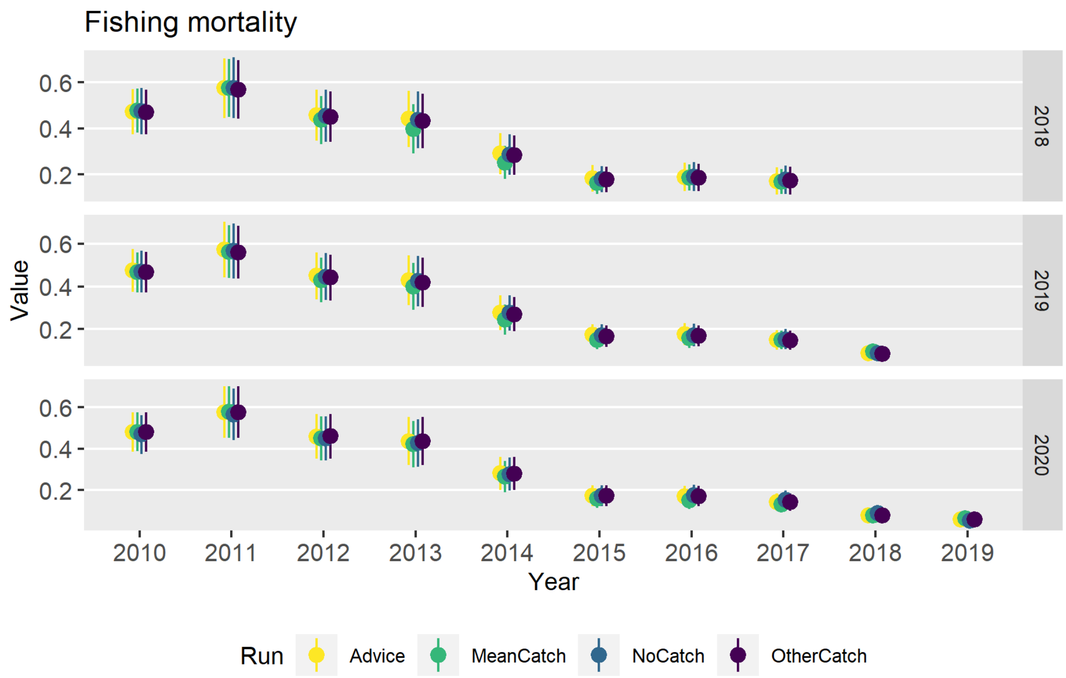

Figure 8.9.6.12. Point estimates and 95% confidence intervals of Fishing mortality and older for 4 runs (Advice, MeanCatch, NoCatch and OtherCatch) for three different assessments (2018, 2019, 2020).

9 Southern Horse Mackerel (hom.27.9.a)

9.1 ACOM Advice Applicable to 2021, 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 2011–2019 has been above the time-series average.

The ICES advice was based on the MSY approach with a $F_{MSY} = 0.11$. ICES therefore recommended that catches in 2021 should not exceed 128 627 t. ICES also recommended that the TAC for this stock should only apply to *Trachurus trachurus*. The TAC of 128 627 t in 2021 has been set for *Trachurus spp*.

In 2019, the Portuguese survey was not carried out, because this survey represents 87% of the total coverage and traverse the majority of the stock area, the combined survey index could not be estimated, the assessment was performed without fishery-independent data. Additionally, there has been a continued and significant shift in relative catch contribution from bottom trawls to purse-seines in the last years. This has led to a change in the age composition of catches, with an increase in the proportion of age-1 individuals. This may violate the assumption of constant selectivity on the last period of the assessment.

9.2 The fishery in 2020

9.2.1 Fishing fleets in 2020

The southern horse mackerel fisheries in Division 9.a are composed 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 had a significant decrease in catches for 2020. The Portuguese artisanal fleet is mainly composed by small size vessels licensed to operate with several gears (gill and trammel nets, 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 slight increase in the last few years. Horse mackerel is the main target species in the Portuguese bottom trawl fleet, in 2020 accounted for 59% of the Portuguese catches, while in Spain main catches are from the purse-seine fleet (82%). Spanish artisanal fishery is negligible (2%). In recent years, and due to the lower catch opportunities for the Iberian sardine stock (pil27.8c9a), 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 (1992–2020) shows a peak in 1998, of 41 564 t, a steady increase since 2011 to 2016 and a decrease was observed in 2020 with catches of 31 333 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 9.2.2.2. 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 but decreased from last year (-16%). Catches from the Spanish bottom trawl are relatively low despite the increase in 6% from 2019 to 2020 and the catches from the Portuguese purse seine decreased highly 40% from 2019 to 2020. The contribution of the artisanal fleet from both Portugal and Spain is very small, respectively representing 8% and 2% of the total catches in 2020.

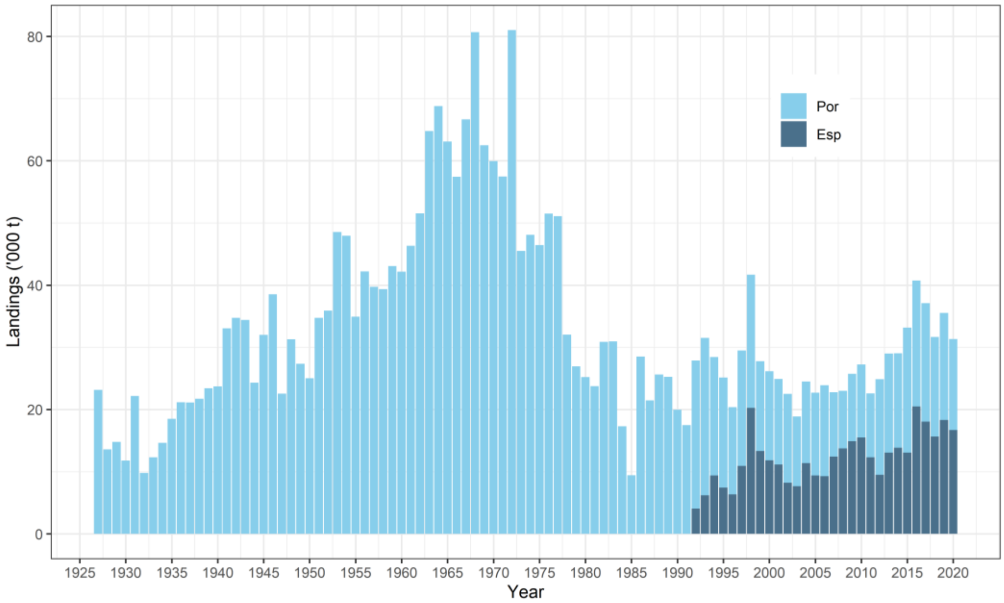

Figure 9.2.2.1. Historical time-series of landings (1927–2020) for southern horse mackerel (Division 27.9.a). Light blue bars are Portuguese landings and dark blue bars are Spanish landings.

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	28,4411
1995	25,147
1996	20,4001
1997	29,491
1998	41,564
1999	27,733
2000	26,160
2001	24,910
2002	22,506 // (23,663)*
2003	18,887 // (19,566)*
2004	23,252 // (23,577)*
2005	22,695 // (23,111)*
2006	23,902 // (24,558)*
2007	22,790 // (23,424)*
2008	22,993 // (23,593)*
2009	25,737 // (26,497)*
2010	26,556// (27,216)*
2011	21,875// (22575)*
2012	24,868//(25316)*
2013	28,993//(29,382)*
2014	29,017//(29,205)*
2015	32,723///(33,178)*
2016	40,741////(41,081)*
2017	36,946///(37,088)*
2018	31,661///(31,920)*
2019	35,520///(36,536)*
2020	30,177///(31,344)*

(*) 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 1992–2020 (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%
2020	10,961	17,588	1,617
	36.34%	58.31%	5.36%

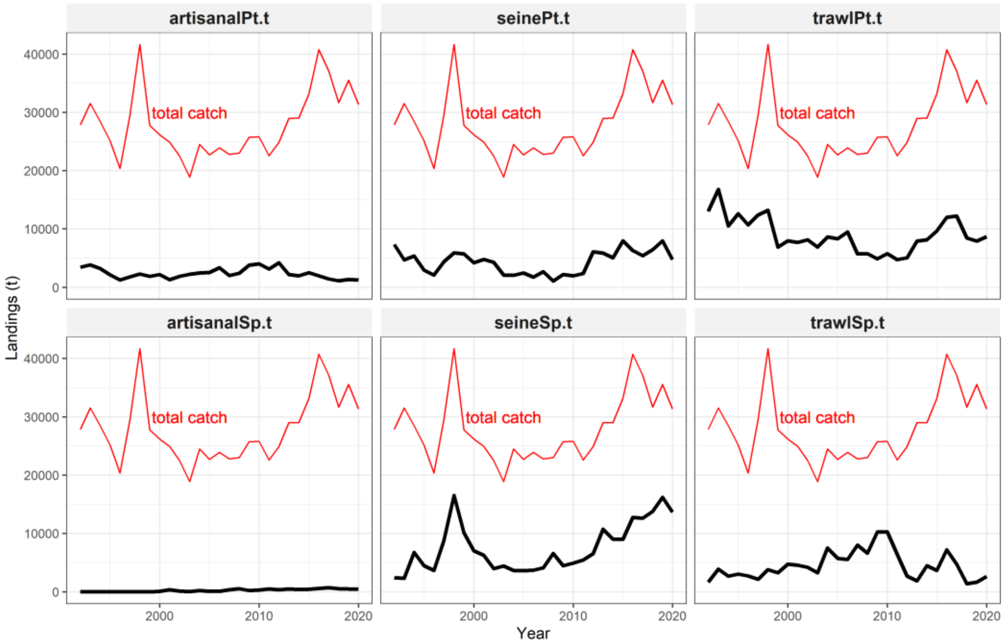

Figure 9.2.2.2. Time-series (1992–2020) of southern horse mackerel catches (in tonnes) by country (Pt – Portugal; Sp – Spain) and gear (artisanal; purse-seine, trawl).

Discards are estimated by both countries (Portugal since 2004, 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 discard sampling in ICES 27.9.a during 2020 was affected by the Covid-19 pandemic: on-board sampling in Portuguese waters of ICES 27.9.a was suspended in March 2020 and was not resumed in that year. In 2017–2019 there was a 5% discard occurrence for trawlers targeting fish and 20% for trawlers targeting crustaceans (horse mackerel catches from this metier are residual). The frequency of occurrence of discards is too low and is considered zero because such low frequency will result in highly biased estimates (Portuguese discards are usually estimated when frequency of occurrence is above 30%). The southern horse mackerel presented no or low occurrence in discards in the previous sampling period (2014–2019) and they have always been reported with zero (or negligible) discards for assessment purposes. Given that the preliminary analysis of the trawl fleet fishing behaviour in 2020 gave no indication of major differences when compared with the one performed in the previous period (2004–2019), it is also assumed that zero (or negligible) discards are expected for 2020.

The horse mackerel Spanish discards come mainly from the bottom trawl fleet. Spanish discards in 2020 at Subdivision 9a were also affected by the COVID19 disruption. On the assumption that Spanish fleet has had the same behaviour that in 2019 it has been estimated that there has been similar level of discards (about 319 t) (Table 9.2.2.3).

Table 9.2.2.3. Discard estimates (tonnes) of southern horse mackerel in 2019 (no estimates are available for 2020) by country (SP – Spain, PT - Portugal), fleet/metier, 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. Portuguese auction market sampling in the 2nd quarter was affected by the Covid-19 pandemic. Length distributions from this quarter were obtained with an alternative solution based on a remote digital measurement system using computer vision and non-contact 3D metrology solutions (http://fishmetrics.pt).

Length distributions of Spanish catches were not available for 2020 due to the low level of sampling and sampling gaps in some strata. Spanish administrative issues and COVID-19 are the reasons for a low quality of the length sampling. It was assumed the same length distribution by gear (artisanal, trawl and purse-seine) observed in Spanish fleets for 2019. 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 1992–2020, with age range 0–11+.

In general, catches are dominated by juveniles and young adults. Catches-at-age-2 showed a decrease in 2020 (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 1992–2020 (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
2020	18471	143836	57686	58352	24715	18078	8181	8553	5985	7025	3035	9365

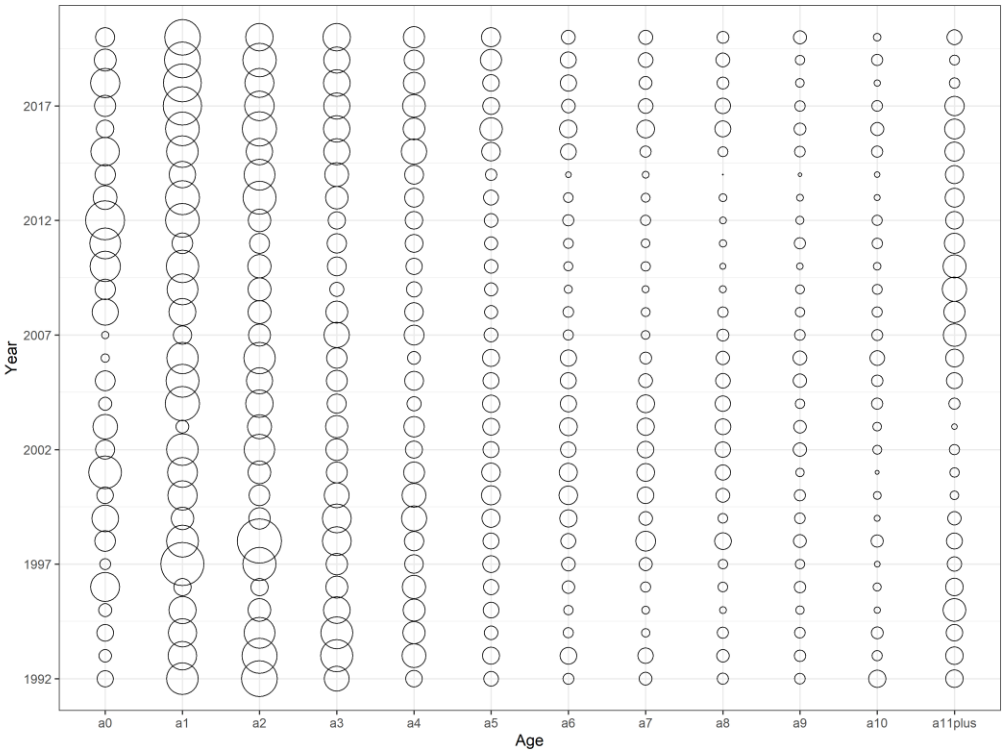

Figure 9.2.4.1. Bubble plot of proportions of southern horse mackerel catch in numbers-at-age in each year (1992–2020).

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 1992–2020. In 2020, 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 2020, 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 1992–2020.

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
2020	340	12702	19697	19380	7833	5031	3057	3304	2480	4485	2220	7690

Purse-seine

YEAR	AGES 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
2020	14992	127345	34698	35464	15550	12088	4628	4832	3191	1995	508	962

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
Artisanal												
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
2020	3138	3789	3291	3508	1332	959	496	417	315	545	306	713

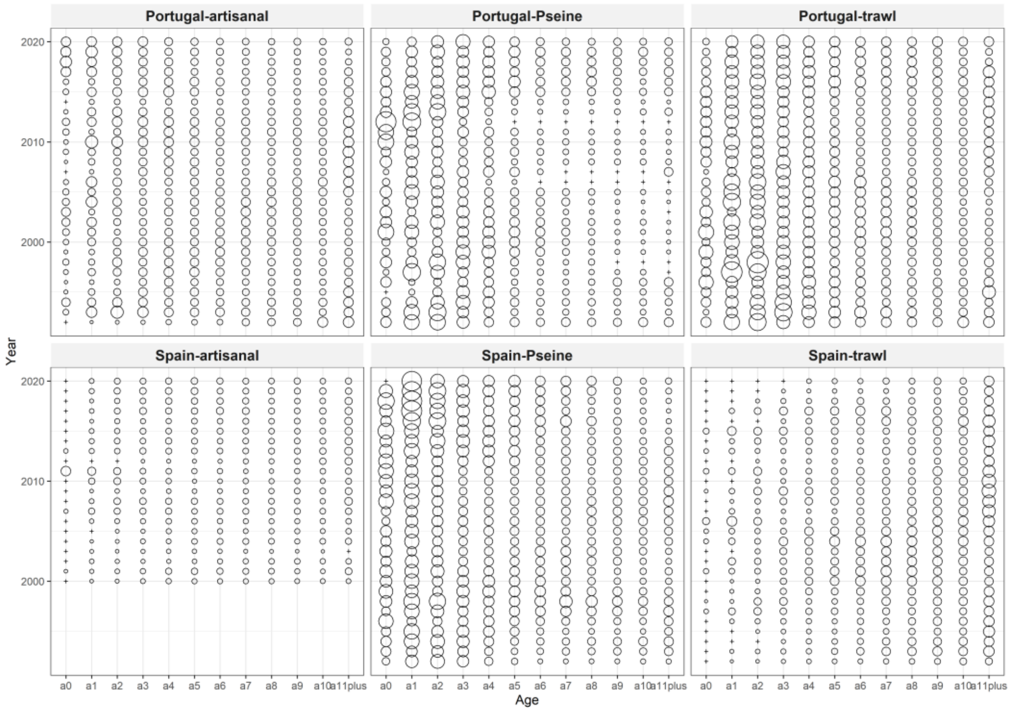

Figure 9.2.4.2. Bubble plot of proportions of southern horse mackerel catch in numbers-at-age by country and fleet in each year (1992–2020).

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 2020.

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 2020, samples of ages 14–15 were only available from area 9.a North.

Table 9.2.5.1. Southern horse mackerel mean weight-at-age (kg) in the catch (1992–2020).

	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
2020	0.02	0.04	0.06	0.07	0.10	0.13	0.16	0.20	0.22	0.25	0.30	0.39

Table 9.2.5.2. Southern horse mackerel mean length-at-age (cm) in the catch from 1992–2020 (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
2020	13.7	16.6	19.2	20.9	23.1	25.1	26.6	28.7	29.9	30.8	32.3	36.0	37.4	39.0	40.5	43.3

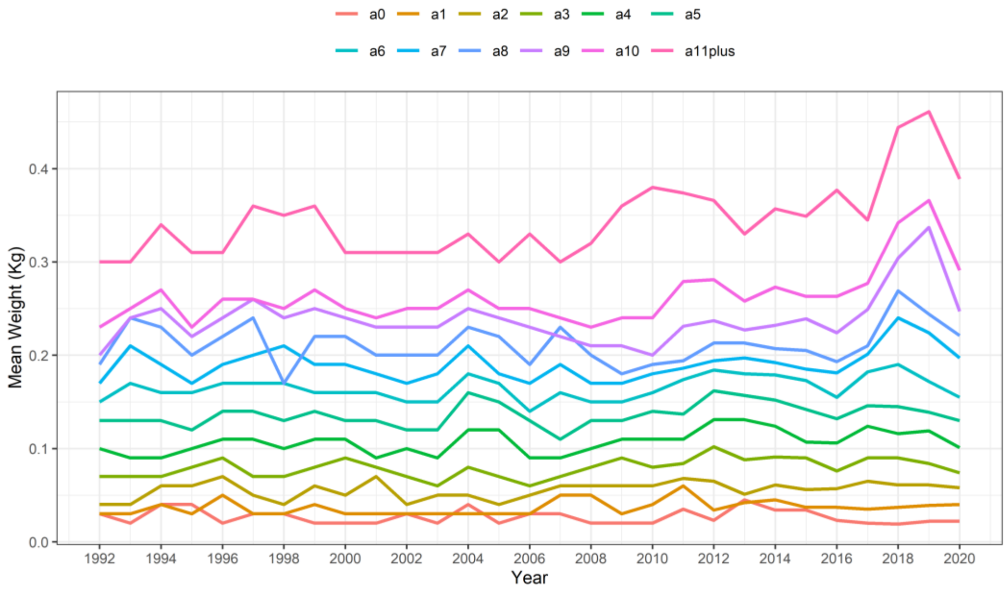

Figure 9.2.5.1. Southern horse mackerel mean weight-at-age (kg) in the catch (age range: 0 to 11+, plus group) (1992–2020).

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 - G8899) and Spain (Sp-GFS-WIBTS-Q4 - G2784) in ICES Division 9.a. Both IBTS surveys cover 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 - G4309), 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 from ICES WGMEGGS 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 2012, 2019 and 2020. Because this survey traverses the majority of the stock area, the combined survey abundance-at-age index could not be estimated for 2012, 2019 and 2020.

Table 9.3.1.1. Southern horse mackerel. CPUE-at-age (number/hour) by survey, in the period 1992–2020. The Portuguese IBTS (October) survey were not conducted in 2012, 2019 and 2020.

Portuguese October Survey

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	452.2	488.2	145.8	26.8	13.2	5.9	4.0	4.3	2.4	2.2	3.0	0.5	0.6	0.2	0.1	0.1
1993	1645.8	183.8	212.2	148.0	32.5	2.0	1.5	0.7	0.5	0.7	0.4	1.0	0.3	0.2	0.0	0.0
1994	3.7	8.0	62.9	36.1	15.2	4.2	2.0	1.7	0.8	0.5	0.3	0.1	0.0	0.0	0.0	0.0
1995	15.8	61.2	89.7	49.7	23.9	6.5	1.4	1.2	0.5	0.2	0.2	0.3	0.3	0.5	0.1	0.1
1996*	1214.1	6.3	8.7	13.5	14.0	3.6	1.7	0.6	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0
1997	2094.7	97.4	69.0	20.4	45.0	55.4	14.9	10.9	4.5	5.3	1.8	0.1	0.0	0.1	0.1	0.0
1998	86.4	33.2	161.7	17.4	2.2	1.4	0.9	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999*	159.5	20.2	31.8	34.8	2.8	1.0	0.5	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2000	2.4	13.7	17.1	19.8	11.9	6.6	4.0	1.3	0.7	0.1	0.1	0.1	0.0	0.0	0.0	0.0
2001	1292.7	1.1	8.8	3.9	6.9	13.8	12.2	11.2	6.6	2.5	1.2	0.2	0.1	0.1	0.0	0.0
2002 [1]	21.1	1.5	11.4	10.0	5.5	2.8	1.0	0.7	0.5	0.3	0.6	0.2	0.1	0.1	0.0	0.0
2003*	56.5	9.1	8.2	10.2	8.8	3.3	2.3	1.2	0.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0
2004	58.6	37.1	111.8	38.0	6.7	3.0	1.4	3.5	5.0	0.9	0.2	0.0	0.0	0.0	0.0	0.0
2005	351.9	1188.6	162.2	45.2	21.7	10.4	13.7	14.4	11.7	6.6	4.1	4.6	4.1	0.9	1.0	0.3
2006	65.1	84.6	181.8	46.6	3.4	10.3	7.4	6.6	2.7	1.4	0.4	0.1	0.0	0.0	0.0	0.0
2007	36.2	2.0	22.6	31.5	25.1	9.2	2.5	1.2	0.1	0.4	1.3	1.1	0.5	0.2	0.2	0.4
2008	47.6	28.2	39.7	20.6	26.7	17.3	2.2	0.8	1.2	1.8	1.3	1.0	0.5	0.9	0.5	1.8
2009	1245.2	79.5	147.0	52.4	44.7	11.6	2.8	1.7	1.4	0.9	0.7	0.4	0.7	1.7	0.4	0.8
2010	83.3	36.8	32.8	25.6	38.3	14.1	5.2	7.0	4.7	4.6	1.6	1.8	1.5	1.9	2.1	3.0
2011	132.8	33.1	24.5	16.2	4.7	1.1	0.3	0.4	0.2	0.4	0.5	0.2	0.3	0.4	0.2	0.2
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	12.5	363.7	820.0	105.4	18.9	3.0	2.5	2.7	2.2	2.2	1.5	0.8	1.2	0.4	0.3	0.2
2014	53.6	33.3	24.1	69.2	25.6	5.2	1.6	1.5	0.9	1.2	2.2	2.6	3.0	2.5	0.9	0.6
2015	900.2	160.3	112.5	46.6	38.0	4.5	2.3	1.0	0.8	0.9	0.7	0.5	0.4	0.5	0.3	0.5
2016	1.6	17.1	23.1	76.8	53.6	7.6	4.3	6.0	2.4	1.3	1.6	2.0	2.7	1.7	0.2	1.7
2017	68.2	440.0	584.2	263.0	177.1	27.9	3.5	13.5	19.2	2.4	2.1	1.6	1.0	0.9	0.0	0.0
2018	124.5	192.6	177.3	96.7	12.5	14.2	19.9	9.4	10.0	3.5	0.3	0.1	0.1	0.0	0.0	0.0
2019	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2020	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

(*) The surveys were carried out with a different research vessel.

(**) Since 1997, another stratification design in the Spanish surveys.

(1) In 2002, the duration of the trawling hauls changed from one hour to 30 minutes.

Spanish October Survey (only Subdivision IXa North)

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	1.0	0.4	0.5	0.3	0.1	0.6
1993	33.1	0.4	1.2	0.9	0.1	0.0	0.6	2.5	2.6	3.6	2.2	4.2	0.8	0.5	0.1	0.2
1994	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6	0.0	3.7	3.0	0.3	1.5
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.6	1.0	2.2	0.6	0.5
1996	8.4	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.7	0.2	0.1	0.5	0.7	0.3	1.1
1997**	0.5	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.5	0.2	0.1	0.1	0.2	0.3	0.7
1998	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.6	0.9	0.7	1.3	0.5	0.4	0.1
2000	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.8	1.0	0.9	0.2	0.2	0.1	0.1	0.1	0.2
2001	3.4	0.8	0.0	0.0	0.0	0.1	0.1	0.7	1.2	1.1	0.9	0.5	0.3	0.3	0.0	0.1
2002	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.4	2.1	2.0	2.5	2.9	1.0	1.2	0.4	0.6
2003	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.2	0.1	0.1	0.0	0.0	0.2
2004	24.1	0.3	0.7	4.3	1.4	1.2	0.5	0.4	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0
2005	938.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.1	0.1	0.0	0.0
2006	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1
2007	0.4	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.4	0.2	0.2	0.2	0.0	0.1	0.1	0.0
2008	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1
2009	23.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1
2010	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.2	0.3	0.3
2011	0.4	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.3	0.3	0.0	0.0	0.0	0.1	0.2
2012	12.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.2
2013	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2014	0.3	7.5	1.2	8.5	8.0	2.6	0.4	0.2	0.2	0.2	0.2	0.1	0.9	0.0	0.0	0.0
2015	6.6	0.0	0.1	1.9	2.8	1.0	0.1	0.2	0.0	0.1	0.2	0.0	0.1	0.0	0.1	0.2
2016	11.9	2.8	20.0	3.2	4.0	11.0	4.6	2.2	0.5	0.3	0.1	0.0	0.0	0.0	0.1	0.1
2017	4.9	27.1	171.7	84.1	48.6	13.4	17.7	0.4	0.7	0.1	0.4	0.1	0.0	0.0	0.0	0.0
2018	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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
2020	12.5	37.4	121.3	32.8	5.1	0.7	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0

***** The surveys were carried out with a different vessel
****** Since 1997 another stratification design was applied in the Spanish surveys
1 In 2002 started a new series in which the duration of the trawling per haul has changed from one hour to thirty minutes

Table 9.3.1.2. Southern horse mackerel. Stratified mean abundance-at-age (number/hour) in the period 1992–2020. There were no Portuguese surveys in 2012, 2019 and 2020 and therefore the combined survey indices for 2012, 2019 and 2020 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
2020	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 1992–2020 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, 2019 and 2020 the Portuguese survey was not carried and, hence, the combined survey indices for 2012, 2019 and 2020 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 dataseries 1992–2020.

Name	Year range	Age range	Assumptions/settings
Catch in weight	1992–2020		Variable in time
Catch-at-age	1992–2020	0–11+	Variable by age and time; assuming a constant CV of 5%
IBTS (Spanish-Portuguese) mean stratified abundance-at-age	1992–2018 (except 2012)	1–11+	Variable by age and time; assuming a constant CV of 30%
Mean weight-at-age (catch & stock)	1992–2020	0–11+	Variable by age and time
Proportion of F and M before spawning	1992–2020	0–11+	Fixed at 0.04 (mid-January)
Natural Mortality	1992–2020	0–11+	Age-dependent; time invariant
Catch-at-age selectivity	1992–2020	0–11+	Dome-shaped; constant at age 7+ Three blocks 1992–1997; 1998–2011; 2012–2020
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—2018	1–11+	Dome-shaped; constant at age 7+ One time-block 1992–2019 (no survey index in 2012, 2019 and 2020)
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	1992–2020	0–11+	Multinomial distribution
Proportion-at-age in the survey	1992–2020	1–11+	Multinomial distribution
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 1992–2020.

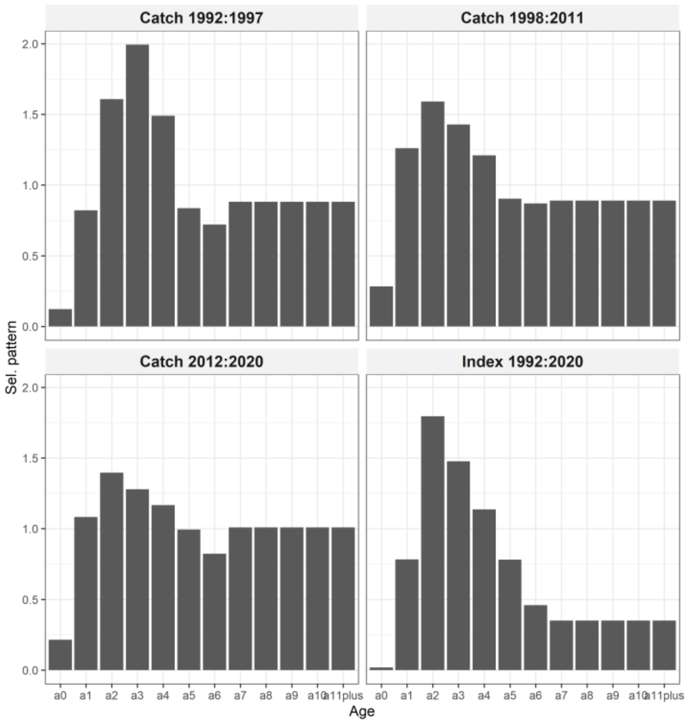

Figure 9.4.1.1. Southern horse mackerel. Estimated selectivity for the catch-at-age (three time blocks) and for the IBTS combined stratified mean abundance-at-age (one time block).

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 (1992-2020). Stock summary table (SSB at spawning time in mid-January).

Year	Recruits (10*3)	SD	CV	SSB (t)	SD	CV	mean F_{2-10}	SD	CV	Catch (t)
1992	4463320	911282	0.20	305266	77129	0.25	0.084	0.020	0.24	27858
1993	3125940	671150	0.21	327415	85434	0.26	0.089	0.022	0.25	31521
1994	3085070	668511	0.22	349669	95011	0.27	0.073	0.019	0.26	28441
1995	4227780	890856	0.21	334146	93880	0.28	0.070	0.018	0.26	25147
1996	11372800	2185470	0.19	355887	102845	0.29	0.051	0.013	0.26	20400
1997	3741120	784521	0.21	374673	108529	0.29	0.070	0.019	0.27	29491
1998	2399250	537215	0.22	378601	108172	0.29	0.093	0.025	0.27	41564
1999	3659150	782399	0.21	431044	127001	0.29	0.057	0.016	0.28	27733
2000	3338670	732204	0.22	416495	125099	0.30	0.059	0.017	0.28	26160
2001	3948390	861384	0.22	400076	122708	0.31	0.058	0.016	0.28	24910
2002	2234510	528314	0.24	387340	120665	0.31	0.057	0.016	0.28	22506
2003	4434010	979395	0.22	387822	122010	0.31	0.048	0.013	0.28	18887
2004	4888150	1079260	0.22	440090	139590	0.32	0.052	0.015	0.28	23252
2005	3074530	713833	0.23	402780	128617	0.32	0.053	0.015	0.28	22695
2006	1603890	412096	0.26	390740	124971	0.32	0.058	0.017	0.29	23902
2007	2377910	590722	0.25	394374	127858	0.32	0.056	0.016	0.29	22790
2008	3771960	924909	0.25	388570	128335	0.33	0.057	0.017	0.3	22993
2009	3520100	905320	0.26	389360	131353	0.34	0.065	0.020	0.31	25737
2010	4403520	1162350	0.26	390933	134668	0.34	0.065	0.020	0.31	26556
2011	10922900	2788260	0.26	393644	138102	0.35	0.041	0.013	0.32	21875
2012	12896200	3298470	0.26	417338	145884	0.35	0.043	0.014	0.32	24868
2013	7128300	1928440	0.27	423390	144967	0.34	0.043	0.014	0.33	28993
2014	9640120	2606320	0.27	533183	176963	0.33	0.038	0.013	0.33	29017
2015	10503200	2948300	0.28	586363	191453	0.33	0.042	0.013	0.32	32723
2016	11626700	3442860	0.30	622618	202322	0.32	0.050	0.016	0.32	40741
2017	15151300	4728890	0.31	735017	239984	0.33	0.040	0.013	0.32	36946
2018	14285000	4843890	0.34	897896	292493	0.33	0.028	0.009	0.32	31661
2019	15326400	5689570	0.37	998293	322319	0.32	0.028	0.009	0.32	35520
2020	5380400	3071090	0.57	983373	317532	0.32	0.024	0.008	0.33	30177
Average	6432089	1781630	0.26	477117	150893	0.31	0.055	0.016	0.29	27761

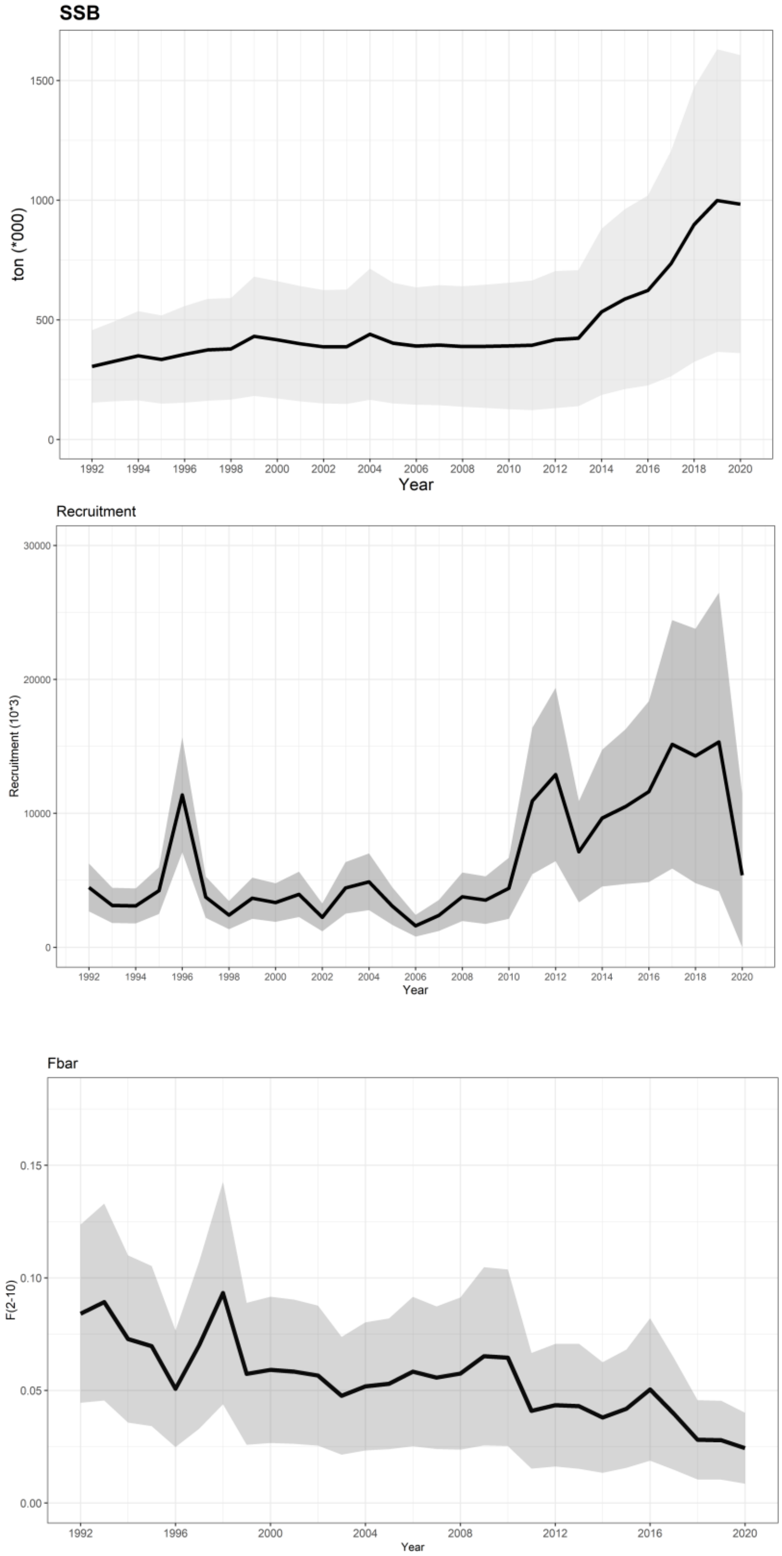

Figure 9.4.1.2. Southern horse mackerel final assessment (1992–2020). Plots of SSB (top), Recruitment (middle) and Fishing mortality (bottom, mean $F_{2–10}$). Grey shaded area shows 95% confidence bounds and average CV is 31% for SSB and 29% for $F_{2–10}$. SSB are in thousand tonnes and recruitment in thousands.

The estimated SSB shows a significant increase from 2013 to 2020 from 403 thousand tonnes to 983 thousand tonnes. Confidence intervals of SSB are in the range 25–35% with an average 31%. The fishing mortality has been below F_{MSY} over the whole time-series and after the slight increase in 2016, showed a decrease in 2017–2020. F in 2020 was estimated at 0.024 lower than the observed value in 2018. Confidence intervals of F are in the range 24–33%. The stock showed a strong recruitment in 1996 and above average recruitments in the most recent years, with high values in 2011, 2012, 2016 and 2019. Although recruitment in 2019 is estimated as the highest recruitment, this estimate presents a high uncertainty due to lack of the 2019 and 2020 survey tuning indices (notably, estimates of age-1 and age-2) in this year's assessment. The latest recruitment in 2020 (5380 million) is estimated to be lower, but with high uncertainty.

Figure 9.4.1.3 shows the scatterplot of the estimated spawning–stock biomass and recruitment in the period 1992–2020.

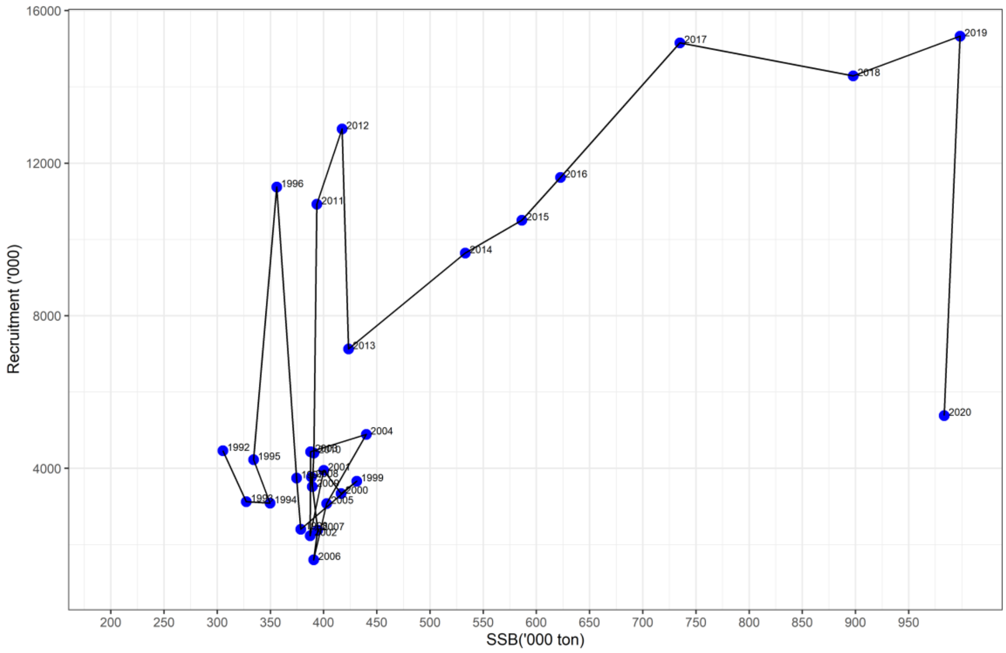

Figure 9.4.1.3. Stock–recruitment data for southern horse mackerel (1992–2020).

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 data series of landings in weight, which was very well fitted by the model (Figure 9.4.2.1). The collection of data from the commercial fishery during 2020 has been impacted by COVID-19 restrictions to a varying degree across Member States. This had an impact on the catch-at-age used in the assessment.

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 and 2020 combined survey indices could not be estimated because the Portuguese survey was not carried out and the current assessment has been performed without 2019 and 2020 tuning indices. As result of lacking 2019 and 2020 indices, a high uncertainty is observed in 2018, 2019 and 2020 recruitments.

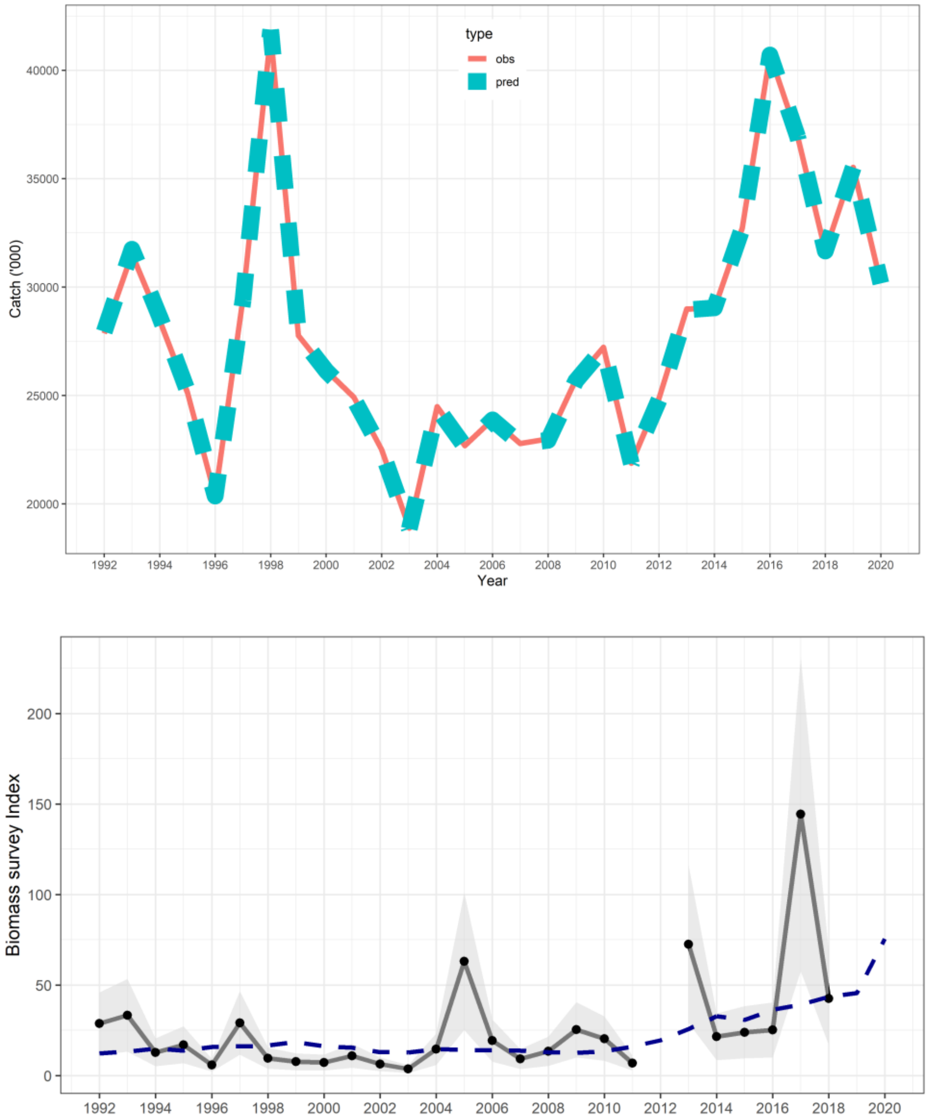

Figure 9.4.2.1. Southern horse mackerel (1992–2020). Catch biomass (top) and survey biomass index (bottom): observed (solid black line) and estimated values (dashed blue line). (grey shaded area shows 95% confidence bounds of survey biomass index).

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

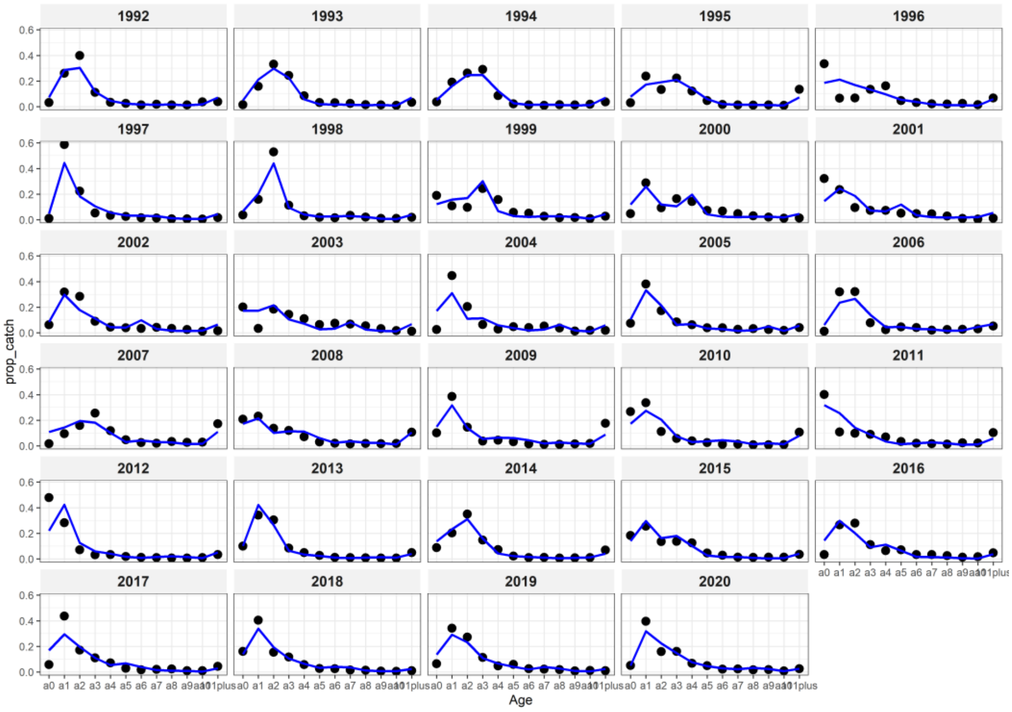

Figure 9.4.2.2. Southern horse mackerel (1992–2020). Comparison of proportions-at-age of the observed and fitted catch data (observed values=dots; fitted values=solid lines).

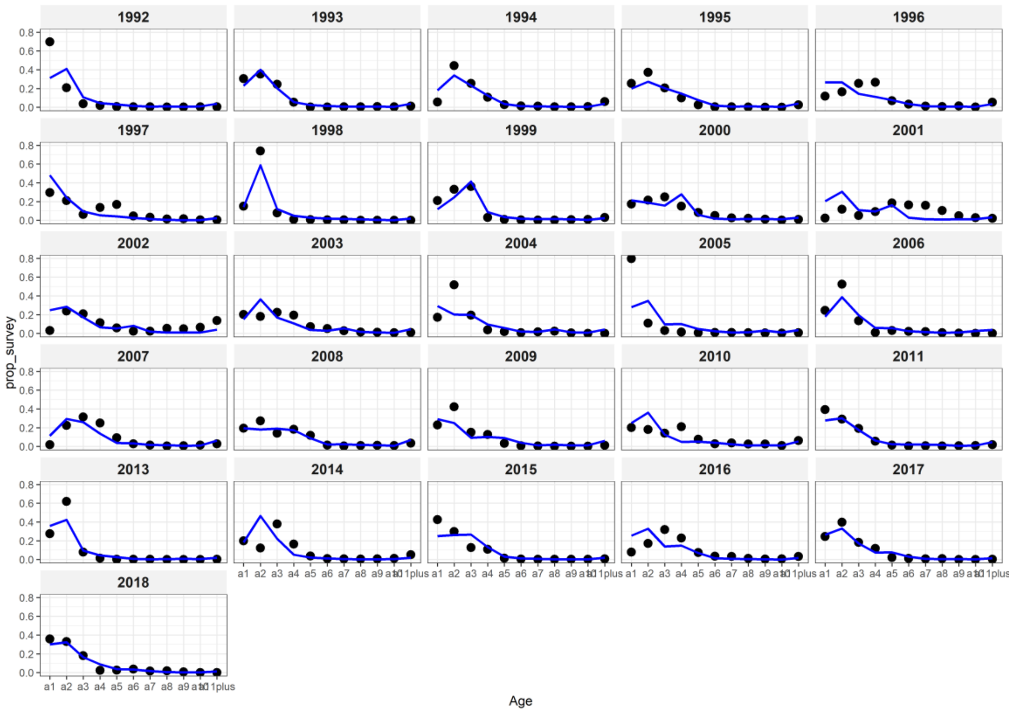

Figure 9.4.2.3. Southern horse mackerel 1992–2020). Comparison of proportions-at-age of the observed and fitted survey data (observed values=dots; fitted values=solid lines).

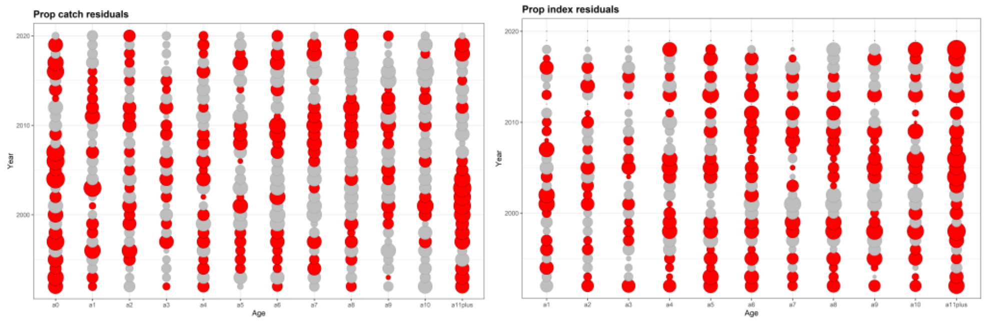

Figure 9.4.2.4. Southern horse mackerel (1992–2020). Bubble plot of catch (left, age range 0–11+) and survey (right, age range: 1–11+) proportion-at-age residuals (negative residuals=red bubbles).

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 variation). The slight decrease in catches observed in 2020 and the continuous increase in stock abundance in last few years resulted in a lower estimate of F_{bar} in 2020 that in the previous year. The uncertainty in the estimated F_{bar} is of similar magnitude around 32% (coefficient of variation). Because there were no available survey indices for 2019 and 2020, the stock assessment was performed without tuning indices in the last two years and therefore recruitments in last few years are highly uncertain (CV: 35% and 53%). Because of the high uncertainty in the assessment recent years, the recruitments for 2018–2022 were replaced by the geometric mean of the available series (1992–2017) in the short-term forecast (STF).

The retrospective analysis on SSB, recruitment and F_{bar} (mean F ages 2–10) was performed for a five-year period, from 1992–2016 to 1992–2020 time-series. The average Mohr´s rho are shown in Figure 9.4.2.5, which indicate an negligible overestimation of the SSB (0.002), overestimation of F (0.21) and underestimation of R estimates (-0.21). Because of the very high uncertainty observed in the last recruitment estimate, the Mohn´s rho for recruitment is calculated without the terminal year (Figure 9.4.2.5). The Mohn´s rho results are below the critical value (± 0.30) and the observed retrospectives are mostly inside the confidence bounds of the last assessment estimates.

WGHANSA argued that the update assessment without the 2019 and 2020 tuning index and the 2020 catch-at-age data impacted by COVID-19 restrictions, is highly uncertain but without the input of additional independent data the model gives a basis for advice. Besides the above-mentioned issues, there has also 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 2012) and needs immediate investigation.

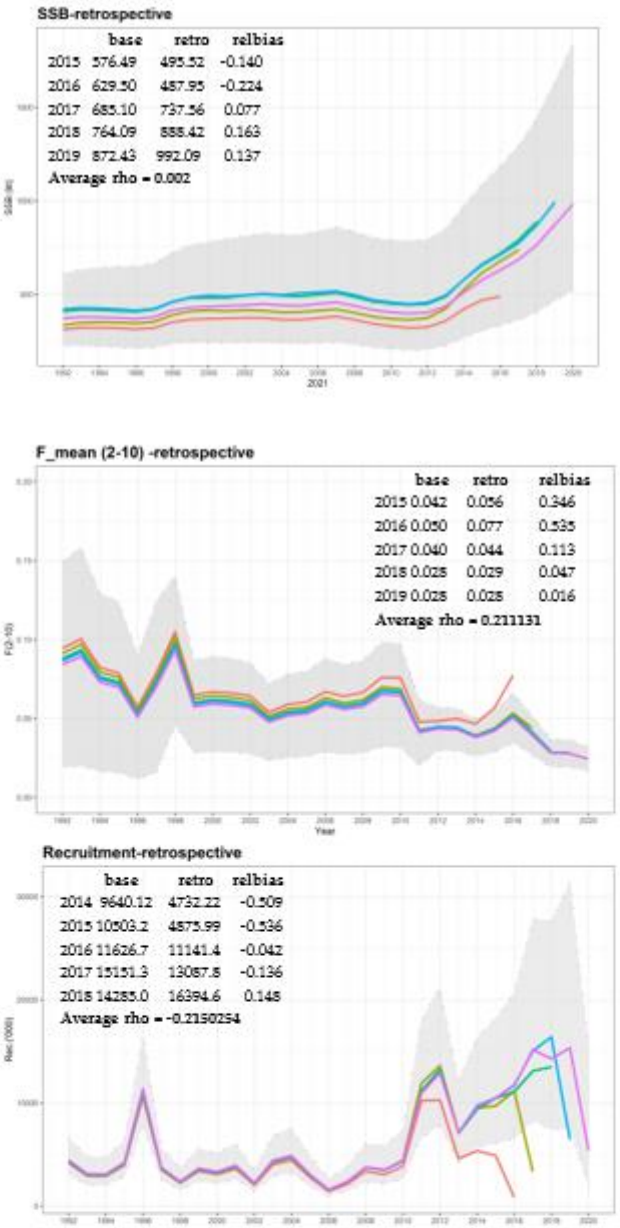

Figure 9.4.2.5. Retrospective analysis results. Trajectories of SSB, Recruitment and Fbar (grey=95% confidence intervals for the current assessment). The table in each graph shows the last assessment estimates (base) compared to each retrospective assessment (retro) and the relative bias in each year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

9.5 Short-term predictions

Deterministic short-term forecasts were carried out with R using the Fisheries Library in R (FLR) "FLAssess" (Version 2.6.3) and "Flash" (Version 2.5.1), following assumptions and settings agreed during the benchmark (ICES, 2017) and described in the Stock Annex. Due to high uncertainty in recruitment since 2018 (details in Section 9.4.2) it is assumed a constant recruitment corresponding to the geometric mean recruitment of the available time-series 1992–2017 (4.806 million fish). Weight-at-age in the catch and in the stock and fishing mortality of the last assessment year are assumed for the interim year. The abundance-at-age 1, age 2 and age 3 in 2021 are the survivors of the geometric mean recruitment assumed for 2020, 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 0.024), SSB in 2021 is estimated to be 981 870 tonnes at spawning time (mid-January). The management options table also include the F based on the management plan (F = MP) and the F_{pa} 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 (2021–2023). N – number of fish;(in thousands), Sel – Selectivity (F-at-age), SWt and CWt – mean weight in the stock and in the catch (in kg).

2021						
Age	N	M	Mat	SWt	Sel	CWt
0	4806105	0.9	0	0.022	0.005	0.022
1	1944552	0.6	0	0.04	0.024	0.04
2	1040664	0.4	0.36	0.058	0.032	0.058
3	673470	0.3	0.82	0.074	0.029	0.074
4	1517259	0.2	0.95	0.101	0.026	0.101
5	911698	0.15	0.97	0.13	0.022	0.13
6	673862	0.15	0.99	0.155	0.019	0.155
7	511255	0.15	1	0.197	0.023	0.197
8	313575	0.15	1	0.221	0.023	0.221
9	469829	0.15	1	0.247	0.023	0.247
10	328952	0.15	1	0.291	0.023	0.291
11	466404	0.15	1	0.389	0.023	0.389
2022						
Age	N	M	Mat	SWt	Sel	CWt
0	4806105	0.9	0	0.022	0.005	0.022
1		0.6	0	0.04	0.024	0.04
2		0.4	0.36	0.058	0.032	0.058
3		0.3	0.82	0.074	0.029	0.074
4		0.2	0.95	0.101	0.026	0.101
5		0.15	0.97	0.13	0.022	0.13
6		0.15	0.99	0.155	0.019	0.155
7		0.15	1	0.197	0.023	0.197
8		0.15	1	0.221	0.023	0.221
9		0.15	1	0.247	0.023	0.247
10		0.15	1	0.291	0.023	0.291
11		0.15	1	0.389	0.023	0.389

2023						
Age	N	M	Mat	SWt	Sel	CWt
0	4806105	0.9	0	0.022	0.005	0.022
1		0.6	0	0.04	0.024	0.04
2		0.4	0.36	0.058	0.032	0.058
3		0.3	0.82	0.074	0.029	0.074
4		0.2	0.95	0.101	0.026	0.101
5		0.15	0.97	0.13	0.022	0.13
6		0.15	0.99	0.155	0.019	0.155
7		0.15	1	0.197	0.023	0.197
8		0.15	1	0.221	0.023	0.221
9		0.15	1	0.247	0.023	0.247
10		0.15	1	0.291	0.023	0.291
11		0.15	1	0.389	0.023	0.389

Table 9.5.2. Short-term forecast (2021–2023) for southern horse mackerel. Catch and SSB (at spawning time) in tonnes.

			2021		2022		2023
	Fmult	Fbar	SSB	Catch	SSB	Catch	SSB
F=0	0.00	0.00			1020305	0	1067543
$F_{sq} = F_{2020}$	1.00	0.03	981870	24155	1019141	24515	1042245
F_{sq}*1.2	1.20	0.03			1018365	29352	1037258
F_{sq}*1.6	1.60	0.05			1014303	38962	1027358
F_{sq}*2.0	2.00	0.06			1012722	48486	1017554
F_MP	4.56	0.11			1015887	107460	957010
$F_{MSY;}$ F_{pa}	6.20	0.15			1014303	143505	920156
F_{lim}	7.84	0.19			1012722	178254	884739
SSB_{2022}=MSY $B_{trigger}$=B_{pa}	74.80	1.82			950233	910765	181000
SSB_{2022}=B_{lim}	98.90	2.41			928708	1005636	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 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).

ICES has redefined F_{pa} as $F_{p0.5}$ (the F that leads to SSB ≥ B_{lim} with 95% probability) and this lead to a change in F_{MSY} value from 0.11 to 0.15 constrained by the $F_{pa.}$ (ICES, 2021). As a result, the F_{MSY} is 0.15 for this stock.

Table 9.6.1. Biological Reference points for southern horse mackerel. Values and the technical basis (weights in thousand tonnes).

BRP	Value	Technical basis
B_{lim}	103	$B_{lim} = B_{pa} * \exp(-1.645\ \sigma)$ σ = 0.32 (0.34)
B_{pa}	181	$B_{pa} = B_{trigger}$
MSY $B_{trigger}$	181	Lower bound (average) of 90%CI of $SSB_{1992–2015}$
F_{lim}	0.19	Stochastic long-term simulations (50% probability SSB > B_{lim})
F_{pa}	0.15	F that leads to SSB ≥ B_{lim} with 95% probability (update ICES, 2021).
F_{MSY}	0.15	Stochastic long-term simulations

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.

ICES has redefined F_{pa} as $F_{p0.5}$ (the F that leads to SSB ≥ B_{lim} with 95% probability) (ICES, 2021a) and this lead to a redefinition of F_{MSY} to 0.15. This updated F_{MSY} differs from the F_{target} (previous F_{MSY}=0.11) considered in the management plan that was evaluated in ICES (2018).

The basis for the advice is the same as last year: the MSY approach (F=0.15) and gives estimated catches in 2022 of 143 505 tonnes. The catch advice for 2022 under the MSY approach, represents an increase of 376% in comparison with catches observed in 2020 (Figure 9.7.1).

There is a MP for this stock, developed within the PELAC-SWWAC framework, that has been evaluated as precautionary by ICES. This year, the management strategy was amended and PELAC requested - via the European Commission – “that ICES use the management strategy as a basis for the top-line of the TAC advice for Southern mackerel in 2022 and onwards, with ICES MSY advice included as part of the subsequent ‘catch options’ table”. If the advice would be based on the MP (107 460 tonnes) then the increase of catches advised for 2022 in relation to actual catches in 2020 would be of 256%. 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 2022 TAC is not based on the plan and the stability clause does not apply.

The advice pertains to *T. trachurus*, while the total allowable catch (TAC) is set for all *Trachurus* species, including *T. picturatus* (blue jack mackerel) and *T. mediterraneus* (Mediterranean horse mackerel). Part of the catches consist of other *Trachurus* spp. than *T. trachurus*, and this percentage can vary from year to year. Estimates indicate that in 2020, less than 10% of the catch consisted of *Trachurus* spp. other than *T. trachurus* (2498 tonnes). ICES considers that management of several species under a combined TAC prevents effective control of the single-species exploitation rates, and could lead to overexploitation of any of the species.

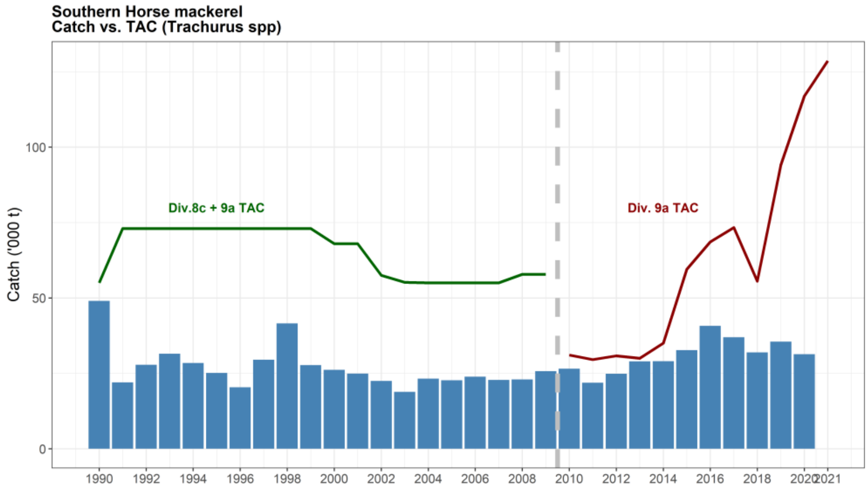

Figure 9.7.1. Catch and TAC for southern horse mackerel. Blue bars show catches for southern horse mackerel, green line shows combined TAC for horse mackerel in division 8c and 9a and red line shows TAC for horse mackerel in Division 9a.

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. In 2019 (technical/legal issues) and 2020 (technical and covid-19 issues), the Portuguese IBTS survey was not carried out.

3. Missing or deteriorated catch data:

Sampling programmes (on-shore, observers on board and biological sampling) coordinated by the IEO, Spain and IPMA, Portugal were affected in a varying degree due to COVID-19 disruption. Official catches were appropriated reported for both countries, but length distribution was missing in Spanish landings and for 2nd quarter Portuguese landings.

4. Missing or deteriorated commercial LPUE/CPUE data:

Not applicable.

5. Missing or deteriorated biological data

The COVID pandemic also affected, but in a less extent, some of the biological samplings made by IEO in Spain and IPMA in Portugal.

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

Exploratory and sensitivity analysis were performed in ICES WGHANSA (2020) to assess if the IBTS Spanish survey could be used as a 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.

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

It was assumed for Spanish landings the same length distribution by gear (artisanal, trawl and purse-seine) observed in Spanish fleets for 2019. Length distributions from the Portuguese second quarter were obtained with an alternative solution based on a remote digital measurement system using computer vision and non-contact 3D metrology solutions (http://fishmetrics.pt). SOP analysis showed robust results in the estimated length distribution.

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

Several exploratory and sensitivity analyses were performed on the impact on the assessment key parameters estimates, using different assumptions for the Spanish landings length distribution.

There was an added assessment uncertainty related to not having the 2019, 2020 biomass tuning index. Notably, there was a significant increase in the uncertainty of the 2018–2020 recruitment estimates that were replaced in the short-term forecast by a constant recruitment, corresponding to the geometric mean recruitment of the available time-series (1992–2017).

10 Blue Jack Mackerel (*Trachurus picturatus*) in Subdivision 10.a.2 (Azores grounds)

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

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.

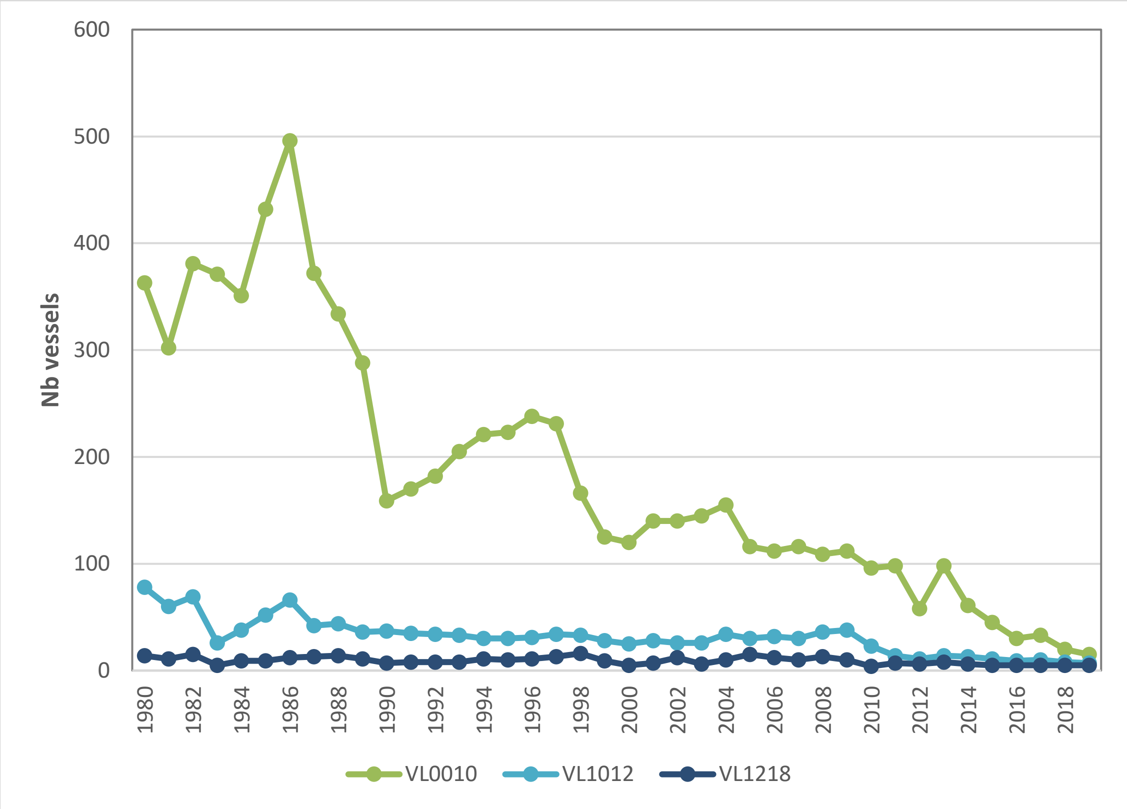

Figure 1. Number of small purse-seine vessels, by length category, of the blue jack mackerel (*T. picturatus*) fishery in the Azores (ICES Subdivision 10.a2) from 1980 to 2019.

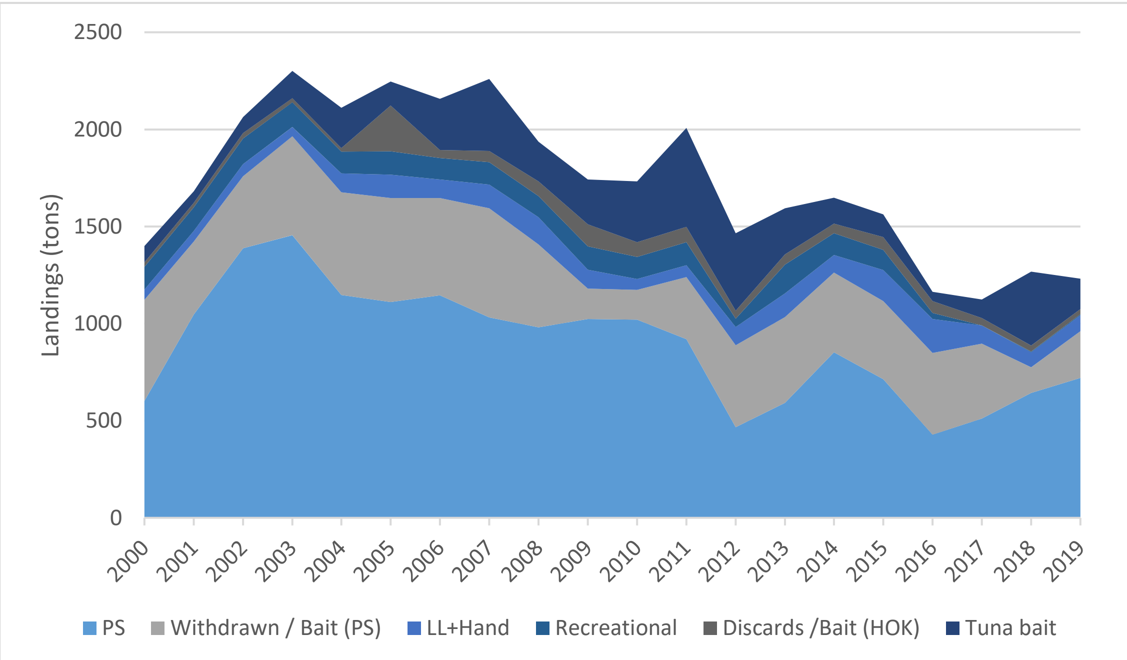

Figure 2. Estimated catches of blue jack mackerel (*T. picturatus*) in the Azores (ICES Subdivision 10.a2) from 1978 to 2019.

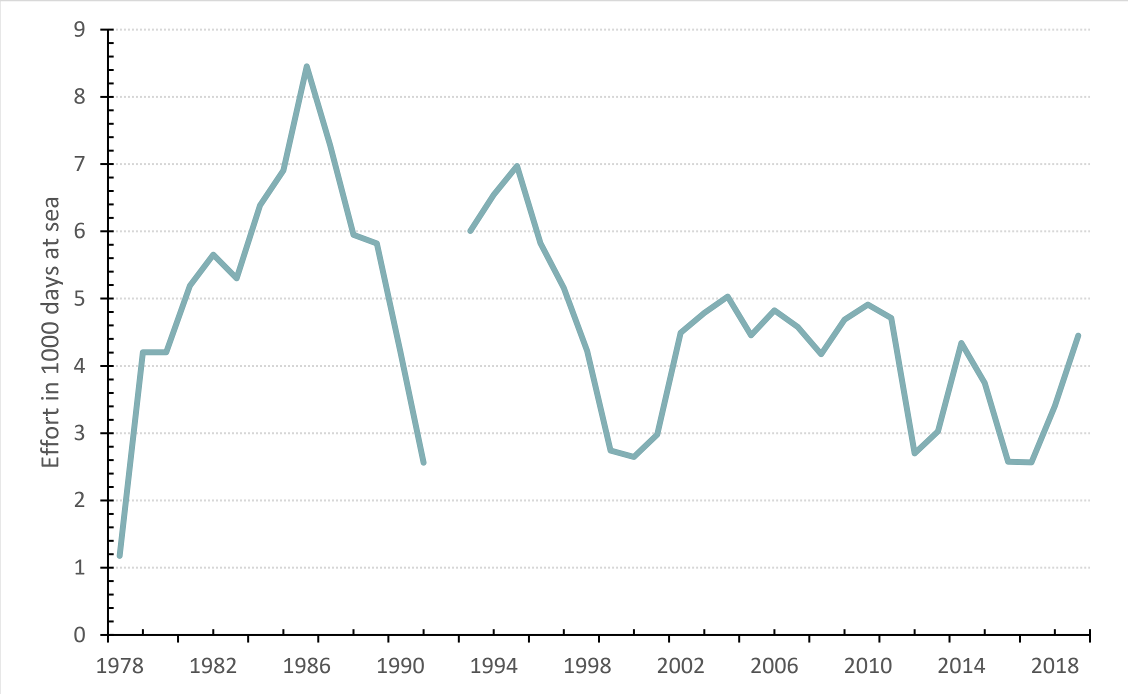

Figure 3. Nominal effort (number of days at sea) of the purse-seine fleet for the period 1978–2019.

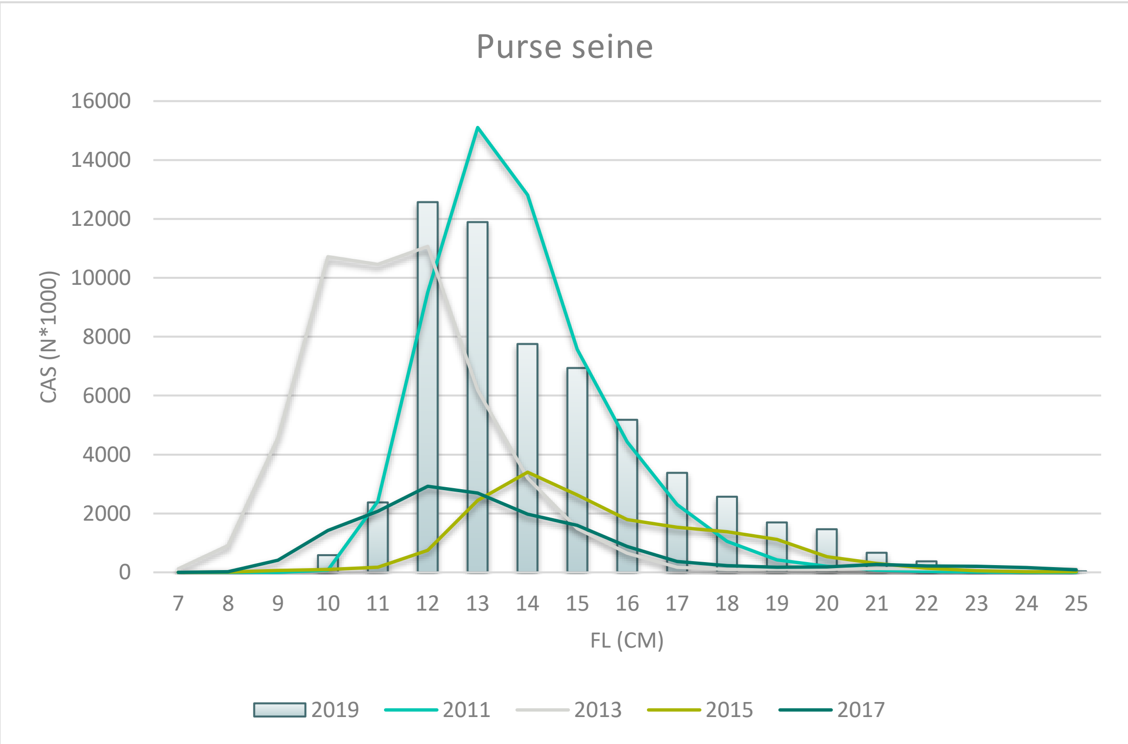

Figure 4. Annual size frequencies of the catches of blue jack mackerel (*T. picturatus*) in the Azores, from several years between 2011 and 2019, from the purse-seine fisheries (targeting juvelines).

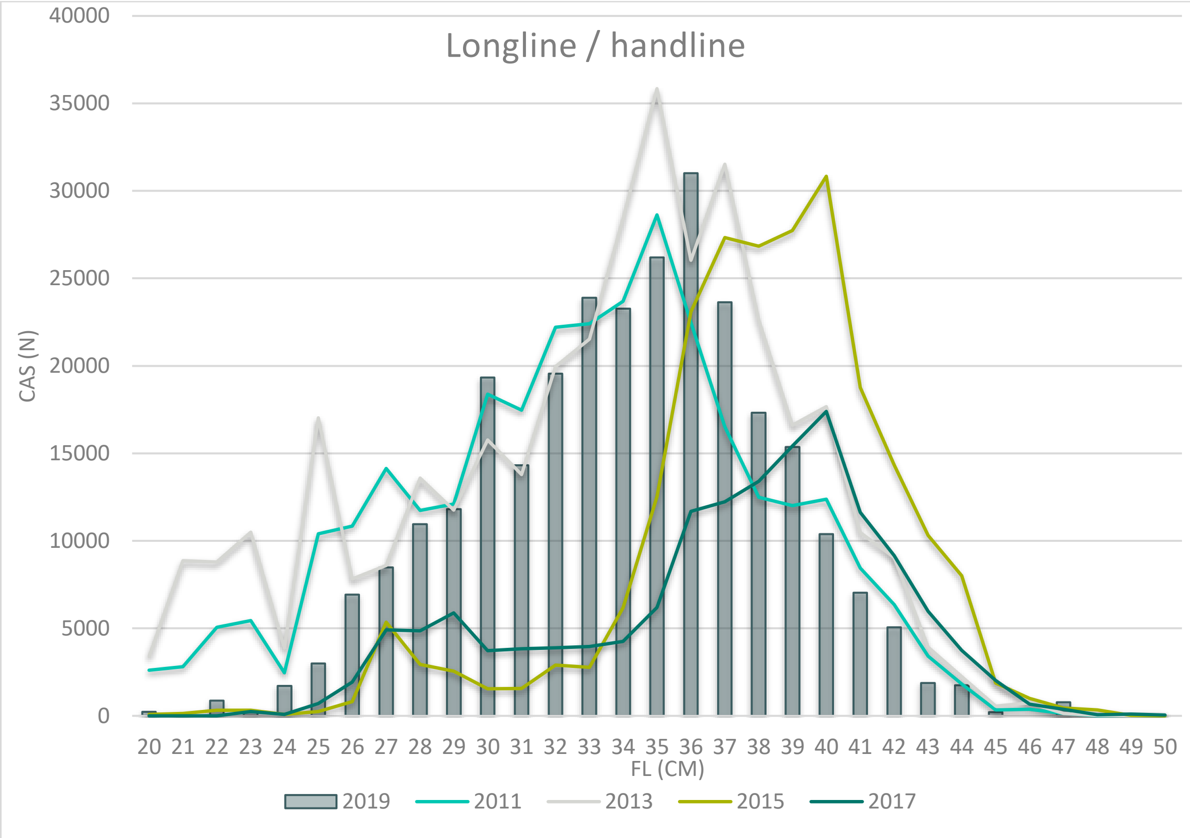

Figure 5. - Annual size frequencies of the catches of blue jack mackerel *(T. picturatus)* in the Azores, from several years between 2011 and 2019, from the longline and handline fisheries (targeting adults).

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

Annex 1: List of participants

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Annex 2: Working documents

The following working documents were presented to WGHANSA 2021 and are presented in full in Annex 2:

WD1: Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ 2020-07* Spanish survey (August 2020). Fernando Ramos, Jorge Tornero, Carlos Farias, Isabel Loureiro, Rosario Navarro.

WD2: Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ-RECLUTAS 2020-10* Spanish survey (October 2020). Fernando Ramos, Pilar Córdoba, Jorge Tornero, Isabel Loureiro, Rosario Navarro.

WD3: Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points. Margarita María Rincón, Fernando Ramos, Jorge Tornero, Susana Garrido, Bjarki Elvarsson, Jamie Lentin.

Working document presented in the ICES Working Group on Southern horse mackerel, Anchovy and Sardine (WGHANSA). On-line meeting, 24-28 May 2021.

Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ 2020-07* Spanish survey (August 2020).

By

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ABSTRACT

The present working document summarises the main results obtained from the *ECOCADIZ 2020-07* Spanish (pelagic ecosystem-) acoustic-trawl survey conducted by IEO between 01st and 14th August 2020 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz (GoC) onboard the R/V *Miguel Oliver*. The 21 foreseen acoustic transects were sampled. A total of 26 valid fishing hauls were carried out for echo-trace ground-truthing purposes. Four additional night trawls were conducted to collect anchovy hydrated females (DEPM-adult *ad hoc* sampling). Chub mackerel was the most frequent captured species in the fishing hauls, followed by mackerel, anchovy, horse mackerel, bogue, sardine, blue jack mackerel and Mediterranean horse mackerel. Round sardinella, longspine snipefish, Atlantic pomfret and transparent goby showed a very low occurrence, whereas the occurrence of boarfish and pearlside was incidental. Chub mackerel, anchovy and sardine showed the highest yields in these hauls. The estimate of total NASC allocated to the "pelagic fish species assemblage" has shown a slight decrease in relation to the historical records in 2018 and 2019, mainly caused by the regional decrease in Spanish waters. However, both total and regional estimates are still above their respective historical averages. Such estimates are the result of the relatively high acoustic contributions of anchovy, sardine (both mainly in Spanish waters), and chub mackerel (in Portuguese waters). GoC anchovy was widely distributed in the surveyed area, showing the highest densities between Cape Santa Maria and Bay of Cadiz. Anchovy acoustic estimates in summer 2020 were of 5153 million fish and 44 877 tones, with the bulk of the population occurring in the Spanish waters. The population was composed by fishes not older than 2 years, with age-0 fish contributing 75% of the total population. The largest (and oldest) fish were distributed in the westernmost waters and the smallest (and youngest) ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters. The current biomass estimate becomes in the second historical maximum within the time-series. GoC sardine distributed almost all over the surveyed area (avoiding the Spanish easternmost waters), but was mainly concentrated between west Cape Santa Maria and the Bay of Cadiz, especially in the Spanish central waters of the Gulf, where numerous dense mid-water schools were recorded in the coastal fringe (20-40 m depth). The estimates of sardine abundance and biomass in summer 2020 were 1923 million fish and 50 721 t, estimates close to the historical average, but lower than the values estimated last year and the most recent maxima reached in 2018. Although up to 5-year olds were recorded in the population, age-0 juveniles accounted for 71% of the total numbers, mainly occurring in relatively shallow waters along the coastal fringe comprised between Tinto-Odiel river mouth and the Bay of Cadiz. Chub mackerel was widely distributed in the surveyed area, mainly in the central and western shelf waters, although the highest densities occurred in the western Algarve. A total of 32 854 t and 448 million fish were estimated for Chub mackerel, estimates similar to the most recent ones and very close to the time-series average. Age-0 and age-1 groups were the dominant age groups and mainly occurring in the Portuguese waters. The oldest fish (3-5 years) occurred almost exclusively in Spanish waters.

INTRODUCTION

The *ECOCADIZ* surveys constitute a series of yearly acoustic-trawl surveys conducted since 2004 by IEO in the Subdivision 9a South (Algarve and Gulf of Cadiz, between 20 – 200 m depth) under the "pelagic ecosystem survey" approach. The series was conducted onboard R/V *Cornide de Saavedra* until 2013, since 2014 on it was conducted onboard R/V *Miguel Oliver*. This series started in 2004 with the *BOCADEVA 0604* pilot combined 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 until 2014 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 2020-07* 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 2020-07* survey was carried out between 01st and 14th August 2020 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 2020* 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 Small Pelagic Fish in NE Atlantic* (WGACEGG; ICES, 2006a,b).

Fishing hauls for echo-trace ground-truthing were opportunistic, according to the echogram information. Hauls PE01 to PE28 were carried out using a ca. 15 m-mean vertical opening pelagic trawl (*Tuneado* gear). At the end of PE28 the *Tuneado* gear suffered a serious breakage because a hooking with an undetected obstacle over the bottom. Fishing hauls PE29 and PE30 were carried out with a *Gloria HOD 352* pelagic trawl gear (ca. 10 m-mean vertical opening net). All the fishing hauls were performed at an average speed of 4-4.5 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20* trawl sonar and a *Marport^{TM} NBTE* (Narrow Band Trawl Eye) 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.

The *Continuous Underway Fish Egg Sampler* (CUFES) was not used in the survey since it was used in the previous *BOCADEVA 0720* anchovy DEPM survey. A *Sea-bird Electronics™ SBE 21 SEACAT* thermosalinograph and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously 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 158 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.

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

A detailed description of protocols and methods followed in this survey series is reported in Doray *et al*. (2021).

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 previous works related with the hydrographic sampling.

Groundtruthing hauls

Twenty six (26) 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 3**).

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, 27% of valid hauls (7 hauls) were conducted over isobath.

All the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working over or very close to the bottom, because of many echo-traces usually occurred close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 36-191 m.

During the survey were captured 2 Chondrichthyan, 40 Osteichthyes, 3 Cephalopod, 1 Crustacean and 1 Cnidarian-Hydrozoa species. The percentage of occurrence of the more frequent fish species (chondricthyans excluded) in the trawl hauls is shown in the enclosed **text table below** (see also **Figure 4**). 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 species set most frequently captured 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 (26 hauls, 100% presence index), followed by mackerel (23 hauls, 88%), anchovy (21 hauls, 81%), horse mackerel (20 hauls, 77%), bogue (17 hauls, 65%), sardine (15 hauls, 58%), blue jack mackerel (12 hauls, 46%) and Mediterranean horse mackerel (6 hauls, 23%). Round sardinella, longspine snipefish, Atlantic pomfret and transparent goby showed a very low occurrence (3 hauls, 12%), whereas the occurrence of boarfish and pearlside (1 haul, 4%) was incidental. Blue whiting was absent in the catches.

For the purposes of the acoustic assessment, anchovy, sardine, round sardinella, mackerel species, horse & jack mackerel species, bogue, snipefish, boarfish 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 20.9 tonnes and 1.1 million fish (**Table 3**). 39% of this fished biomass corresponded to anchovy, 29% to chub mackerel, 23% to sardine, 3% to horse mackerel, and contributions lower than 3% to the remaining species. The most abundant species in ground-truthing trawl hauls was also anchovy (72%), followed by sardine (19%) and chub mackerel (8%), with the remaining species showing lower contributions than 0.3%.

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 all over the surveyed area, although the highest yields were recorded between eastern Algarve and 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 and easternmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters (**Figure 5**). Sardine catches also showed widely distributed along the surveyed area, but showing the highest yields in three spots located in the surroundings of the Bay of Cadiz, central waters of the Gulf and Cape Santa María. The largest sardines were captured in the Portuguese waters, whereas juvenile sardines were mainly captured in the shallowest hauls conducted in the coastal fringe between Tinto-Odiel river mouth and the Bay of Cadiz (**Figure 6**). 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. Conversely, mackerel recorded the highest yields in Spanish waters. Mediterranean horse mackerel was restricted to the central and easternmost Spanish waters. The size composition of these last species in fishing hauls is shown in **Figures 7** to **16**.

Species	OCCURRENCE (Number of valid hauls)	OCCURRENCE (% over Total valid hauls)	Total weight (Kg)	Total number
Scomber colias	26	100,00 %	6124,053	92522
Merluccius merluccius	24	92,31 %	78,230	679
Scomber scombrus	23	88,46 %	54,274	390
Engraulis encrasicolus	21	80,77 %	8150,282	805650
Trachurus trachurus	20	76,92 %	300,078	3877
Boops boops	17	65,38 %	172,764	1297
Alosa fallax	16	61,54 %	24,489	94
Sardina pilchardus	15	57,69 %	4823,831	211225
Spondyliosoma cantharus	14	53,85 %	127,919	817
Trachurus picturatus	12	46,15 %	35,099	534
Pagellus erythrinus	9	34,62 %	91,251	539
Diplodus annularis	7	26,92 %	4,158	65
Trachurus mediterraneus	6	23,08 %	582,839	3015
Diplodus vulgaris	6	23,08 %	210,017	1437
Trachinus draco	5	19,23 %	1,470	11
Pagellus acarne	4	15,38 %	26,933	116
Diplodus bellottii	4	15,38 %	5,192	72
Sardinella aurita	3	11,54 %	70,874	379
Macroramphosus scolopax	3	11,54 %	8,250	1136
Brama brama	3	11,54 %	4,070	4
Pagellus bellottii bellottii	3	11,54 %	11,435	73
Aphia minuta	3	11,54 %	0,270	742
Spicara flexuosa	3	11,54 %	4,371	102
Pomatomus saltatrix	2	7,69 %	0,775	2
Chelidonichthys lucerna	2	7,69 %	0,315	2
Xenodermichthys copei	1	3,85 %	10,000	62
Maurolicus muelleri	1	3,85 %	0,081	67
Belone belone belone	1	3,85 %	1,405	2
Zenopsis conchifer	1	3,85 %	0,210	1
Capros aper	1	3,85 %	3,830	784
Mugil cephalus	1	3,85 %	1,750	1
Caranx rhonchus	1	3,85 %	0,565	4
Trachinotus ovatus	1	3,85 %	0,230	1
Pomadasys incisus	1	3,85 %	0,570	5
Pagellus bogaraveo	1	3,85 %	0,075	1
Diplodus puntazzo	1	3,85 %	0,360	1
Dentex gibbosus	1	3,85 %	8,765	1
Sparus aurata	1	3,85 %	0,815	2
Mullus surmuletus	1	3,85 %	0,120	1
Stromateus fiatola	1	3,85 %	0,775	1
Chelidonichthys obscurus	1	3,85%	0,09	1

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

A total of 322 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 211 nmi (11 transects) were sampled in Spanish waters, and 111 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	SAA	ANE	MAC	VMA	HOM	HMM	JAA	BOG	BOC	SNS	MAV
Total Area	184301	43118	2028	64869	6	44927	5415	16096	1143	1849	124	227	4499
(%)	(100.0)	(23.4)	(1.1)	(35.2)	(0.003)	(24.4)	(2.9)	(8.7)	(0.6)	(1.0)	(0.1)	(0.1)	(2.4)
Portugal	61499	12983	0	7245	1	32915	5090	0	1141	1312	124	227	461
(%)	(33.4)	(30.1)	(0.0)	(11.2)	(22,2)	(73,3)	(94.4)	(0.0)	(99.8)	(70.9)	(100.0)	(100.0)	(10.2)
Spain	122802	30135	2028	57623	5	12012	325	16096	2	537	0	0	4038
(%)	(66.6)	(69.9)	(100.0)	(88.8)	(77.8)	(26.7)	(6.0)	(100.0)	(0.2)	(29.1)	(0.0)	(0.0)	(89.8)

For this “pelagic fish assemblage” has been estimated a total of 184 301 m^2 nmi^{-2}, an acoustic energy which has experienced a slight decrease in relation to the time-series maxima recorded in 2018 and 2019 both for this total and for the Spanish contribution. Even so, these values are above the historical average (**Figure 17**). Portuguese waters accounted for 33% of this total back-scattering energy and the Spanish waters the remaining 67%. 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 17**. By species, anchovy (35%), chub mackerel (24%) and sardine (23%), were the most important species in terms of their contributions to the total back-scattering energy. Mediterranean horse mackerel (9%), horse mackerel (3%), pearlside (2%) and round sardinella and bogue (1% each), 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: sardine, round sardinella, anchovy, mackerel, Mediterranean horse mackerel, and pearlside seemed to show greater densities in the Spanish waters, whereas chub mackerel, blue jack mackerel, horse mackerel, bogue, boarfish 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, boarfish, 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 mapped in **Figure 18**. The estimated abundance and biomass by size class and age group are given in **Tables 5** and **6**, and **Figures 19** and **20**.

Anchovy (35% of the total NASC attributed to fish) was widely distributed in the surveyed area, showing the highest densities between Cape Santa Maria and Bay of Cadiz (**Figure 20**). The *PELAGO 20* spring survey not recorded the species to the west of Cape Santa Maria.

Twelve (12) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing stations (**Figure 18**). The acoustic estimates by homogeneous post-stratum and total area are shown in **Table 5** and **Figure 19**. Overall acoustic estimates in summer 2020 were 5153 million fish and 44 877 tonnes. By geographical strata, the Spanish waters yielded 91% (4714 million) and 83% (37 114 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 439 million and 7773 t. The current biomass estimate (44 877 t) becomes in the second historical maximum within the time-series (historical maximum in 2019: 57 700 t; **Figure 45**). The *PELAGO 20* spring Portuguese survey previously estimated for this same area 49 787 t and 5639 million (Portuguese waters: 1789 t, 89 million; Spanish waters: 47 998 t, 5550 million).

The size class range of the assessed anchovy population in summer 2020 varied between the 7.0 and 18.0 cm size classes, with two modal classes, the main mode at 11.5 cm and a secondary mode at 9.5 cm. The size composition of anchovy throughout the surveyed area confirms the usual pattern exhibited by the species during the survey 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 19;** see also **Figure 5**).

The 2020 summer estimates of mean size and weight of the whole population (11.0 cm, 8.7 g) were somewhat lower than their respective time-series averages (12.3 cm, 12.6 g). As it has been occurring in the last years, a relatively high contribution of the small fish (ca. 40 % of the total population is composed by fish ≤10 cm) during the survey season might be the cause of the value of such estimates in 2020.

The population was composed by fishes not older than 2 years. As it has been happening in the last years, during the 2020 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 74% and 57% of the total estimated abundance and biomass, respectively. Age 1 fish represented 26% and 41% of the total abundance and biomass (**Table 6**; **Figure 20**).

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 21**. Estimated abundance and biomass by size class and age group are given in **Tables 7** and **8** and **Figures 22** and **23**.

Sardine recorded a relatively high acoustic echo-integration in summer 2020 (23% of the total NASC attributed to pelagic fish species assemblage), as a consequence of the occurrence of dense mid-water schools in the coastal fringe (20-40 m depth) of the Spanish central waters of the Gulf (**Figure 21**). This distribution pattern of acoustic densities was quite similar to the recorded one during the *PELAGO* survey in spring, although acoustic detections were weaker during *ECOCADIZ*, especially in the western Algarve. Thus, sardine distributed almost all over the surveyed area (avoiding the Spanish easternmost waters), but was mainly concentrated between west Cape Santa Maria and the Bay of Cadiz.

Eight (8) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 21**). The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2020 were 1923 million fish and 50 721 t, estimates close to the historical average (ca. 1955 million; 50 kt), but lower than the values estimated last year and the most recent maxima reached in 2018 (114 631 t; see **Figure 45**). Spanish waters concentrated 71% and 62% of the total estimated abundance and biomass, respectively (2495 million and 44 899 t). The estimates for the Portuguese waters were 554 million and 19 464 t. The *PELAGO 20* spring Portuguese survey previously estimated for this same area the triple of biomass and abundance than the estimated later in summer by *ECOCADIZ*, 155 017 t (6547 million): 47 415 t (1024 million) in Portuguese waters and 107 602 t (5523 million) in Spanish waters, with similar regional relative contributions.

Sizes of the assessed sardine population in summer 2020 ranged between 8.5 and 21.5 cm size classes. The length frequency distribution of the population was clearly bimodal, with one main mode at 14.0 cm size class and a secondary one at 17.0 cm (**Table 7**, **Figure 22**). The juvenile fraction in the estimated population (≤11.5 cm), was mainly located in relatively shallow waters along the coastal fringe comprised between Tinto-Odiel river mouth and the Bay of Cadiz. (**Table 8**, **Figure 23;** see also **Figure 6**). The 2020 summer estimates of mean length and weight of the whole population (14.7 cm, 26.4 g) have experienced an increase in relation to the last year's estimates. Mean length in summer 2020 is close to the historical average (15.0 cm) and mean weight is higher than the historical mean value (22.5 g), a probable consequence of the relative importance of the abovementioned secondary modal component in the estimated population biomass.

The population was composed by fishes not older than 5 years, with the 71% of the estimated numbers belonging to the age group 0 (56% of the estimated biomass; **Table 8**; **Figure 23**). Age 1 sardines accounted for 17% and 25% of the abundance and biomass of the whole population, respectively. Age 0 sardines occurred almost exclusively in Spanish waters (83% of the age 0 fish estimated in the entire Gulf), where they also were the dominant age group (83% and 71% of abundance and biomass). Although 0 to 5 year olds were also present in the Portuguese waters, the population was mainly distributed between the 0 and 3 age groups. Age 0 fish was also the main age group in those waters (41% in abundance and 30% in biomass), but it was not so dominant as in the Spanish waters, with the regional contributions of the 2 and 3 year olds to the estimated Portuguese fraction of the population abundance being 33% and 23%.

Round sardinella

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 24**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 25**.

Round sardinella (1% of the total NASC) showed very low densities, mainly restricted to the easternmost coastal waters in the Gulf (**Figure 24**; see also **Figure 7**).

Two (2) size-based homogeneous post-strata were delimited for the acoustic assessment (**Figure 24**). The estimates of round sardinella abundance and biomass in summer 2020 were 26 million fish and 4838 t (**Table 9**). Spanish waters concentrated the whole estimated population.

The size class range of the assessed population varied between the 22.0 and 34.5 cm size classes, with two modal classes, the main one at 30.0 cm and a secondary mode at 25.5 cm (**Table 9**, **Figure 25**).

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 26**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 27**.

Atlantic mackerel (0.003% of the total NASC) showed a relatively wide distribution all over the surveyed area, but showing somewhat higher densities in Spanish waters (**Figure 26**). Sub-adult/juvenile fish were mainly recorded in outer shelf of west Algarve and the Spanish central and easternmost waters, whereas larger fish occurred in shallower waters (**Figure 8**).

Eight (8) size-based homogeneous post-strata were delimited for the acoustic assessment (**Figure 26**). The estimates of Atlantic mackerel abundance and biomass in summer 2020 were 1 million fish and 230 t (**Table 10**). Spanish waters concentrated 79% and 74% of the total estimated abundance and biomass, respectively (1 million and 171 t). The estimates for the Portuguese waters were 0.3 million and 59 t.

The size class range of the assessed population varied between the 16.0 and 34.5 cm size classes, with two modal classes, the main one at 28.5 cm and a secondary mode at 18.0 cm (**Table 10**, **Figure 27**).

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 28**. Estimated abundance and biomass by size class and age group are given in **Tables 11** and **12** and **Figures 29** and **30**.

Chub mackerel was widely distributed in the surveyed area, mainly in the central and western shelf waters, although the highest densities occurred in the western Algarve (**Figure 28**).

Sixteen (16) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 28**). The estimates of Gulf of Cadiz chub mackerel abundance and biomass in summer 2020 were 448 million fish and 32 854 t. These estimates and the most recent ones showed a relative stable recent trend, with biomasses very close to the historical average (ca. 35 kt; see **Figure 45**). Portuguese waters concentrated the bulk of the population (356 million and 24 495 t). The estimates for the Spanish waters were 92 million and 8358 t.

Sizes of the assessed population ranged between 15.0 and 35.5 cm size classes. The length frequency distribution of the population showed two modes, the main mode at 19.0 cm size class and a secondary one at 21.0 cm (**Table 11**; **Figure 29**). Larger fish were located in Portuguese waters, although the largest ones were recorded in the coastal waters in front Matalascañas. Smaller sub-adult fish were found in the Spanish outer shelf waters (**Figures 9** and **29**).

The population was composed by fishes not older than 5 years, with the 48% (217 million fish) and 41% (183 millions) of the estimated numbers belonging to the age-0 and age-1 groups, respectively (36% and 45% of the estimated biomass, 11 988 t and 14 636 t, respectively; **Table 12**; **Figure 30**). About 80% of the 0- and 1-year old fish occurred in Portuguese waters. Conversely, the whole of the population fraction belonging to the age-group 3 and older occurred in Spanish waters.

Blue jack-mackerel

The survey's length-weight relationship for this species is given in **Table 4**. The distribution of the back-scattering energy attributed to this species and the coherent post-strata considered for the acoustic estimation are illustrated in **Figure 31**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 32**.

The species (0.6% of the total NASC) restricted almost exclusively to Algarve shelf waters, with spots of higher densities in the westernmost waters (**Figure 31**). The species' spatial distribution resembles the horse mackerel distribution. Larger fish seems to be more frequent in Portuguese waters (**Figure 10**).

Three (3) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 31**). The estimates of Gulf of Cadiz Blue Jack mackerel abundance and biomass in summer 2020 were 14 million fish and 838 t. Portuguese waters concentrated the bulk of the population (13 million and 837 t). The estimates for the Spanish waters were 0.02 million and 1 t only.

Sizes of the assessed population ranged between 15.5 and 25.5 cm size classes. The length frequency distribution of the population showed one single mode at 19.5 cm size class (**Table 13**; **Figure 32**).

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 shown in **Figure 33**. Estimated abundance and biomass by size class are given in **Table 14** and **Figure 34**.

Horse mackerel (3% of the total NASC) showed a quite similar distribution pattern to the abovementioned one for blue jack mackerel, with the species being almost absent in the Spanish shelf and showing relatively higher densities in the shelf area comprised between Cape San Vicente and Cape Santa Maria (**Figure 33**). Juveniles occurred in the Spanish outer shelf central waters (**Figure 11**).

Eight (8) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 34**). The estimates of Gulf of Cadiz horse mackerel abundance and biomass in summer 2020 were 53 million fish and 4065 t. Portuguese waters concentrated the bulk of the population (94% in terms of abundance and biomass, 50 million and 3837 t). The estimates for the Spanish waters were 3 million and 228 t.

Sizes of the assessed population ranged between 11.5 and 32.5 cm size classes. The length frequency distribution of the population showed two modes, the main one at 29.0 cm size class and a secondary mode at 13.5 cm size class (**Table 14**; **Figure 34**).

Mediterranean horse-mackerel

The survey's length-weight relationship for this species 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 35**. Estimated abundance and biomass by size class are given in **Table 15** and **Figure 36**.

Mediterranean horse mackerel (9% of the total NASC) was a typically Spanish species in summer 2020 (as usual). The species distributed as far as the Tinto-Odiel river mouth, mainly over the inner-mid shelf waters with the population mainly being composed by adult fish (**Figures 12** and **35**).

Four (4) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 36**). The estimates of Mediterranean horse mackerel abundance and biomass in summer 2020 were 86 million fish and 16 200 t. As described above, the population was restricted to the Spanish waters.

The size class range of the assessed population varied between the 21.0 and 36.0 cm size classes, outstanding a main one at 29.0 cm size class (**Table 15**, **Figure 36**).

Bogue

Parameters of the survey's length-weight relationship for bogue 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 37**. Estimated abundance and biomass by size class are given in **Table 16** and **Figure 38**.

Bogue (1% of the total NASC), although widely distributed, showed higher densities in the west Algarve waters (**Figure 38**). Larger fish occurred in Spanish waters (**Figure 13**).

Seven (7) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 37**). The estimates of Gulf of Cadiz bogue abundance and biomass in summer 2020 were 10 million fish and 1301 t. Portuguese waters concentrated the bulk of the population (78% in terms of abundance and 66% in biomass, namely, 8 million and 3837 t). The estimates for the Spanish waters were 3 million and 858 t. The estimates for the Spanish waters were 2 million and 443 t.

Sizes of the assessed population ranged between 16.5 and 33.5 cm size classes. The length frequency distribution of the population showed two modes, the main one at 22.0 cm size class and a secondary mode at 28.5 cm size class (**Table 16**; **Figure 38**).

Longspine snipefish

The survey's length-weight relationship for this species 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 shown in **Figure 39**. Estimated abundance and biomass by size class are given in **Table 17** and **Figure 40**.

M. scolopax (0.1% of the total NASC) showed an incidental occurrence in the surveyed area, mainly restricted to the westernmost Algarve outer shelf waters, like boarfish, and also close to the Cape Santa Maria (**Figures 14** and **39**).

Two (2) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 39**). The estimates of longspine snipefish abundance and biomass in summer 2020 were 105 million fish and 786 t. The estimated population was restricted to the Portuguese waters only.

Sizes of the assessed population ranged between 10.0 and 14.5 cm size classes. The length frequency distribution of the population showed one single mode at 11.0 cm size class (**Table 17**; **Figure 40**).

Boarfish

Parameters of the survey's length-weight relationship for boarfish 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 41**. Estimated abundance and biomass by size class are given in **Table 18** and **Figure 42**.

Boarfish (0.1% of the total NASC) showed an incidental occurrence in the westernmost Algarve outer shelf waters (**Figures 15** and **41**).

One (1) size-based homogeneous sector was delimited for the acoustic assessment (**Figure 41**). The estimates of boarfish abundance and biomass in summer 2020 in the Gulf of Cadiz shelf waters were 8 million fish and 38 t only. The estimated population was restricted to the Portuguese waters only.

Sizes of the assessed population ranged between 4.5 and 9.0 cm size classes. The length frequency distribution of the population showed one single mode at 6.0 cm size class (**Table 18**; **Figure 42**).

Pearlside

The survey's length-weight relationship for this species 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 shown in **Figure 43**. Estimated abundance and biomass by size class are given in **Table 19** and **Figure 44**.

Pearlside (2% of the total NASC) was only detected in the oceanic limit of the acoustic transects, just in the upper slope. More common in Spanish waters (**Figures 16** and **43**).

Four (4) size-based homogeneous sectors were delimited for the acoustic assessment (**Figure 43**). The estimates of pearlside abundance and biomass in summer 2020 in the Gulf of Cadiz shelf waters were 1370 million fish and 1814 t. Spanish waters concentrated the bulk of the population (87% in terms of abundance and biomass, namely, 1192 million and 1579 t). The estimates for the Portuguese waters were 178 million and 235 t.

Sizes of the assessed population ranged between 4.0 and 6.0 cm size classes. The length frequency distribution of the population showed one single mode at 5.5 cm size class (**Table 19**; **Figure 44**).

(SHORT) DISCUSSION

The total NASC estimated in this survey for "pelagic fish assemblage", 184 301 m^2 nmi^{-2}, is the third highest estimate ever recorded within the time-series (**Figure 17**), a situation which was repeated in the last two years' surveys. In the current survey such an increase in acoustic energy is again the result of the relatively high partial contributions of anchovy, sardine and chub mackerel (as was also the case of the last two years). Anchovy contributed with 35% of the total NASC allocated to the pelagic fish assemblage, with the Spanish waters accounting 89% of the species' NASC. Sardine still showed during the 2020 summer survey the occurrence of dense schools in the coastal (20-40 m) waters in the central part of the Gulf (between the Guadiana river mouth and Doñana).

The current anchovy biomass estimate (44 877 t), although experienced a slight decrease in relation to the last year, becomes in the second historical maximum within the time-series (after reaching the historical maximum in 2019: 57 700 t; see **Figure 45**). The spring *PELAGO 20* survey estimated, however, increased biomass population levels (49 787 t) in relation to those recorded the last year (29 876 t).

The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2020 were 1923 million fish and 50 721 t, a biomass very close to the historical average (ca. 50 kt), but lower than the biomass estimated the previous two years (114 631 t in 2018 and 62 682 t in 2019, **Figure 45**). The *PELAGO 20* spring Portuguese survey previously estimated for this same area the triple of biomass and abundance than the estimated later in summer by *ECOCADIZ*, 155 017 t (6547 million). Again *PELAGO* and *ECOCADIZ* exhibit an opposite trend for this last year in the series.

Chub mackerel acoustic estimates were of 448 million fish and 32 854 t, with the bulk of the population concentrated in the Portuguese waters. The biomass estimates showed a relative stable recent trend, with the recent biomasses very close to the historical average (ca. 35 kt; **Figure 45**).

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Table 1. *ECOCADIZ 2020-07 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	Cape Trafalgar	02/08/20	36º 12,880' N	06º 08,840' W	6:06	24	36º 02,160' N	06º 28,870' W	9:48	220
R02	Sancti-Petri	02/08/20	36º 08,898' N	06º 34,152' W	10:44	175	36º 19,490' N	06º 14,670' W	16:40	24
R03	Cádiz	03/08/20	36º 26,702' N	06º 19,114' W	6:01	31	36º 17,111' N	06º 36,809' W	9:29	219
R04	Rota	03/08/20	36º 24,560' N	06º 40,681' W	10:23	181	36º 34,879' N	06º 21,880' W	14:04	21
R05	Chipiona	04/08/20	36º 40,394' N	06º 29,386' W	6:00	22	36º 31,176' N	06º 46,423' W	9:44	182
R06	Doñana	04/08/20	36º 08,078' N	06º 51,475'W	10:57	167	36º 46,708'N	06º 35,591' W	16:09	23
R07	Matalascañas	05/08/20	36º 54,385' N	06º 39,191' W	6:08	20	36º 43,948' N	06º 58,417' W	8:03	213
R08	Mazagón	06/08/20	37º 00,862' N	06º 44,971' W	7:35	23	36º 48,940' N	07º 05,670' W	11:35	268
R09	Punta Umbría	06/08/20	36º 49,737' N	07º 06,547' W	13:44	157	37º 03,920' N	06º 56,385' W	17:41	30
R10	El Rompido	07/08/20	37º 07,962' N	07º 07,192' W	6:32	20	36º 49,985' N	07º 07,201' W	9:56	218
R11	Isla Cristina	08/08/20	37º 06,847' N	07º 17,346' W	7:31	24	36º 53,310' N	07º 17,160' W	10:34	253
R12	V.R. do Sto. Antonio	08/08/20	36º 56,324' N	07,27,127' W	12:21	199	369º 06,420' N	07º 27,168' W	13:21	20
R13	Tavira	09/08/20	37º 04,465' N	07º 37,127' W	6:09	25	36º 56,929' N	07º 37,095' W	8:50	272
R14	Fuzeta	09/08/20	36º 55,551' N	07º 47,076' W	9:43	192	36º 59,385' N	07º 47,079' W	10:06	29
R15	Cape Sta. María	10/08/20	36º 55,746' N	07º 57,021' W	6:30	63	36º 52,070' N	07º 57,969' W	6:53	214
R16	Quarteira	10/08/20	36º 49,745' N	08º 06,883' W	9:36	200	37º 00,125' N	08º 07,056' W	10:41	35
R17	Albufeira	11/08/20	37º 02,270' N	08º 17,041' W	6:34	22	36º 49,448' N	08º 16,880' W	9:38	199
R18	Alfanzina	11/08/20	36º 50,239' N	08º 26,758' W	10:32	206	37º 04,522' N	08º 27,027' W	14:02	22
R19	Portimao	12/08/20	37º 05,982' N	08º 37,059' W	6:29	25	36º 51,512' N	08º 36,750' W	7:55	193
R20	Burgau	12/08/20	36º 51,947' N	08º 46,677' W	10:07	197	37º 02,731' N	08º 46,931' W	13:39	44
R21	Ponta de Sagres	12/08/20	36º 58,882' N	08º 56,783' W	14:51	31	36º 50,531' N	08º 56,601' W	16:30	216

Table 2. *ECOCADIZ 2020-07* survey. Descriptive characteristics of the fishing hauls. PE01-PE28 carried out with the *Tuneado* gear, PE29-PE30 with the Gloria HOD 352 gear. Hauls shaded in grey were conducted by night to collect anchovy hydrated females (DEPM).

FISHING STATION	DATE	POSITION						TIMING				TRAWLED DISTANCE (nmi)	ACOUSTIC TRANSECT	ZONE/LANDMARK
		START			END			START	END	EFFECTIVE TRAWLING	TOTAL MANOEUVRE			
		LAT.	LON.	DEP.	LAT.	LON.	DEP.	UTC	UTC					
PE01	02-08-2020	36º 03.8961 N	6º 25.4461 W	102,2	36º 05.9067 N	6º 22.1191 W	55,44	08:03	08:51	00:48	01:10	3,362	R01	Cape Trafalgar
PE02	02-08-2020	36º 11.8475 N	6º 28.3901 W	103,57	36º 09.8838 N	6º 32.3501 W	130	11:40	12:34	00:54	01:16	3,758	R02	Sancti-Petri
PE03	02-08-2020	36º 17.0228 N	6º 18.8575 W	43,76	36º 14.8750 N	6º 22.8320 W	52,92	14:37	15:31	00:54	01:13	3,864	R02	Sancti-Petri
PE04	03-08-2020	36º 22.8547 N	6º 26.3554 W	58,23	36º 24.5949 N	6º 22.9591 W	46,77	06:58	07:43	00:45	01:08	3,246	R03	Cádiz
PE05	03-08-2020	36º 29.5434 N	6º 31.7356 W	65,79	36º 27.5109 N	6º 35.2552 W	92,08	11:39	12:27	00:48	01:09	3,49	R04	Rota
PE06	04-08-2020	36º 35.5284 N	6º 38.3322 W	70,26	36º 37.9722 N	6º 33.9490 W	39,63	07:09	08:09	00:59	01:21	4,291	R05	Chipiona
PE07	04-08-2020	36º 41.0306 N	6º 46.3194 W	95,57	36º 39.3219 N	6º 50.3730 W	127,37	11:42	12:30	00:48	01:10	3,681	R06	Doñana
PE08	04-08-2020	36º 43.0302 N	6º 42.3165 W	53,87	36º 41.2464 N	6º 45.7079 W	88,11	14:08	14:52	00:44	01:07	3,257	R06	Doñana
PE09	05-08-2020	36º 44.4801 N	6º 57.2988 W	137,9	36º 46.2178 N	6º 54.3289 W	104,29	08:33	09:15	00:41	01:13	2,951	R07	Matalascañas
PE10	05-08-2020	36º 44.6802 N	6º 56.8048 W	130,82	36º 45.8449 N	6º 55.0405 W	112,1	18:22	18:48	00:26	00:54	1,834	R07	Matalascañas
PE11	05-08-2020	36º 45.8382 N	6º 54.8398 W	111,07	36º 44.6895 N	6º 57.0451 W	131,56	19:37	20:07	00:30	00:52	2,111	R07	Matalascañas
PE12	06-08-2020	36º 57.2017 N	6º 48.5350 W	35,59	36º 58.9782 N	6º 50.9701 W	35,93	08:35	09:13	00:38	00:-01	2,637	R08	Mazagón
PE13	06-08-2020	36º 50.5042 N	7º 04.0333 W	128,16	36º 52.5112 N	7º 00.5593 W	102,5	11:59	12:46	00:47	01:11	3,434	R08	Mazagón
PE14	06-08-2020	36º 57.1975 N	7º 01.1755 W	73,22	36º 54.7629 N	7º 02.6937 W	97,87	15:39	16:18	00:38	01:03	2,719	R09	Punta Umbría
PE15	07-08-2020	36º 56.4820 N	7º 07.1253 W	95,56	36º 59.3737 N	7º 07.2618 W	67,68	08:01	08:41	00:39	01:02	2,89	R10	El Rompido
PE16	07-08-2020	36º 50.3188 N	7º 07.2193 W	190,84	36º 53.1177 N	7º 07.2580 W	117,93	11:14	11:53	00:39	01:10	2,795	R10	El Rompido
PE17	07-08-2020	36º 56.9920 N	7º 01.2897 W	73,74	36º 55.2672 N	7º 02.3785 W	91,77	19:45	20:10	00:25	00:46	1,931	R09	Punta Umbría
PE18	07-08-2020	36º 55.1620 N	7º 02.3589 W	91,65	36º 57.1665 N	7º 01.1956 W	70,77	20:49	21:19	00:30	00:48	2,208	R09	Punta Umbría
PE19	08-08-2020	36º 57.0655 N	7º 17.1874 W	104,7	36º 59.9715 N	7º 17.2321 W	82,65	08:55	09:35	00:40	01:05	2,902	R11	Isla Cristina
PE20	08-08-2020	37º 01.7614 N	7º 25.4350 W	89,05	37º 02.3014 N	7º 28.6177 W	87,27	14:29	15:04	00:35	01:10	2,605	R12	Vila Real do Santo Antonio
PE21	09-08-2020	37º 02.5972 N	7º 36.0627 W	62	37º 02.1297 N	7º 37.6191 W	64,93	07:45	08:04	00:18	00:39	1,331	R13	Tavira
PE22	09-08-2020	36º 56.6653 N	7º 47.3578 W	90,68	36º 58.1019 N	7º 44.2978 W	95,66	11:20	11:58	00:37	01:02	2,841	R14	Fuzeta
PE23	09-08-2020	36º 57.4293 N	7º 37.0581 W	163,71	36º 59.1574 N	7º 37.0833 W	102,49	13:17	13:40	00:23	00:51	1,726	R13	Tavira
PE24	10-08-2020	36º 53.6404 N	7º 58.3531 W	92,56	36º 53.9695 N	7º 56.1154 W	91,41	07:50	08:15	00:25	00:47	1,825	R15	Cape Santa María
PE25	10-08-2020	36º 58.8162 N	8º 07.1766 W	41,47	36º 55.7527 N	8º 06.9198 W	51,76	11:18	12:00	00:41	01:05	3,066	R16	Cuarteira
PE26	11-08-2020	36º 52.5466 N	8º 16.9699 W	108,93	36º 56.0752 N	8º 17.0067 W	80,39	07:51	08:40	00:49	01:12	3,524	R17	Albufeira
PE27	11-08-2020	36º 50.8603 N	8º 24.8509 W	137,47	36º 50.9034 N	8º 22.8960 W	126,03	11:45	12:06	00:21	00:53	1,57	R18	Alfanzina
PE28	11-08-2020	36º 59.1541 N	8º 24.5935 W	45,45	36º 59.2177 N	8º 24.9019 W	45,87	15:17	15:22	00:04	00:24	0,255	R18	Alfanzina
PE29	12-08-2020	36º 52.8229 N	8º 36.7441 W	115,12	36º 55.3597 N	8º 36.7837 W	98,13	08:15	08:52	00:36	01:03	2,534	R19	Portimao
PE30	12-08-2020	36º 56.0071 N	8º 46.8201 W	114,55	36º 52.8661 N	8º 46.5577 W	112,34	11:33	12:15	00:42	01:10	3,144	R20	Burgau

Table 3. *ECOCADIZ 2020-07* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing hauls.

Fishing haul	CATCH IN NUMBERS													
	ANE	PIL	SAA	MAS	MAC	HOM	JAA	HMM	BOG	BOC	SNS	MAV	OTHERS SPP	TOTAL
01	13946	0	0	667	67	1228	2	0	1	0	0	0	120	**16031**
02	275	0	0	16807	21	1	0	10	0	0	0	0	0	**17114**
03	0	0	356	77	0	0	0	964	3	0	0	0	291	**1691**
04	1613	35778	3	1762	3	8	0	1354	172	0	0	0	341	**41034**
05	25245	36359	0	548	53	1	0	0	18	0	0	0	108	**62332**
06	114750	421	0	9	8	9	0	56	34	0	0	0	119	**115406**
07	49868	0	0	120	20	0	0	0	0	0	0	0	50	**50058**
08	103187	8118	0	141	24	24	0	0	3	0	0	0	80	**111577**
09	77913	0	0	1283	45	1	2	0	0	0	0	0	66	**79310**
12	95	3	20	814	0	1	0	626	70	0	0	0	175	**1804**
13	79653	0	0	107	5	0	1	5	1	0	0	0	37	**79809**
14	60536	29482	0	5391	41	2	0	0	0	0	0	0	19	**95471**
15	25047	40324	0	883	6	1	0	0	3	0	0	0	36	**66300**
16	79633	10	0	149	18	10	1	0	0	0	0	67	45	**79933**
19	6004	0	0	1008	18	9	0	0	0	0	0	0	33	**7072**
20	92664	1898	0	43	13	1	0	0	0	0	0	0	24	**94643**
21	65155	7183	0	1009	8	0	0	0	0	0	0	0	8	**73363**
22	1	9	0	6275	6	192	18	0		0	0	0	7	**6508**
23	0	0	0	127	2	58	14	0	1	0	112	0	2	**316**
24	1692	13104	0	481	9	497	28	0	52	0	0	0	69	**15932**
25	0	38467	0	46800	7	297	8	0	681	0	0	0	1430	**87690**
26	1509	32	0	7590	6	142	2	0	68	0	0	0	179	**9528**
27	0	0	0	20	7	0	14	0	0	0	0	0	6	**47**
28	0	37	0	66	0	1382	442	0	188	0	0	0	799	**2914**
29	6694	0	0	13	1	0	0	0	1	784	28	0	21	**7542**
30	170	0	0	316	2	13	2	0	1	0	996	0	19	**1519**
TOTAL	**805650**	**211225**	**379**	**92506**	**390**	**3877**	**534**	**3015**	**1297**	**784**	**1136**	**67**	**4084**	**1124944**

Table 3. *ECOCADIZ 2020-07* survey. Cont'd.

Fishing haul	CATCH IN WEIGHT (kg)													
	ANE	PIL	SAA	MAS	MAC	HOM	JAA	HMM	BOG	BOC	SNS	MAV	OTHERS SPP	TOTAL
01	212,345	0	0	35,035	3,260	89,525	0,034	0	0,044	0	0	0	26,759	**367,002**
02	7,410	0	0	891,425	0,740	0,098	0	4,050	0	0	0	0	0	**903,723**
03	0	0	65,475	8,235	0	0	0	192,420	0,495	0	0	0	41,845	**308,470**
04	17,461	582,176	0,284	187,766	1,060	0,654	0	250,149	29,550	0	0	0	48,911	**1118,011**
05	233,085	489,821	0	38,830	11,000	0,085	0	0	4,395	0	0	0	17,955	**795,171**
06	582,878	4,796	0	0,795	1,480	0,170	0	11,160	8,940	0	0	0	15,645	**625,864**
07	370,215	0	0	7,433	3,152	0	0	0	0	0	0	0	8,235	**389,035**
08	492,806	98,233	0	11,155	4,045	0,376	0	0	0,635	0	0	0	18,595	**625,845**
09	844,715	0	0	78,400	6,115	0,210	0,09	0	0	0	0	0	8,890	**938,420**
12	0,990	0,032	5,115	194,235	0	0,025	0	124,060	16,480	0	0	0	25,050	**365,987**
13	903,590	0	0	5,485	0,520	0	0,03	1,000	0,260	0	0	0	9,330	**920,215**
14	569,937	599,568	0	432,275	7,605	0,050	0	0	0	0	0	0	7,090	**1616,525**
15	232,626	1080,325	0	50,800	1,180	0,030	0	0	0,545	0	0	0	5,160	**1370,666**
16	1125,821	0,320	0	10,455	1,855	1,980	0,04	0	0	0	0	0,081	5,760	**1146,312**
19	82,902	0	0	86,050	2,635	0,560	0	0	0	0	0	0	3,290	**175,437**
20	1245,826	46,027	0	2,375	1,185	0,190	0	0	0	0	0	0	2,050	**1297,653**
21	984,406	237,874	0	72,990	1,280	0	0	0	0	0	0	0	1,015	**1297,565**
22	0,024	0,545	0	599,080	1,620	14,110	1,05	0	2,130	0	0	0	1,110	**619,669**
23	0	0	0	14,150	0,415	9,770	1,815	0	0,170	0	1,3	0	0,225	**27,845**
24	40,180	555,210	0	32,305	1,020	40,440	1,54	0	7,310	0	0	0	9,905	**687,910**
25	0	1125,129	0	2828,557	3,210	20,885	0,546	0	76,190	0	0	0	197,010	**4251,527**
26	33,660	1,840	0	498,010	0,410	15,090	0,11	0	7,370	0	0	0	18,270	**574,760**
27	0	0	0	1,402	0,347	0	1,224	0	0	0	0	0	0,320	**3,293**
28	0	1,935	0	5,995	0	104,505	28,48	0	18,050	0	0	0	146,750	**305,715**
29	164,030	0	0	1,025	0,050	0	0	0	0,090	3,83	0,165	0	1,580	**170,770**
30	5,375	0	0	29,790	0,090	1,325	0,14	0	0,110	0	6,785	0	1,9950	**45,610**
TOTAL	**8150,282**	**4823,831**	**70,874**	**6124,053**	**54,274**	**300,078**	**35,099**	**582,839**	**172,764**	**3,83**	**8,25**	**0,081**	**622,745**	**20949**

Table 4. *ECOCADIZ 2020-07* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: ANE: *Engraulis encrasicolus*; PIL: *Sardina pilchardus*; SAA: *Sardinella aurita*; VAM: *Scomber colias*; MAC: *Scomber scombrus*; HOM: *Trachurus trachurus*; JAA: *Trachurus picturatus;* HMM: *Trachurus mediterraneus*; BOG: *Boops boops*; BOC: *Capros aper*; SNS: *Macrorhamphosus scolopax*; MAV: *Maurolicus muelleri* (*: parameters from the ECOCADIZ 2019-07 survey).

PARAMETER	ANE	PIL	SAA	VAM	MAC	HOM	JAA	HMM	BOG
Size range (mm)	72 - 186	108 - 216	223 - 349	163 - 388	164 - 403	78 - 337	145 - 281	168 - 412	164 - 331
n	1509	639	345	1199	387	416	133	203	367
a	0.002151	0.004150	0.026995	0.003621	0.001368	0.009470	0.004957	0.018000	0.008441
b	3.414748	3.238180	2.621522	3.243804	3.512345	2.940128	3.150865	2.733727	3.022297
r^2	0.98	0.98	0.89	0.98	0.99	0.99	0.96	0.96	0.97

PARAMETER	BOC	SNS	MAV(*)
Size range (mm)	47 - 93	83 - 145	36 - 64
n	170	284	98
a	0.026171	0.003501	0,010578
b	2.849139	3.134380	2,869503
r^2	0.90	0.89	0,96

Table 5. *ECOCADIZ 2020-07* 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 18**.

ECOCADIZ 2020-07 . Engraulis encrasicolus . ABUNDANCE (in numbers and million fish)																			
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	POL12	POL13	*n*			Millions		
														PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	25826006	0	0	0	0	0	0	25826006	25826006	0	26	26
7,5	0	0	0	0	0	0	0	189088838	0	0	0	0	0	0	189088838	189088838	0	189	189
8	0	0	0	0	0	0	0	260328587	0	0	0	0	0	0	260328587	260328587	0	260	260
8,5	0	0	0	0	0	0	0	269849042	0	406033	0	0	0	0	270255075	270255075	0	270	270
9	0	250390	0	0	0	5799098	0	386101751	3635224	93714	0	0	0	250390	395629787	395880177	0	396	396
9,5	0	0	0	0	0	13353196	0	508716153	24720234	343495	0	0	0	0	547133078	547133078	0	547	547
10	0	0	0	0	0	31222831	0	279916324	39991011	62538	0	0	0	0	351192704	351192704	0	351	351
10,5	0	0	1492128	73025	2933	156660616	425654	184445807	35629450	93714	2028898	326100	0	1492128	379686197	381178325	1	380	381
11	0	0	5133118	251215	10089	371854836	1464308	158362785	34173235	1405342	6122290	975561	123	5133118	574619784	579752902	5	575	580
11,5	0	0	22240760	1088465	43712	503306766	6344548	45949260	19632337	1124385	15270129	1463341	492	22240760	594223435	616464195	22	594	616
12	0	0	55806852	2731192	109683	420770331	15919836	20658771	13088225	812066	18687221	3578882	369	55806852	496356576	552163428	56	496	552
12,5	0	1604645	46011327	2251798	90431	231154492	13125500	0	5091440	218605	8151188	6831664	492	47615972	266915610	314531582	48	267	315
13	0	4824009	58301953	2853302	114586	143429181	16631606	5167236	726336	31176	4413744	8618365	861	63125962	181986393	245112355	63	182	245
13,5	106717	7452805	45063177	2205395	88567	64706857	12855024	0	0	93714	1708546	5691683	1231	52622699	87351017	139973716	53	87	140
14	533585	15557635	36583615	1790405	71901	38733859	10436087	0	0	0	1032247	3414462	861	52674835	55479822	108154657	53	55	108
14,5	533585	27485074	13311048	651444	26161	19253664	3797199	0	0	0	0	1625021	615	41329707	25354104	66683811	41	25	67
15	1600755	30021103	8349283	408615	16410	2982649	2381772	0	0	0	0	161680	861	39971141	5951987	45923128	40	6	46
15,5	3308227	19938807	2240312	109641	4403	0	639086	0	0	0	0	975561	4061	25487346	1732752	27220098	25	2	27
16	4482114	10403140	389797	19077	766	0	111196	0	0	0	0	1301661	11814	15275051	1444514	16719565	15	1	17
16,5	4695548	4952300	0	0	0	0	0	0	0	0	0	1951121	7384	9647848	1958505	11606353	10	2	12
17	1600755	2852104	0	0	0	0	0	0	0	0	0	1301661	3938	4452859	1305599	5758458	4	1	6
17,5	960453	603955	0	0	0	0	0	0	0	0	0	0	615	1564408	615	1565023	2	0,001	2
18	320151	0	0	0	0	0	0	0	0	0	0	0	123	320151	123	320274	0,3	0,0001	0,3
18,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19,5	0	0	0	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	0	0	0
TOTAL *n*	18141890	125945967	294923370	14433574	579642	2003228376	84131816	2334410560	176687492	4684782	57414263	38216763	33840	439011227	4713821108	5152832335	**439**	**4714**	**5153**
Millions	**18**	**126**	**295**	**14**	**1**	**2003**	**84**	**2334**	**177**	**5**	**57**	**38**	**0,03**						

Table 5. *ECOCADIZ 2020-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

ECOCADIZ 2020-07 . Engraulis encrasicolus . BIOMASS (t)																
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**POL12**	**POL13**	**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	48,152	0	0	0	0	0	**0**	**48,152**	**48,152**
7,5	0	0	0	0	0	0	0	442,719	0	0	0	0	0	**0**	**442,719**	**442,719**
8	0	0	0	0	0	0	0	754,575	0	0	0	0	0	**0**	**754,575**	**754,575**
8,5	0	0	0	0	0	0	0	956,230	0	1,439	0	0	0	**0**	**957,669**	**957,669**
9	0	1,073	0	0	0	24,843	0	1654,069	15,573	0,401	0	0	0	**1,073**	**1694,886**	**1695,959**
9,5	0	0	0	0	0	68,471	0	2608,545	126,758	1,761	0	0	0	**0**	**2805,535**	**2805,535**
10	0	0	0	0	0	189,916	0	1702,616	243,249	0,380	0	0	0	**0**	**2136,161**	**2136,161**
10,5	0	0	10,679	0,523	0,021	1121,195	3,046	1320,049	254,994	0,671	14,52	2,334	0	**10,679**	**2717,353**	**2728,032**
11	0	0	42,907	2,100	0,084	3108,248	12,240	1323,718	285,646	11,747	51,175	8,154	0,001	**42,907**	**4803,113**	**4846,020**
11,5	0	0	215,665	10,555	0,424	4880,493	61,522	445,563	190,372	10,903	148,072	14,190	0,005	**215,665**	**5762,099**	**5977,764**
12	0	0	623,906	30,534	1,226	4704,104	177,980	230,960	146,323	9,079	208,918	40,011	0,004	**623,906**	**5549,139**	**6173,045**
12,5	0	20,565	589,691	28,860	1,159	2962,527	168,219	0	65,253	2,802	104,467	87,556	0,006	**610,256**	**3420,849**	**4031,105**
13	0	70,504	852,096	41,702	1,675	2096,251	243,075	75,520	10,616	0,456	64,508	125,959	0,013	**922,60**	**2659,775**	**3582,375**
13,5	1,770	123,611	747,412	36,578	1,469	1073,219	213,212	0	0	1,554	28,338	94,401	0,020	**872,793**	**1448,791**	**2321,584**
14	9,998	291,509	685,48	33,547	1,347	725,770	195,545	0	0	0	19,342	63,978	0,016	**986,987**	**1039,545**	**2026,532**
14,5	11,247	579,360	280,585	13,732	0,551	405,849	80,041	0	0	0	0	34,254	0,013	**871,192**	**534,440**	**1405,632**
15	37,811	709,114	197,214	9,652	0,388	70,452	56,259	0	0	0	0	3,819	0,020	**944,139**	**140,59**	**1084,729**
15,5	87,242	525,814	59,080	2,891	0,116	0	16,854	0	0	0	0	25,727	0,107	**672,136**	**45,695**	**717,831**
16	131,511	305,242	11,437	0,560	0,022	0	3,263	0	0	0	0	38,193	0,347	**448,190**	**42,385**	**490,575**
16,5	152,795	161,15	0	0	0	0	0	0	0	0	0	63,490	0,240	**313,945**	**63,730**	**377,675**
17	57,593	102,615	0	0	0	0	0	0	0	0	0	46,832	0,142	**160,208**	**46,974**	**207,182**
17,5	38,097	23,956	0	0	0	0	0	0	0	0	0	0	0,024	**62,053**	**0,024**	**62,077**
18	13,963	0	0	0	0	0	0	0	0	0	0	0	0,005	**13,963**	**0,005**	**13,968**
18,5	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
19	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
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**
TOTAL	**542,027**	**2914,513**	**4316,152**	**211,234**	**8,482**	**21431,338**	**1231,256**	**11562,716**	**1338,784**	**41,193**	**639,340**	**648,898**	**0,963**	**7772,692**	**37114,204**	**44886,896**

Table 6. *ECOCADIZ 2019-07* survey. Anchovy (*E. encrasicolus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group (years). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 18** and ordered from west to east.

Age class	POL 01	POL 02	POL 03	POL 04	POL 05	POL 06	POL 07	POL 08	POL 09	POL 10	POL 11	POL 12	POL 13	PT	ES	TOTAL
	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
0	200	6161	91427	4474	180	1217760	26081	2250386	150228	3480	32260	9821	1	97788	3694672	3792460
I	13293	104151	198535	9716	390	779871	56636	83993	26455	1204	25092	26416	25	315979	1009799	1325778
II	4649	15634	4961	243	10	5597	1415	32	4	0,2	62	1980	7	25244	9351	34595
III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	18142	125946	294923	14434	580	2003228	84132	2334411	176687	4685	57414	38217	34	439011	4713821	5152832

Age class	POL 01	POL 02	POL 03	POL 04	POL 05	POL 06	POL 07	POL 08	POL 09	POL 10	POL 11	POL 12	POL 13	PT	ES	TOTAL
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
0	5	111	1113	54	2	11713	318	10834	1083	28	333	123	0,02	1229	24490	25718
I	385	2398	3099	152	6	9608	884	728	255	13	305	467	1	5882	12419	18302
II	152	406	104	5	0,2	110	30	0,5	0,1	0,003	1	59	0,2	662	205	867
III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	542	2915	4316	211	8	21431	1231	11563	1339	41	639	649	1	7773	37114	44887

Table 7. *ECOCADIZ 2020-07* survey. Sardine (*S. pilchardus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 21**.

***ECOCADIZ 2020-07. Sardina pilchardus*. ABUNDANCE (in numbers and million fish)**														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	***n***			**Millions**		
									PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8,5	0	56277	0	0	1983	861394	0	0	58260	861394	919654	0,1	1	1
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	2972384	0	0	2972384	2972384	0	3	3
10,5	0	0	0	0	0	0	25997500	0	0	25997500	25997500	0	26	26
11	0	47205	0	784338	1664	722534	49511572	3509973	833207	53744079	54577286	1	54	55
11,5	0	112554	0	784338	3967	1722788	41040571	5263513	900859	48026872	48927731	1	48	49
12	0	1218858	0	3137353	42955	18656221	20982522	20472434	4399166	60111177	64510343	4	60	65
12,5	0	4479513	0	9412060	157866	68564803	20750372	26320460	14049439	115635635	129685074	14	116	130
13	0	11811053	0	17998500	416241	180783616	10371664	28661407	30225794	219816687	250042481	30	220	250
13,5	0	13582593	0	17214162	478673	207899349	2398964	13452487	31275428	223750800	255026228	31	224	255
14	0	13978913	793166	32116589	492640	213965543	1023687	4679000	47381308	219668230	267049538	47	220	267
14,5	0	6375330	3993660	23488868	224677	97582762	1613	584513	34082535	98168888	132251423	34	98	132
15	0	3869368	4800741	13581437	136363	59225742	3226	584513	22387909	59813481	82201390	22	60	82
15,5	0	3435416	3993660	14200651	121070	52583539	281868	0	21750797	52865407	74616204	22	53	75
16	17864	3287435	9601483	23571430	115855	50318498	4840	0	36594067	50323338	86917405	37	50	87
16,5	17864	1939505	23196625	47762074	68351	29686655	8838	0	72984419	29695493	102679912	73	30	103
17	38519	2892676	62381807	53169881	101943	44276185	3226	0	118584826	44279411	162864237	119	44	163
17,5	160775	1882807	44793004	27121593	66353	28818825	32968	0	74024532	28851793	102876325	74	29	103
18	228323	1324772	21596378	11517389	46687	20277374	157838	0	34713549	20435212	55148761	35	20	55
18,5	254561	304981	6400988	0	10748	4668139	45805	0	6971278	4713944	11685222	7	5	12
19	192595	304981	0	0	10748	4668139	24970	0	508324	4693109	5201433	1	5	5
19,5	159659	182804	0	660495	6442	2798050	168290	0	1009400	2966340	3975740	1	3	4
20	121140	91633	793166	0	3229	1402567	176288	0	1009168	1578855	2588023	1	2	3
20,5	38519	0	0	0	0	0	3226	0	38519	3226	41745	0,04	0,003	0,04
21	74247	30544	0	0	1076	467522	0	0	105867	467522	573389	0,1	0,5	1
21,5	17864	0	0	0	0	0	0	0	17864	0	17864	0,02	0	0,02
22	0	0	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	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	1321930	71209218	182344678	296521158	2509531	1089950245	175962232	103528300	553906515	1369440777	1923347292	**554**	**1369**	**1923**
Millions	**1**	**71**	**182**	**297**	**3**	**1090**	**176**	**104**	**554**	**1369**	**1923**			

Table 7. *ECOCADIZ 2020-07* survey. Sardine (*S. pilchardus*). Cont'd.

ECOCADIZ 2020-07 . Sardina pilchardus . BIOMASS (t)											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**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	0,262	0	0	0,009	4,014	0	0	0,271	4,014	4,285
9	0	0	0	0	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	23,121	0	0	23,121	23,121
10,5	0	0	0	0	0	0	235,951	0	0	235,951	235,951
11	0	0,496	0	8,248	0,017	7,598	520,633	36,909	8,761	565,14	573,901
11,5	0	1,363	0	9,495	0,048	20,855	496,813	63,717	10,906	581,385	592,291
12	0	16,886	0	43,466	0,595	258,469	290,698	283,631	60,947	832,798	893,745
12,5	0	70,644	0	148,433	2,490	1081,301	327,244	415,087	221,567	1823,632	2045,199
13	0	210,974	0	321,497	7,435	3229,24	185,263	511,963	539,906	3926,466	4466,372
13,5	0	273,537	0	346,672	9,640	4186,84	48,312	270,917	629,849	4506,069	5135,918
14	0	316,037	17,932	726,096	11,138	4837,359	23,144	105,783	1071,203	4966,286	6037,489
14,5	0	161,163	100,956	593,780	5,680	2466,813	0,041	14,776	861,579	2481,63	3343,209
15	0	108,964	135,193	382,464	3,840	1667,844	0,091	16,460	630,461	1684,395	2314,856
15,5	0	107,397	124,849	443,938	3,785	1643,857	8,812	0	679,969	1652,669	2332,638
16	0,618	113,716	332,127	815,364	4,008	1740,576	0,167	0	1265,833	1740,743	3006,576
16,5	0,682	74,007	885,135	1822,501	2,608	1132,781	0,337	0	2784,933	1133,118	3918,051
17	1,617	121,409	2618,231	2231,597	4,279	1858,319	0,135	0	4977,133	1858,454	6835,587
17,5	7,402	86,684	2062,261	1248,673	3,055	1326,813	1,518	0	3408,075	1328,331	4736,406
18	11,501	66,733	1087,881	580,169	2,352	1021,438	7,951	0	1748,636	1029,389	2778,025
18,5	13,996	16,768	351,932	0	0,591	256,658	2,518	0	383,287	259,176	642,463
19	11,531	18,260	0	0	0,644	279,490	1,495	0	30,435	280,985	311,420
19,5	10,387	11,892	0	42,969	0,419	182,028	10,948	0	65,667	192,976	258,643
20	8,545	6,464	55,951	0	0,228	98,939	12,436	0	71,188	111,375	182,563
20,5	2,940	0	0	0	0	0	0,246	0	2,940	0,246	3,186
21	6,122	2,519	0	0	0,089	38,551	0	0	8,730	38,551	47,281
21,5	1,588	0	0	0	0	0	0	0	1,588	0	1,588
22	0	0	0	0	0	0	0	0	0	0	0
22,5	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**76,929**	**1786,175**	**7772,448**	**9765,362**	**62,950**	**27339,783**	**2197,874**	**1719,243**	**19463,864**	**31256,900**	**50720,764**

Table 8. *ECOCADIZ 2019-07* survey. Sardine (*S. pilchardus*). Estimated abundance (thousands of individuals) and biomass (t) by age group (years). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 21** and ordered from west to east.

Age class	POL 01	POL 02	POL 03	POL 04	POL 05	POL 06	POL 07	POL 08	PT	ES	TOTAL
	N	N	N	N	N	N	N	N	N	N	N
0	40	56218	28398	141923	1981	860495	175070	103169	228561	1138735	1367295
I	404	9847	79965	92939	347	150719	430	286	183502	151435	334937
II	623	4510	65222	55264	159	69024	369	73	125778	69466	195244
III	141	548	7787	5835	19	8395	38	0	14331	8433	22764
IV	73	74	933	559	3	1131	44	0	1643	1175	2817
V	40	12	40	0	0,4	187	10	0	92	197	289
TOTAL	1322	71209	182345	296521	2510	1089950	175962	103528	553907	1369441	1923347

Age class	POL 01	POL 02	POL 03	POL 04	POL 05	POL 06	POL 07	POL 08	PT	ES	TOTAL
	B	B	B	B	B	B	B	B	B	B	B
0	2	1207	1034	3551	43	18473	2152	1711	5836	22337	28172
I	21	354	3424	3612	12	5417	17	7	7424	5440	12864
II	36	195	2914	2327	7	2982	22	2	5479	3006	8485
III	9	25	352	249	1	387	2	0	636	389	1025
IV	6	4	46	27	0,2	67	3	0	83	70	153
V	3	1	3	0	0,03	15	1	0	7	15	22
TOTAL	77	1786	7772	9765	63	27340	2198	1719	19464	31257	50721

Table 9. *ECOCADIZ 2020-07* survey. Round sardinella (*S. aurita*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 24**.

***ECOCADIZ 2020-07. Sardinella aurita*. ABUNDANCE (in numbers and million fish)**								
Size class	**POL01**	**POL02**	***n***			**Millions**		
			PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
20	0	0	0	0	0	0	0	0
20,5	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0
21,5	0	0	0	0	0	0	0	0
22	763	73337	0	74100	74100	0	0,1	0,1
22,5	763	73337	0	74100	74100	0	0,1	0,1
23	5344	513358	0	518702	518702	0	1	1
23,5	3054	293348	0	296402	296402	0	0,3	0,3
24	11452	1100053	0	1111505	1111505	0	1	1
24,5	9925	953380	0	963305	963305	0	1	1
25	13743	1320064	0	1333807	1333807	0	1	1
25,5	14506	1393401	0	1407907	1407907	0	1	1
26	8398	806706	0	815104	815104	0	1	1
26,5	7635	733369	0	741004	741004	0	1	1
27	4581	440021	0	444602	444602	0	0,4	0,4
27,5	5344	513358	0	518702	518702	0	1	1
28	9162	880043	0	889205	889205	0	1	1
28,5	9162	880043	0	889205	889205	0	1	1
29	29776	2860139	0	2889915	2889915	0	3	3
29,5	26722	2566791	0	2593513	2593513	0	3	3
30	35120	3373497	0	3408617	3408617	0	3	3
30,5	34357	3300160	0	3334517	3334517	0	3	3
31	16797	1613412	0	1630209	1630209	0	2	2
31,5	10689	1026716	0	1037405	1037405	0	1	1
32	7635	733369	0	741004	741004	0	1	1
32,5	3054	293348	0	296402	296402	0	0,3	0,3
33	0	0	0	0	0	0	0	0
33,5	1527	146674	0	148201	148201	0	0,1	0,1
34	763	73337	0	74100	74100	0	0,1	0,1
34,5	1527	146674	0	148201	148201	0	0,1	0,1
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
37	0	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0
38,5	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0
39,5	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0
TOTAL *n*	271799	26107935	0	26379734	26379734	**0**	**26**	**26**
Millions	**0,3**	**26**	**0**	**26**	**26**			

Table 9. *ECOCADIZ 2020-07* survey. Round sardinella (*S. aurita*). Cont'd.

ECOCADIZ 2020-07. Sardinella aurita . BIOMASS (t)					
Size class	**POL01**	**POL02**	**PORTUGAL**	**SPAIN**	**TOTAL**
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
22	0,070	6,740	0	6,810	6,810
22,5	0,074	7,144	0	7,218	7,218
23	0,551	52,943	0	53,494	53,494
23,5	0,333	31,989	0	32,322	32,322
24	1,319	126,692	0	128,011	128,011
24,5	1,206	115,834	0	117,040	117,040
25	1,760	169,019	0	170,779	170,779
25,5	1,955	187,820	0	189,775	189,775
26	1,191	114,360	0	115,551	115,551
26,5	1,137	109,236	0	110,373	110,373
27	0,716	68,802	0	69,518	69,518
27,5	0,876	84,188	0	85,064	85,064
28	1,575	151,238	0	152,813	152,813
28,5	1,649	158,357	0	160,006	160,006
29	5,606	538,456	0	544,062	544,062
29,5	5,259	505,185	0	510,444	510,444
30	7,221	693,611	0	700,832	700,832
30,5	7,374	708,329	0	715,703	715,703
31	3,761	361,251	0	365,012	365,012
31,5	2,495	239,655	0	242,150	242,150
32	1,857	178,340	0	180,197	180,197
32,5	0,773	74,272	0	75,045	75,045
33	0	0	0	0	0
33,5	0,418	40,183	0	40,601	40,601
34	0,217	20,881	0	21,098	21,098
34,5	0,452	43,379	0	43,831	43,831
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
37	0	0	0	0	0
37,5	0	0	0	0	0
38	0	0	0	0	0
38,5	0	0	0	0	0
39	0	0	0	0	0
39,5	0	0	0	0	0
40	0	0	0	0	0
TOTAL	**49,845**	**4787,904**	**0**	**4837,749**	**4837,749**

Table 10. *ECOCADIZ 2020-07* survey. Mackerel (*S. scombrus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 26**.

***ECOCADIZ 2020-07. Scomber scombrus*. ABUNDANCE (in numbers and million fish)**														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	***n***			**Millions**		
									PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	2550	0	2550	2550	0	0,003	0,003
16,5	0	0	0	0	0	11462	0	7650	0	19112	19112	0	0,02	0,02
17	0	0	0	0	0	22924	0	5100	0	28024	28024	0	0,03	0,03
17,5	0	0	0	0	0	0	0	43348	0	43348	43348	0	0,04	0,04
18	2576	5151	43	1049	7112	57311	0	45898	7727	111413	119140	0,01	0,1	0,1
18,5	0	0	0	0	0	22924	0	25499	0	48423	48423	0	0,05	0,05
19	2576	5151	43	1049	7112	11462	0	22949	7727	42615	50342	0,01	0,04	0,1
19,5	0	0	0	0	0	0	0	2550	0	2550	2550	0	0,003	0,003
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20,5	0	0	0	0	0	0	0	2550	0	2550	2550	0	0,003	0,003
21	0	0	0	0	0	11462	0	0	0	11462	11462	0	0,01	0,01
21,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	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	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	11462	0	0	0	11462	11462	0	0,01	0,01
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	11462	2786	2550	0	16798	16798	0	0,02	0,02
26,5	0	0	0	0	0	22924	2786	0	0	25710	25710	0	0,03	0,03
27	2576	5151	43	1049	7112	68773	0	2550	7727	79527	87254	0,01	0,1	0,1
27,5	7727	15453	130	3147	21335	45849	2786	2550	23180	75797	98977	0,02	0,1	0,1
28	10302	20604	174	4196	28446	34387	2786	0	30906	69989	100895	0,03	0,1	0,1
28,5	23180	46359	391	9441	64004	80235	19499	0	69539	173570	243109	0,1	0,2	0,2
29	23180	46359	391	9441	64004	57311	33426	0	69539	164573	234112	0,1	0,2	0,2
29,5	18029	36057	304	7343	49781	11462	25070	0	54086	93960	148046	0,1	0,1	0,1
30	7727	15453	130	3147	21335	34387	30641	2550	23180	92190	115370	0,02	0,1	0,1
30,5	5151	10302	87	2098	14223	0	11142	2550	15453	30100	45553	0,02	0,03	0,05
31	0	0	0	0	0	0	5571	0	0	5571	5571	0	0,01	0,01
31,5	0	0	0	0	0	0	5571	0	0	5571	5571	0	0,01	0,01
32	0	0	0	0	0	0	2786	0	0	2786	2786	0	0,003	0,003
32,5	2576	5151	43	1049	7112	0	0	0	7727	8204	15931	0,01	0,01	0,02
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	2786	0	0	2786	2786	0	0,003	0,003
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	105600	211191	1779	43009	291576	515797	147636	170844	316791	1170641	1487432	**0,3**	**1**	**1**
Millions	**0,1**	**0,2**	**0,002**	**0,04**	**0,3**	**1**	**0,1**	**0,2**	**0,3**	**1**	**1**			

Table 10. *ECOCADIZ 2020-07* survey. Mackerel (*S. scombrus*). Cont'd.

ECOCADIZ 2020-07. Scomber scombrus. BIOMASS (t)											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	0,062	0	0,062	0,062
16,5	0	0	0	0	0	0,312	0	0,208	0	0,520	0,520
17	0,000	0,000	0,000	0,000	0,000	0,693	0	0,154	0	0,847	0,847
17,5	0,000	0,000	0,000	0,000	0,000	0,000	0	1,448	0	1,448	1,448
18	0,095	0,190	0,002	0,039	0,262	2,111	0	1,690	0,285	4,104	4,389
18,5	0,000	0,000	0,000	0,000	0,000	0,928	0	1,033	0,000	1,961	1,961
19	0,114	0,229	0,002	0,047	0,316	0,509	0	1,019	0,343	1,893	2,236
19,5	0	0	0	0	0	0	0	0,124	0	0,124	0,124
20	0	0	0	0	0	0	0	0	0	0	0
20,5	0	0	0	0	0	0	0	0,147	0	0,147	0,147
21	0	0	0	0	0	0,720	0	0	0	0,720	0,720
21,5	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0
22,5	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0
23,5	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	1,231	0	0	0	1,231	1,231
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	1,513	0,368	0,337	0	2,218	2,218
26,5	0	0	0	0	0	3,234	0,393	0	0	3,627	3,627
27	0,388	0,776	0,006	0,158	1,071	10,354	0	0,384	1,164	11,973	13,137
27,5	1,240	2,480	0,021	0,505	3,424	7,358	0,447	0,409	3,720	12,164	15,884
28	1,760	3,521	0,030	0,717	4,861	5,876	0,476	0	5,281	11,960	17,241
28,5	4,213	8,425	0,071	1,716	11,632	14,581	3,544	0	12,638	31,544	44,182
29	4,476	8,951	0,075	1,823	12,358	11,066	6,454	0	13,427	31,776	45,203
29,5	3,695	7,389	0,062	1,505	10,201	2,349	5,137	0	11,084	19,254	30,338
30	1,679	3,358	0,028	0,684	4,636	7,472	6,658	0,554	5,037	20,032	25,069
30,5	1,186	2,371	0,020	0,483	3,274	0	2,564	0,587	3,557	6,928	10,485
31	0	0	0	0	0	0	1,357	0	0	1,357	1,357
31,5	0	0	0	0	0	0	1,435	0	0	1,435	1,435
32	0	0	0	0	0	0	0,758	0	0	0,758	0,758
32,5	0,740	1,479	0,012	0,301	2,042	0	0	0	2,219	2,355	4,574
33	0	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0,985	0	0	0,985	0,985
35	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**19,586**	**39,169**	**0,329**	**7,978**	**54,077**	**70,307**	**30,576**	**8,156**	**58,755**	**171,423**	**230,178**

Table 11. *ECOCADIZ 2020-07* 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 28**.

ECOCADIZ 2020-07. *Scomber colias*. ABUNDANCE (in numbers and million fish)																						
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	POL11	POL12	POL13	POL14	POL15	POL16	*n*			Millions		
																	PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	428	0	0	124055	0	0	0	0	0	0	0	428	124055	124483	0,0004	0,1	0,1
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	52	0	0	15033	0	0	0	0	0	0	11649	52	26682	26734	0,0001	0,03	0,03
16,5	0	0	0	0	0	685	0	0	198479	0	0	148759	4786	0	5261	11649	685	368934	369619	0,001	0,4	0,4
17	0	0	0	0	39116	4486	238	5037	1299820	77901	0	487382	46392	0	50998	210846	43602	2178614	2222216	0,04	2	2
17,5	0	95316	0	651000	219560	12320	1335	28272	3569576	437260	0	1484894	112310	594425	123461	703997	978196	7055530	8033726	1	7	8
18	0	1743636	0	11908856	233270	10617	1418	30037	3076136	464564	0	1129418	54224	743031	59608	830139	13896379	6388575	20284954	14	6	20
18,5	26807	5492780	191056	37515138	284271	6752	1728	36604	1956188	566133	0	1172895	45849	0	50401	472811	43516804	4302609	47819413	44	4	48
19	104387	6131310	743961	41876232	563994	4488	3429	72623	1300324	1123210	0	1091868	67250	222909	73927	497587	49424372	4453127	53877499	49	4	54
19,5	64175	5408247	457377	36937785	1013779	2816	6163	130540	816022	2018969	0	834592	105538	222909	116017	357934	43884179	4608684	48492863	44	5	48
20	387896	4285188	2764524	29267405	1236974	2655	7520	159280	769336	2463468	0	719539	114567	297212	125942	330201	37944642	4987065	42931707	38	5	43
20,5	377335	2536701	2689259	17325411	1545437	1185	9395	198999	343426	3077781	0	526118	115356	58447	126810	107663	24475328	4563995	29039323	24	5	29
21	706742	2955182	5036934	20183595	1627417	2235	9894	209555	647591	3241045	0	212933	117885	161974	129589	116310	30512105	4846776	35358881	31	5	35
21,5	931762	2076842	6640647	14184626	1793013	1467	10900	230878	425167	3570835	0	336253	114024	191198	125345	55287	25628357	5059887	30688244	26	5	31
22	1170186	2030946	8339888	13871159	2268651	2325	13792	292124	673755	4518081	0	372329	97680	775670	107379	104661	27683155	6955471	34638626	28	7	35
22,5	1571486	1018565	11199940	6956694	2311233	1776	14051	297607	514627	4602883	51563	354291	96212	1197410	105765	31990	23059694	7266399	30326093	23	7	30
23	1510154	406579	10762827	2776894	1705637	2673	10369	219627	774542	3396824	92814	445090	71247	1683332	78321	31990	17164764	6804156	23968920	17	7	24
23,5	642567	108728	4579557	742604	1132240	1317	6883	145793	381660	2254886	237192	171827	61268	1338383	67351	0	7207013	4665243	11872256	7	5	12
24	385865	47658	2750050	325500	644187	1198	3916	82949	347065	1282917	237192	166797	32687	823238	35933	0	4154458	3012694	7167152	4	3	7
24,5	248984	0	1774506	0	492473	993	2994	63414	287566	980774	185628	123319	26976	1016923	29655	0	2516956	2717249	5234205	3	3	5
25	120634	0	859752	0	326740	307	1986	42073	89087	650711	92814	0	17676	220421	19431	0	1307433	1134199	2441632	1	1	2
25,5	40211	0	286584	0	98278	307	597	12655	89087	195722	185628	23068	7043	533489	7743	0	425380	1055032	1480412	0,4	1	1
26	26807	0	191056	0	155499	0	945	20023	0	309680	51563	64175	2393	236277	2631	0	373362	687687	1061049	0,4	1	1
26,5	64175	0	457377	0	84756	0	515	10914	0	168795	288755	0	0	161974	0	0	606308	630953	1237261	1	1	1
27	26807	0	191056	0	107056	0	651	13785	0	213206	237192	0	0	177830	0	0	324919	642664	967583	0,3	1	1
27,5	64175	47658	457377	325500	0	0	0	0	0	0	185628	0	0	116895	0	0	894710	302523	1197233	1	0,3	1
28	0	0	0	0	56504	0	344	7276	0	112530	330006	0	0	148606	0	0	56504	598762	655266	0,1	1	1
28,5	0	0	0	0	0	0	0	0	0	0	237192	0	0	74303	0	0	0	311495	311495	0	0,3	0,3
29	0	0	0	0	0	0	0	0	0	0	804389	0	0	0	0	10170	0	814559	814559	0	1	1
29,5	0	0	0	0	0	0	0	0	0	0	618761	0	0	148606	0	0	0	767367	767367	0	1	1
30	0	0	0	0	0	0	0	0	0	0	474383	0	0	74303	0	0	0	548686	548686	0	1	0,5
30,5	0	0	0	0	0	0	0	0	0	0	1051893	0	0	0	0	0	0	1051893	1051893	0	1	1
31	0	0	0	0	0	0	0	0	0	0	670324	0	0	0	0	0	0	670324	670324	0	1	1
31,5	0	0	0	0	0	0	0	0	0	0	433133	0	0	0	0	0	0	433133	433133	0	0,4	0,4
32	0	0	0	0	0	0	0	0	0	0	185628	0	0	0	0	0	0	185628	185628	0	0,2	0,2
32,5	0	0	0	0	0	0	0	0	0	0	567197	0	0	0	0	0	0	567197	567197	0	1	1
33	0	0	0	0	0	0	0	0	0	0	567197	0	0	0	0	0	0	567197	567197	0	1	1
33,5	0	0	0	0	0	0	0	0	0	0	185628	0	0	0	0	0	0	185628	185628	0	0,2	0,2
34	0	0	0	0	0	0	0	0	0	0	92814	0	0	0	0	0	0	92814	92814	0	0,1	0,1
34,5	0	0	0	0	0	0	0	0	0	0	144378	0	0	0	0	0	0	144378	144378	0	0,1	0,1
35	0	0	0	0	0	0	0	0	0	0	92814	0	0	148606	0	0	0	241420	241420	0	0,2	0,2
35,5	0	0	0	0	0	0	0	0	0	0	92814	0	0	74303	0	0	0	167117	167117	0	0,2	0,2
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	8471155	34385336	60373728	234848399	17940085	61082	109063	2310065	17698542	35728175	8394520	9865547	1311363	11442674	1441568	3884884	356079785	92186401	448266186	**356**	**92**	**448**
Millions	**8**	**34**	**60**	**235**	**18**	**0,1**	**0,1**	**2**	**18**	**36**	**8**	**10**	**1**	**11**	**1**	**4**						

Table 11. *ECOCADIZ 2020-07* survey. Chub mackerel (*S. colias*). Cont'd.

ECOCADIZ 2019-07 . Scomber colias . BIOMASS (t)																			
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**POL11**	**POL12**	**POL13**	**POL14**	**POL15**	**POL16**	**PORTUGAL**	**SPAIN**	**TOTAL**
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0,011	0	0	3,096	0	0	0	0	0	0	0	0,011	3,096	3,107
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0,002	0	0	0,461	0	0	0	0	0	0	0,357	0,002	0,818	0,820
16,5	0	0	0	0	0	0,023	0	0	6,715	0	0	5,033	0,162	0	0,178	0,394	0,023	12,482	12,505
17	0	0	0	0	1,456	0,167	0,009	0,187	48,378	2,899	0	18,140	1,727	0	1,898	7,847	1,623	81,085	82,708
17,5	0	3,892	0	26,583	8,965	0,503	0,055	1,154	145,758	17,855	0	60,633	4,586	24,272	5,041	28,747	39,943	288,101	328,044
18	0	77,913	0	532,135	10,423	0,474	0,063	1,342	137,454	20,759	0	50,467	2,423	33,202	2,664	37,094	620,945	285,468	906,413
18,5	1,308	267,930	9,319	1829,935	13,866	0,329	0,084	1,785	95,420	27,615	0	57,212	2,236	0	2,458	23,063	2122,687	209,873	2332,56
19	5,546	325,730	39,523	2224,701	29,963	0,238	0,182	3,858	69,081	59,671	0	58,006	3,573	11,842	3,927	26,435	2625,701	236,575	2862,276
19,5	3,705	312,237	26,406	2132,549	58,529	0,163	0,356	7,537	47,112	116,562	0	48,184	6,093	12,869	6,698	20,665	2533,589	266,076	2799,665
20	24,286	268,299	173,089	1832,456	77,448	0,166	0,471	9,973	48,169	154,240	0	45,051	7,173	18,609	7,885	20,674	2375,744	312,245	2687,989
20,5	25,570	171,902	182,240	1174,072	104,728	0,080	0,637	13,485	23,273	208,569	0	35,653	7,817	3,961	8,593	7,296	1658,592	309,284	1967,876
21	51,739	216,341	368,741	1477,588	119,139	0,164	0,724	15,341	47,408	237,268	0	15,588	8,630	11,858	9,487	8,515	2233,712	354,819	2588,531
21,5	73,557	163,954	524,238	1119,789	141,547	0,116	0,860	18,226	33,564	281,895	0	26,545	9,001	15,094	9,895	4,365	2023,201	399,445	2422,646
22	99,447	172,598	708,757	1178,826	192,799	0,198	1,172	24,826	57,258	383,964	0	31,642	8,301	65,920	9,125	8,895	2352,625	591,103	2943,728
22,5	143,534	93,032	1022,963	635,400	211,100	0,162	1,283	27,182	47,004	420,411	4,710	32,360	8,788	109,367	9,660	2,922	2106,191	663,687	2769,878
23	148,010	39,849	1054,866	272,164	167,170	0,262	1,016	21,526	75,913	332,923	9,097	43,623	6,983	164,984	7,676	3,135	1682,321	666,876	2349,197
23,5	67,478	11,418	480,916	77,984	118,901	0,138	0,723	15,310	40,079	236,794	24,908	18,044	6,434	140,548	7,073	0	756,835	489,913	1246,748
24	43,354	5,355	308,984	36,572	72,378	0,135	0,440	9,320	38,995	144,143	26,650	18,741	3,673	92,496	4,037	0	466,778	338,495	805,273
24,5	29,890	0	213,022	0	59,119	0,119	0,359	7,613	34,521	117,738	22,284	14,804	3,238	122,077	3,560	0	302,150	326,194	628,344
25	15,452	0	110,128	0	41,853	0,039	0,254	5,389	11,411	83,351	11,889	0	2,264	28,234	2,489	0	167,472	145,281	312,753
25,5	5,489	0	39,120	0	13,415	0,042	0,081	1,727	12,161	26,717	25,339	3,149	0,961	72,824	1,057	0	58,066	144,016	202,082
26	3,895	0	27,759	0	22,593	0	0,137	2,909	0	44,994	7,492	9,324	0,348	34,329	0,382	0	54,247	99,915	154,162
26,5	9,913	0	70,647	0	13,092	0	0,080	1,686	0	26,072	44,602	0	0	25,019	0	0	93,652	97,459	191,111
27	4,397	0	31,338	0	17,560	0	0,107	2,261	0	34,971	38,905	0	0	29,169	0	0	53,295	105,413	158,708
27,5	11,166	8,292	79,579	56,634	0	0	0	0	0	0	32,297	0	0	20,339	0	0	155,671	52,636	208,307
28	0	0	0	0	10,417	0	0,063	1,341	0	20,747	60,842	0	0	27,398	0	0	10,417	110,391	120,808
28,5	0	0	0	0	0	0	0	0	0	0	46,291	0	0	14,501	0	0	0	60,792	60,792
29	0	0	0	0	0	0	0	0	0	0	166,017	0	0	0	0	2,099	0	168,116	168,116
29,5	0	0	0	0	0	0	0	0	0	0	134,924	0	0	32,404	0	0	0	167,328	167,328
30	0	0	0	0	0	0	0	0	0	0	109,188	0	0	17,102	0	0	0	126,290	126,29
30,5	0	0	0	0	0	0	0	0	0	0	255,336	0	0	0	0	0	0	255,336	255,336
31	0	0	0	0	0	0	0	0	0	0	171,454	0	0	0	0	0	0	171,454	171,454
31,5	0	0	0	0	0	0	0	0	0	0	116,640	0	0	0	0	0	0	116,640	116,64
32	0	0	0	0	0	0	0	0	0	0	52,587	0	0	0	0	0	0	52,587	52,587
32,5	0	0	0	0	0	0	0	0	0	0	168,906	0	0	0	0	0	0	168,906	168,906
33	0	0	0	0	0	0	0	0	0	0	177,415	0	0	0	0	0	0	177,415	177,415
33,5	0	0	0	0	0	0	0	0	0	0	60,943	0	0	0	0	0	0	60,943	60,943
34	0	0	0	0	0	0	0	0	0	0	31,961	0	0	0	0	0	0	31,961	31,961
34,5	0	0	0	0	0	0	0	0	0	0	52,110	0	0	0	0	0	0	52,110	52,11
35	0	0	0	0	0	0	0	0	0	0	35,088	0	0	56,180	0	0	0	91,268	91,268
35,5	0	0	0	0	0	0	0	0	0	0	36,728	0	0	29,403	0	0	0	66,131	66,131
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**767,736**	**2138,742**	**5471,635**	**14607,388**	**1506,461**	**3,531**	**9,156**	**193,978**	**1023,231**	**3000,158**	**1924,603**	**592,199**	**94,411**	**1214,001**	**103,783**	**202,503**	**24495,493**	**8358,023**	**32853,516**

Table 12. *ECOCADIZ 2019-07* survey. Chub mackerel (*S. colias*). Estimated abundance (thousands of individuals) and biomass (t) by age group (years). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 28** and ordered from west to east.

Age class	POL 01	POL 02	POL 03	POL 04	POL 05	POL 06	POL 07	POL 08	POL 09	POL 10	POL 11	POL 12	POL 13	POL 14	POL 15	POL 16	PT	ES	TOTAL
	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
0	872	21895	6216	149542	4274	43	26	550	12396	8511	0	6688	571	1952	628	3153	182841	34476	217317
I	5582	11644	39783	79524	10411	14	63	1341	4075	20734	581	2544	598	4957	657	681	146957	36230	183187
II	2017	847	14375	5783	3255	4	20	419	1227	6483	3018	634	143	4131	157	46	26281	16278	42559
III	0	0	0	0	0	0	0	0	0	0	4339	0	0	217	0	5	0	4560	4560
IV	0	0	0	0	0	0	0	0	0	0	341	0	0	167	0	0	0	508	508
V	0	0	0	0	0	0	0	0	0	0	116	0	0	19	0	0	0	135	135
TOTAL	8471	34385	60374	234848	17940	61	109	2310	17699	35728	8395	9866	1311	11443	1442	3885	356080	92186	448266

Age class	POL 01	POL 02	POL 03	POL 04	POL 05	POL 06	POL 07	POL 08	POL 09	POL 10	POL 11	POL 12	POL 13	POL 14	POL 15	POL 16	PT	ES	TOTAL
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
0	58	1212	416	8279	258	2	2	33	572	514	0	328	30	97	33	152	10226	1762	11988
I	493	846	3515	5776	892	1	5	115	320	1777	70	197	49	483	54	45	11523	3113	14636
II	216	81	1540	553	356	0,5	2	46	131	709	572	68	15	510	17	5	2747	2075	4821
III	0	0	0	0	0	0	0	0	0	0	1124	0	0	54	0	1	0	1178	1178
IV	0	0	0	0	0	0	0	0	0	0	119	0	0	64	0	0	0	183	183
V	0	0	0	0	0	0	0	0	0	0	40	0	0	7	0	0	0	47	47
TOTAL	768	2139	5472	14607	1506	4	9	194	1023	3000	1925	592	94	1214	104	203	24495	8358	32854

Table 13. *ECOCADIZ 2020-07* survey. Blue Jack mackerel (*T. picturatus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 31**.

ECOCADIZ 2020-07. Trachurus picturatus. ABUNDANCE (in numbers and million fish)									
Size class	POL01	POL02	POL03	*n*			Millions		
				PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
10	0	0	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
11,5	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0	0	0
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
15,5	30516	31	9	30516	40	30556	0,03	0,00004	0,03
16	61033	62	18	61033	80	61113	0,1	0,0001	0,1
16,5	122065	123	36	122065	159	122224	0,1	0,0002	0,1
17	0	0	0	0	0	0	0	0	0
17,5	152581	154	45	152581	199	152780	0,2	0,0002	0,2
18	427228	431	127	427228	558	427786	0,4	0,001	0,4
18,5	1251168	1261	372	1251168	1633	1252801	1	0,002	1
19	2441303	2460	725	2441303	3185	2444488	2	0,003	2
19,5	3784020	3814	1124	3784020	4938	3788958	4	0,005	4
20	2197173	2214	653	2197173	2867	2200040	2	0,003	2
20,5	1373233	1384	408	1373233	1792	1375025	1	0,002	1
21	671358	677	199	671358	876	672234	1	0,001	1
21,5	427228	431	127	427228	558	427786	0	0,001	0,4
22	122065	123	36	122065	159	122224	0	0,0002	0,1
22,5	152581	154	45	152581	199	152780	0	0,0002	0,2
23	152581	154	45	152581	199	152780	0	0,0002	0,2
23,5	61033	62	18	61033	80	61113	0	0,0001	0,1
24	0	0	0	0	0	0	0	0	0
24,5	30516	31	9	30516	40	30556	0,03	0,00004	0,03
25	0	0	0	0	0	0	0	0	0
25,5	30516	31	9	30516	40	30556	0,03	0,00004	0,03
26	0	0	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0
28,5	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0
TOTAL *n*	13488198	13597	4005	13488198	17602	13505800	**13**	**0,02**	**14**
Millions	**13**	**0,01**	**0,004**	**13**	**0,02**	**14**			

Table 13. *ECOCADIZ 2020-07* survey. Blue Jack mackerel (*T. picturatus*). Cont'd.

***ECOCADIZ 2020-07. Trachurus picturatus*. BIOMASS (t)**						
Size class	**POL01**	**POL02**	**POL03**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	0
10,5	0	0	0	0	0	0
11	0	0	0	0	0	0
11,5	0	0	0	0	0	0
12	0	0	0	0	0	0
12,5	0	0	0	0	0	0
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
15,5	0,896	0,001	0	0,896	0,001	0,897
16	1,977	0,002	0,001	1,977	0,003	1,980
16,5	4,350	0,004	0,001	4,350	0,005	4,355
17	0	0	0	0	0	0
17,5	6,528	0,007	0,002	6,528	0,009	6,537
18	19,950	0,020	0,006	19,950	0,026	19,976
18,5	63,619	0,064	0,019	63,619	0,083	63,702
19	134,866	0,136	0,040	134,866	0,176	135,042
19,5	226,633	0,228	0,067	226,633	0,295	226,928
20	142,379	0,143	0,042	142,379	0,185	142,564
20,5	96,096	0,097	0,029	96,096	0,126	96,222
21	50,640	0,051	0,015	50,640	0,066	50,706
21,5	34,676	0,035	0,010	34,676	0,045	34,721
22	10,643	0,011	0,003	10,643	0,014	10,657
22,5	14,269	0,014	0,004	14,269	0,018	14,287
23	15,280	0,015	0,005	15,280	0,020	15,300
23,5	6,536	0,007	0,002	6,536	0,009	6,545
24	0	0	0	0	0	0
24,5	3,721	0,004	0,001	3,721	0,005	3,726
25	0	0	0	0	0	0
25,5	4,216	0,004	0,001	4,216	0,005	4,221
26	0	0	0	0	0	0
26,5	0	0	0	0	0	0
27	0	0	0	0	0	0
27,5	0	0	0	0	0	0
28	0	0	0	0	0	0
28,5	0	0	0	0	0	0
29	0	0	0	0	0	0
29,5	0	0	0	0	0	0
30	0	0	0	0	0	0
TOTAL	**837,275**	**0,843**	**0,248**	**837,275**	**1,091**	**838,366**

Table 14. *ECOCADIZ 2020-07* 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 33**.

ECOCADIZ 2020-07. 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
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11,5	0	0	0	0	369	96	136	15463	369	15695	16064	0,0004	0,02	0,02
12	0	0	0	0	492	129	181	20618	492	20928	21420	0,0005	0,02	0,02
12,5	0	0	0	0	1784	466	657	74740	1784	75863	77647	0,002	0,1	0,1
13	0	0	0	0	2337	611	861	97935	2337	99407	101744	0,002	0,1	0,1
13,5	2258	0	57446	0	1538	402	567	64431	61242	65400	126642	0,061	0,1	0,1
14	0	0	0	0	677	177	249	28350	677	28776	29453	0,001	0,03	0,03
14,5	0	0	0	0	62	16	23	2577	62	2616	2678	0,0001	0,00	0,003
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	18387	0	467850	0	0	0	0	0	486237	0	486237	0,5	0	0,5
17,5	22526	0	573181	0	984	257	363	41236	596691	41856	638547	1	0,0419	1
18	80529	0	2049064	0	2583	675	952	108244	2132176	109871	2242047	2	0,110	2
18,5	35135	0	893995	0	5474	1431	2017	229373	934604	232821	1167425	1	0,233	1
19	82629	0	2102479	0	2583	675	952	108244	2187691	109871	2297562	2	0,110	2
19,5	132800	0	3379070	0	5166	1351	1904	216487	3517036	219742	3736778	4	0,220	4
20	262150	34779	6670371	0	3260	852	1201	136593	6970560	138646	7109206	7	0,139	7
20,5	343193	86948	8732504	0	9717	2540	3581	407202	9172362	413323	9585685	9	0,413	10
21	316129	191285	8043860	0	9041	2363	3332	378853	8560315	384548	8944863	9	0,385	9
21,5	191981	365180	4884950	0	8733	2283	3219	365967	5450844	371469	5822313	5	0,371	6
22	100575	226064	2559127	0	7749	2026	2856	324731	2893515	329613	3223128	3	0,3296	3
22,5	40530	191285	1031275	0	4551	1190	1677	190715	1267641	193582	1461223	1	0,1936	1
23	25332	260843	644567	0	2583	675	952	108244	933325	109871	1043196	1	0,1099	1
23,5	6198	121727	157696	0	1968	514	725	82471	287589	83710	371299	0,3	0,0837	0,4
24	10351	173895	263369	96097	1599	418	589	67008	545311	68015	613326	1	0,1	1
24,5	2196	382570	55866	0	677	177	249	28350	441309	28776	470085	0,4	0,03	0,5
25	2258	173895	57446	0	1292	338	476	54122	234891	54936	289827	0,2	0,1	0,3
25,5	3940	139116	100251	96097	0	0	0	0	339404	0	339404	0,3	0	0,3
26	8301	86948	211212	211413	308	80	113	12886	518182	13079	531261	1	0,01	1
26,5	19525	17390	496823	0	0	0	0	0	533738	0	533738	1	0	1
27	4812	17390	122443	307510	0	0	0	0	452155	0	452155	0,5	0	0,5
27,5	4361	0	110961	307510	0	0	0	0	422832	0	422832	0,4	0	0,4
28	2617	0	66577	0	0	0	0	0	69194	0	69194	0,1	0	0,1
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	1744	0	44385	96097	0	0	0	0	142226	0	142226	0,1	0	0,1
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	1744	0	44385	0	0	0	0	0	46129	0	46129	0,05	0	0,05
30,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32,5	11676	0	297093	0	0	0	0	0	308769	0	308769	0,3	0	0,3
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	1733877	2469315	44118246	1114724	75527	19742	27832	3164840	49511689	3212414	52724103	50	3	53
Millions	2	2	44	1	0,1	0,02	0,03	3	50	3	53			

Table 14. *ECOCADIZ 2020-07* survey. Horse mackerel (*T. trachurus*). Cont'd.

ECOCADIZ 2020-07. Trachurus trachurus. BIOMASS (t)											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0
11,5	0	0	0	0	0,005	0,001	0,002	0,205	0,005	0,208	0,213
12	0	0	0	0	0,007	0,002	0,003	0,309	0,007	0,314	0,321
12,5	0	0	0	0	0,030	0,008	0,011	1,260	0,030	1,279	1,309
13	0	0	0	0	0,044	0,012	0,016	1,848	0,044	1,876	1,920
13,5	0,048	0	1,209	0	0,032	0,008	0,012	1,356	1,289	1,376	2,665
14	0	0	0	0	0,016	0,004	0,006	0,663	0,016	0,673	0,689
14,5	0	0	0	0	0,002	0,000	0,001	0,067	0,002	0,068	0,070
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	0,754	0	19,176	0	0	0	0	0	19,930	0	19,930
17,5	1,004	0	25,552	0	0,044	0,011	0,016	1,838	26,600	1,865	28,465
18	3,895	0	99,121	0	0,125	0,033	0,046	5,236	103,141	5,315	108,456
18,5	1,840	0	46,823	0	0,287	0,075	0,106	12,013	48,950	12,194	61,144
19	4,676	0	118,975	0	0,146	0,038	0,054	6,125	123,797	6,217	130,014
19,5	8,103	0	206,188	0	0,315	0,082	0,116	13,210	214,606	13,408	228,014
20	17,216	2,284	438,067	0	0,214	0,056	0,079	8,971	457,781	9,106	466,887
20,5	24,214	6,135	616,133	0	0,686	0,179	0,253	28,731	647,168	29,163	676,331
21	23,922	14,475	608,701	0	0,684	0,179	0,252	28,669	647,782	29,100	676,882
21,5	15,556	29,590	395,818	0	0,708	0,185	0,261	29,654	441,672	30,100	471,772
22	8,713	19,583	221,691	0	0,671	0,176	0,247	28,131	250,658	28,554	279,212
22,5	3,748	17,689	95,369	0	0,421	0,110	0,155	17,637	117,227	17,902	135,129
23	2,497	25,714	63,542	0	0,255	0,067	0,094	10,671	92,008	10,832	102,840
23,5	0,650	12,775	16,549	0	0,207	0,054	0,076	8,655	30,181	8,785	38,966
24	1,155	19,402	29,385	10,722	0,178	0,047	0,066	7,476	60,842	7,589	68,431
24,5	0,260	45,325	6,619	0	0,080	0,021	0,030	3,359	52,284	3,410	55,694
25	0,284	21,850	7,218	0	0,162	0,042	0,060	6,800	29,514	6,902	36,416
25,5	0,524	18,517	13,344	12,791	0	0	0	0	45,176	0	45,176
26	1,169	12,247	29,749	29,777	0,043	0,011	0,016	1,815	72,985	1,842	74,827
26,5	2,907	2,589	73,969	0	0	0	0	0	79,465	0	79,465
27	0,757	2,734	19,250	48,345	0	0	0	0	71,086	0	71,086
27,5	0,723	0	18,403	51,000	0	0	0	0	70,126	0	70,126
28	0,457	0	11,637	0	0	0	0	0	12,094	0	12,094
28,5	0	0	0	0	0	0	0	0	0	0	0
29	0,338	0	8,593	18,606	0	0	0	0	27,537	0	27,537
29,5	0	0	0	0	0	0	0	0	0	0	0
30	0,373	0	9,486	0	0	0	0	0	9,859	0	9,859
30,5	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0
32,5	3,152	0	80,194	0	0	0	0	0	83,346	0	83,346
33	0	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**128,935**	**250,909**	**3280,761**	**171,241**	**5,362**	**1,401**	**1,978**	**224,699**	**3837,208**	**228,078**	**4065,286**

Table 15. *ECOCADIZ 2020-07* 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 35**.

***ECOCADIZ 2020-07. Trachurus mediterraneus*. ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**Millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
15	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
18,5	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
21	26	7336	13683	74041	0	95086	95086	0	0,1	0,1
21,5	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0
22,5	79	22008	41048	222122	0	285257	285257	0	0,3	0,3
23	134	37278	69528	376235	0	483175	483175	0	0,5	0,5
23,5	79	22008	41048	222122	0	285257	285257	0	0,3	0,3
24	204	56794	105927	573200	0	736125	736125	0	1	1
24,5	242	67248	125425	678705	0	871620	871620	0	1	1
25	112	31193	58178	314816	0	404299	404299	0	0,4	0,4
25,5	224	62357	116304	629350	0	808235	808235	0	1	1
26	173	48235	89964	486819	0	625191	625191	0	1	1
26,5	167	46462	86658	468929	0	602216	602216	0	1	1
27	232	64700	120674	652997	0	838603	838603	0	1	1
27,5	428	119029	222004	1201321	0	1542782	1542782	0	2	2
28	1413	393089	733158	3967302	0	5094962	5094962	0	5	5
28,5	2906	808738	1508396	8162305	0	10482345	10482345	0	10	10
29	5673	1578709	2944486	15933346	0	20462214	20462214	0	20	20
29,5	2719	756526	1411013	7635341	0	9805599	9805599	0	10	10
30	3618	1006912	1878014	10162403	0	13050947	13050947	0	13	13
30,5	1371	381483	711513	3850171	0	4944538	4944538	0	5	5
31	3129	870631	1623833	8786962	0	11284555	11284555	0	11	11
31,5	294	81818	152601	825764	0	1060477	1060477	0	1	1
32	167	46462	86658	468929	0	602216	602216	0	1	1
32,5	53	14672	27365	148081	0	190171	190171	0	0,2	0,2
33	134	37278	69528	376235	0	483175	483175	0	0	0
33,5	136	37876	70643	382267	0	490922	490922	0	0	0
34	29	7934	14797	80073	0	102833	102833	0	0	0
34,5	26	7336	13683	74041	0	95086	95086	0	0,1	0,1
35	0	0	0	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0	0	0	0
36	29	7934	14797	80073	0	102833	102833	0	0,1	0,1
36,5	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0
38,5	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0
39,5	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	23797	6622046	12350926	66833950	0	85830719	85830719	**0**	**86**	**86**
Millions	**0,02**	**7**	**12**	**67**	**0**	**86**	**86**			

Table 15. *ECOCADIZ 2020-07* survey. Mediterranean horse mackerel (*T. mediterraneus*). Cont'd.

***ECOCADIZ 2020-07 . Trachurus mediterraneus* . BIOMASS (t)**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
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
16,5	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0
18,5	0	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	0	0	0	0	0	0
21	0,002	0,562	1,047	5,667	0	7,278	7,278
21,5	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0
22,5	0,007	2,030	3,786	20,487	0	26,310	26,310
23	0,013	3,649	6,806	36,827	0	47,295	47,295
23,5	0,008	2,283	4,258	23,044	0	29,593	29,593
24	0,022	6,237	11,633	62,951	0	80,843	80,843
24,5	0,028	7,809	14,565	78,815	0	101,217	101,217
25	0,014	3,826	7,136	38,613	0	49,589	49,589
25,5	0,029	8,069	15,050	81,442	0	104,590	104,590
26	0,024	6,579	12,270	66,398	0	85,271	85,271
26,5	0,024	6,672	12,445	67,344	0	86,485	86,485
27	0,035	9,774	18,230	98,648	0	126,687	126,687
27,5	0,068	18,898	35,247	190,731	0	244,944	244,944
28	0,236	65,532	122,225	661,393	0	849,386	849,386
28,5	0,508	141,449	263,821	1427,599	0	1833,377	1833,377
29	1,040	289,445	539,850	2921,263	0	3751,598	3751,598
29,5	0,522	145,282	270,968	1466,275	0	1883,047	1883,047
30	0,727	202,379	377,462	2042,543	0	2623,111	2623,111
30,5	0,288	80,189	149,562	809,316	0	1039,355	1039,355
31	0,687	191,259	356,721	1930,307	0	2478,974	2478,974
31,5	0,067	18,771	35,010	189,448	0	243,296	243,296
32	0,040	11,125	20,749	112,277	0	144,191	144,191
32,5	0,013	3,664	6,834	36,978	0	47,489	47,489
33	0,035	9,703	18,097	97,926	0	125,761	125,761
33,5	0,037	10,269	19,153	103,640	0	133,099	133,099
34	0,008	2,239	4,176	22,600	0	29,023	29,023
34,5	0,008	2,154	4,018	21,742	0	27,922	27,922
35	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0
36	0,010	2,615	4,877	26,393	0	33,895	33,895
36,5	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0
38,5	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0
39,5	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0
TOTAL	**4,490**	**1249,848**	**2331,119**	**12614,274**	**0**	**16199,731**	**16199,731**

Table 16. *ECOCADIZ 2020-07* survey. Bogue (*B. boops*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 37**.

ECOCADIZ 2020-07. Boops boops. ABUNDANCE (in numbers and million fish)													
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	*n*			Millions		
								PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
10	0	0	0	0	0	0	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
11,5	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0
16,5	25497	0	0	0	0	0	0	25497	0	25497	0,03	0	0,03
17	0	0	0	0	0	0	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0	0	0	0	0	0	0
18	12749	0	0	0	0	0	0	12749	0	12749	0,01	0	0,01
18,5	38246	0	0	0	0	0	0	38246	0	38246	0,04	0	0,04
19	110825	0	0	0	0	0	5192	110825	5192	116017	0,1	0,01	0,1
19,5	127486	0	0	0	0	0	5192	127486	5192	132678	0,1	0,01	0,1
20	244147	0	0	0	0	15039	15575	244147	30614	274761	0,2	0,03	0,3
20,5	435375	0	0	0	0	0	20766	435375	20766	456141	0,4	0,02	0,5
21	661687	0	0	0	0	0	62299	661687	62299	723986	1	0,1	1
21,5	671435	0	0	0	0	0	67490	671435	67490	738925	1	0,1	1
22	1277822	185852	0	0	0	0	83065	1463674	83065	1546739	1	0,1	2
22,5	1010234	0	0	0	0	0	72682	1010234	72682	1082916	1	0,1	1
23	842840	0	0	0	0	0	93448	842840	93448	936288	1	0,1	1
23,5	564360	185852	0	0	0	0	88257	750212	88257	838469	0,8	0,1	1
24	492956	185852	0	0	0	15039	62299	678808	77338	756146	1	0,1	1
24,5	348972	0	0	0	0	0	15575	348972	15575	364547	0,3	0,02	0,4
25	167655	0	0	0	0	0	15575	167655	15575	183230	0,2	0,02	0,2
25,5	85327	0	0	0	0	0	5192	85327	5192	90519	0,1	0,01	0,1
26	59830	0	269	888	10615	0	15575	60099	27078	87177	0,1	0,03	0,1
26,5	12749	0	0	0	0	15039	10383	12749	25422	38171	0,01	0,03	0,04
27	0	185852	808	2664	31844	0	0	186660	34508	221168	0,2	0,03	0,2
27,5	0	0	1346	4441	53073	15039	10383	1346	82936	84282	0,001	0,1	0,1
28	0	0	1885	6217	74303	45116	15575	1885	141211	143096	0,002	0,1	0,1
28,5	0	0	5386	17763	212294	15039	25958	5386	271054	276440	0,01	0,3	0,3
29	0	0	2962	9770	116762	75193	20766	2962	222491	225453	0,003	0,2	0,2
29,5	0	0	2424	7993	95532	30077	10383	2424	143985	146409	0,002	0,1	0,1
30	0	0	2693	8882	106147	45116	25958	2693	186103	188796	0,003	0,2	0,2
30,5	0	0	808	2664	31844	75193	41533	808	151234	152042	0,001	0,2	0,2
31	0	0	0	0	0	60154	20766	0	80920	80920	0	0,1	0,1
31,5	0	0	0	0	0	30077	25958	0	56035	56035	0	0,1	0,1
32	0	0	269	888	10615	75193	41533	269	128229	128498	0,0003	0,1	0,1
32,5	0	0	0	0	0	0	5192	0	5192	5192	0	0,01	0,01
33	0	0	0	0	0	0	5192	0	5192	5192	0	0,01	0,01
33,5	0	0	0	0	0	0	5192	0	5192	5192	0	0,01	0,01
34	0	0	0	0	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	7190192	743408	18850	62170	743029	511314	892954	7952450	2209467	10161917	**8**	**2**	**10**
Millions	**7**	**1**	**0,02**	**0,1**	**1**	**1**	**1**	**8**	**2**	**10**			

Table 16. *ECOCADIZ 2020-07* survey. Bogue (*B. boops*). Cont'd.

***ECOCADIZ 2020-07. Boops boops*. BIOMASS (t)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0
11,5	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0
12,5	0	0	0	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	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
16,5	1,077	0	0	0	0	0	0	1,077	0	1,077
17	0	0	0	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0	0	0	0
18	0,698	0	0	0	0	0	0	0,698	0	0,698
18,5	2,272	0	0	0	0	0	0	2,272	0	2,272
19	7,128	0	0	0	0	0	0,334	7,128	0,334	7,462
19,5	8,861	0	0	0	0	0	0,361	8,861	0,361	9,222
20	18,301	0	0	0	0	1,127	1,167	18,301	2,294	20,595
20,5	35,132	0	0	0	0	0	1,676	35,132	1,676	36,808
21	57,377	0	0	0	0	0	5,402	57,377	5,402	62,779
21,5	62,462	0	0	0	0	0	6,278	62,462	6,278	68,740
22	127,326	18,519	0	0	0	0	8,277	145,845	8,277	154,122
22,5	107,656	0	0	0	0	0	7,745	107,656	7,745	115,401
23	95,917	0	0	0	0	0	10,635	95,917	10,635	106,552
23,5	68,491	22,555	0	0	0	0	10,711	91,046	10,711	101,757
24	63,714	24,021	0	0	0	1,944	8,052	87,735	9,996	97,731
24,5	47,974	0	0	0	0	0	2,141	47,974	2,141	50,115
25	24,484	0	0	0	0	0	2,275	24,484	2,275	26,759
25,5	13,222	0	0	0	0	0	0,805	13,222	0,805	14,027
26	9,826	0	0,044	0,146	1,743	0	2,558	9,870	4,447	14,317
26,5	2,217	0	0	0	0	2,615	1,805	2,217	4,420	6,637
27	0	34,173	0,149	0,490	5,855	0,000	0,000	34,322	6,345	40,667
27,5	0	0	0,261	0,863	10,310	2,921	2,017	0,261	16,111	16,372
28	0	0	0,386	1,275	15,235	9,250	3,193	0,386	28,953	29,339
28,5	0	0	1,164	3,840	45,898	3,251	5,612	1,164	58,601	59,765
29	0	0	0,675	2,225	26,594	17,126	4,730	0,675	50,675	51,350
29,5	0	0	0,581	1,916	22,902	7,210	2,489	0,581	34,517	35,098
30	0	0	0,679	2,239	26,762	11,375	6,545	0,679	46,921	47,600
30,5	0	0	0,214	0,706	8,436	19,921	11,003	0,214	40,066	40,280
31	0	0	0	0	0	16,732	5,776	0	22,508	22,508
31,5	0	0	0	0	0	8,777	7,575	0	16,352	16,352
32	0	0	0,082	0,272	3,248	23,005	12,707	0,082	39,232	39,314
32,5	0	0	0	0	0	0	1,664	0	1,664	1,664
33	0	0	0	0	0	0	1,742	0	1,742	1,742
33,5	0	0	0	0	0	0	1,822	0	1,822	1,822
34	0	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0
TOTAL	**754,135**	**99,268**	**4,235**	**13,972**	**166,983**	**125,254**	**137,097**	**857,638**	**443,306**	**1300,944**

Table 17. *ECOCADIZ 2020-07* survey. Longspine snipefish (*M. 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 39**.

***ECOCADIZ 2020-07. Macroramphosus scolopax*. ABUNDANCE (in numbers and million fish)**								
Size class	**POL01**	**POL 02**	***n***			**Millions**		
			PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
5	0	0	0	0	0	0	0	0
5,5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0	0
10	4958516	0	4958516	0	4958516	5	0	5
10,5	16425085	0	16425085	0	16425085	16	0	16
11	34296404	39231	34335635	0	34335635	34	0	34
11,5	24999186	215770	25214956	0	25214956	25	0	25
12	19317553	274616	19592169	0	19592169	20	0	20
12,5	2892468	510001	3402469	0	3402469	3	0	3
13	0	490386	490386	0	490386	0,5	0	0,5
13,5	0	510001	510001	0	510001	1	0	1
14	0	137308	137308	0	137308	0,1	0	0,1
14,5	0	19615	19615	0	19615	0,02	0	0,02
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	0	0	0	0	0	0
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	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
TOTAL *n*	102889212	2196928	105086140	0	105086140	**105**	**0**	**105**
Millions	**103**	**2**	**105**	**0**	**105**			

Table 17. *ECOCADIZ 2020-07* survey. Longspine snipefish (*M. scolopax*). Cont'd.

***ECOCADIZ 2020-07. Macroramphosus scolopax*. BIOMASS (t)**					
Size class	**POL01**	**POL02**	**PORTUGAL**	**SPAIN**	**TOTAL**
5	0	0	0	0	0
5,5	0	0	0	0	0
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	25,562	0	25,562	0	25,562
10,5	98,306	0	98,306	0	98,306
11	236,704	0,271	236,975	0	236,975
11,5	197,732	1,707	199,439	0	199,439
12	174,112	2,475	176,587	0	176,587
12,5	29,553	5,211	34,764	0	34,764
13	0	5,652	5,652	0	5,652
13,5	0	6,602	6,602	0	6,602
14	0	1,988	1,988	0	1,988
14,5	0	0,316	0,316	0	0,316
15	0	0	0	0	0
15,5	0	0	0	0	0
16	0	0	0	0	0
16,5	0	0	0	0	0
17	0	0	0	0	0
17,5	0	0	0	0	0
18	0	0	0	0	0
18,5	0	0	0	0	0
19	0	0	0	0	0
19,5	0	0	0	0	0
20	0	0	0	0	0
TOTAL	**761,969**	**24,222**	**786,191**	**0**	**786,191**

Table 18. *ECOCADIZ 2020-07* survey. Boarfish (*C. aper*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 41**.

ECOCADIZ 2020-07. 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	48860	48860	0	48860	0,05	0	0,05
5	273618	273618	0	273618	0,3	0	0,3
5,5	2247579	2247579	0	2247579	2	0	2
6	2745955	2745955	0	2745955	3	0	3
6,5	1710114	1710114	0	1710114	2	0	2
7	449516	449516	0	449516	0,4	0	0,4
7,5	87949	87949	0	87949	0,1	0	0,1
8	48860	48860	0	48860	0,05	0	0,05
8,5	0	0	0	0	0	0	0
9	48860	48860	0	48860	0,05	0	0,05
9,5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
TOTAL *n*	7661311	7661311	0	7661311	**8**	**0**	**8**
Millions	**8**	**8**	**0**	**8**			

ECOCADIZ 2020-07. Trachurus trachurus. BIOMASA (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	0,108	0,108	0	0,108
5	0,807	0,807	0	0,807
5,5	8,589	8,589	0	8,589
6	13,307	13,307	0	13,307
6,5	10,319	10,319	0	10,319
7	3,325	3,325	0	3,325
7,5	0,787	0,787	0	0,787
8	0,522	0,522	0	0,522
8,5	0	0	0	0
9	0,724	0,724	0	0,724
9,5	0	0	0	0
10	0	0	0	0
TOTAL	**38,488**	**38,488**	**0**	**38,488**

Table 19. *ECOCADIZ 2020-07* survey. Pearlside (*M. muelleri*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 43**.

***ECOCADIZ 2020-07. Maurolicus muelleri*. ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**Millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	21160296	51051	133147164	9218244	21211347	142365408	163576755	21	142	164
4,5	21160296	51051	133147164	9218244	21211347	142365408	163576755	21	142	164
5	50255704	121246	316224514	21893329	50376950	338117843	388494793	50	338	388
5,5	76706075	185059	482658468	33416133	76891134	516074601	592965735	77	516	593
6	7935111	19144	49930186	3456841	7954255	53387027	61341282	8	53	61
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
TOTAL *n*	177217482	427551	1115107496	77202791	177645033	1192310287	1369955320	**178**	**1192**	**1370**
Millions	**177**	**0,4**	**1115**	**77**	**178**	**1192**	**1370**			

***ECOCADIZ 2020-07. Maurolicus muelleri*. BIOMASS (t)**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**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	14,226	0,034	89,513	6,197	14,260	95,710	109,970
4,5	19,574	0,047	123,168	8,527	19,621	131,695	151,316
5	61,955	0,149	389,840	26,990	62,104	416,830	478,934
5,5	122,769	0,296	772,503	53,483	123,065	825,986	949,051
6	16,133	0,039	101,516	7,028	16,172	108,544	124,716
6,5	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
TOTAL	**234,657**	**0,565**	**1476,540**	**102,225**	**235,222**	**1578,765**	**1813,987**

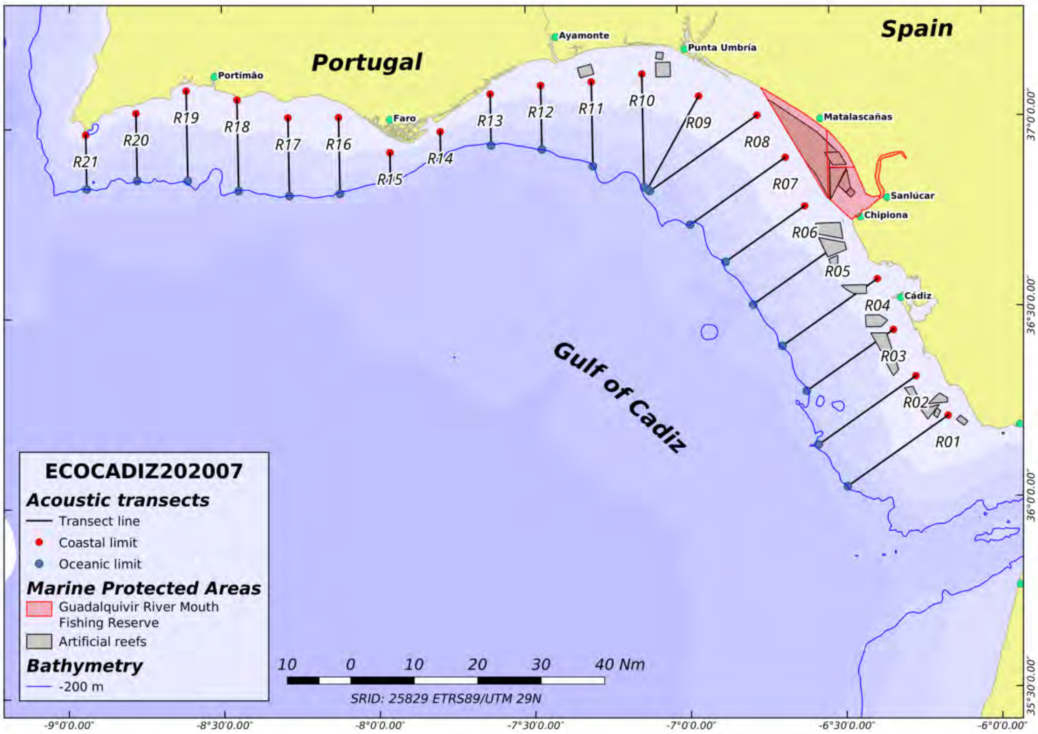


Figure 1. *ECOCADIZ 2020-07* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

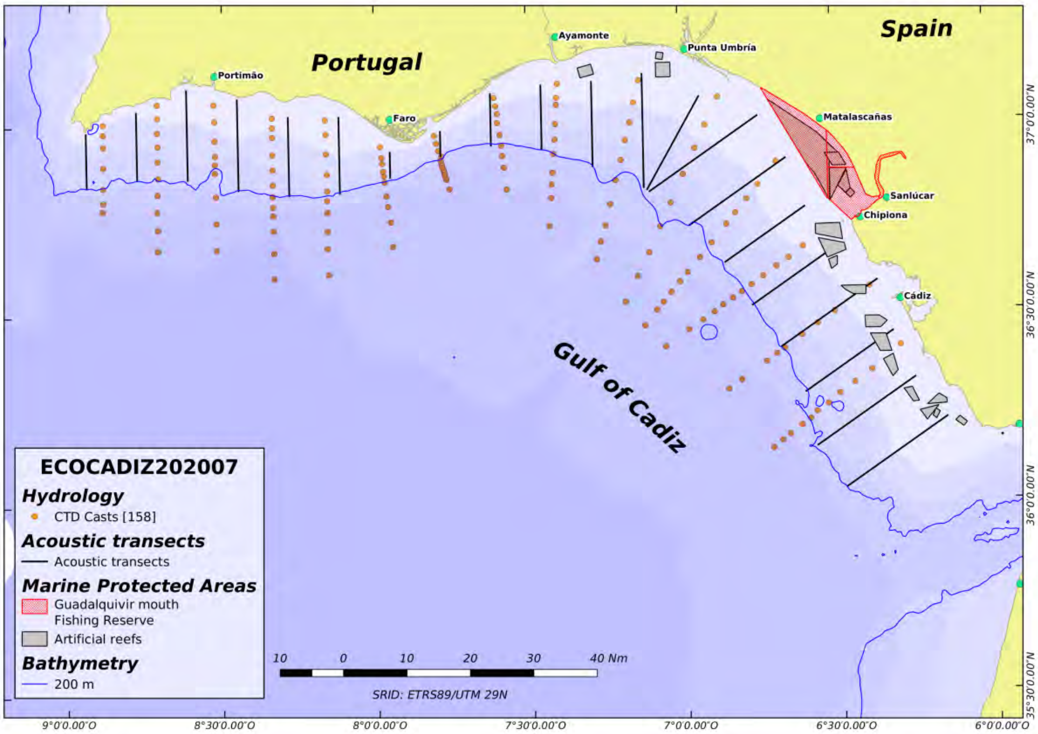


Figure 2. *ECOCADIZ 2020-07* survey. Location of CTD-LADCP stations.

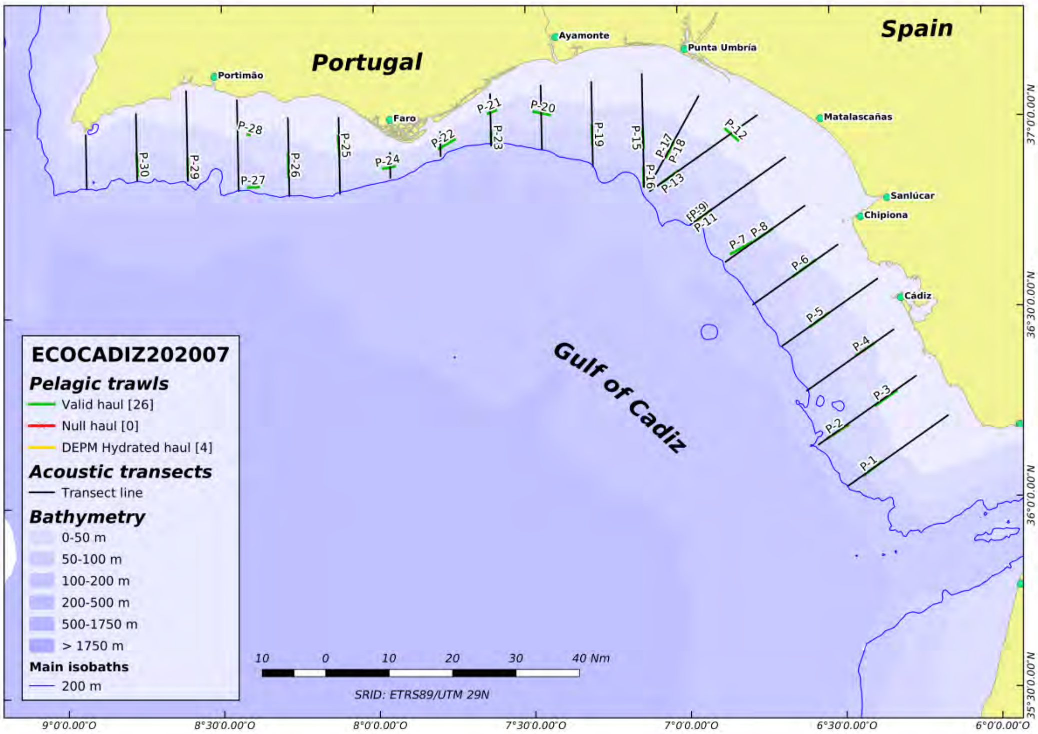


Figure 3. *ECOCADIZ 2020-07* survey. Location of ground-truthing fishing hauls.

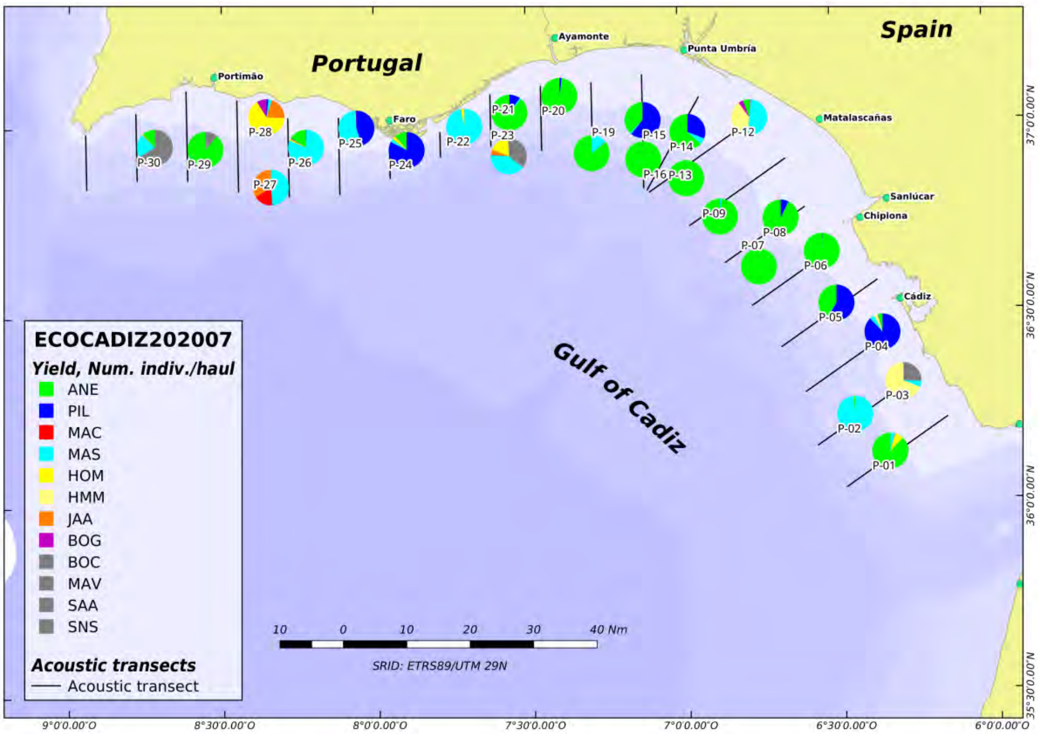


Figure 4. *ECOCADIZ 2020-07* survey. Species composition (percentages in number) in fishing hauls.

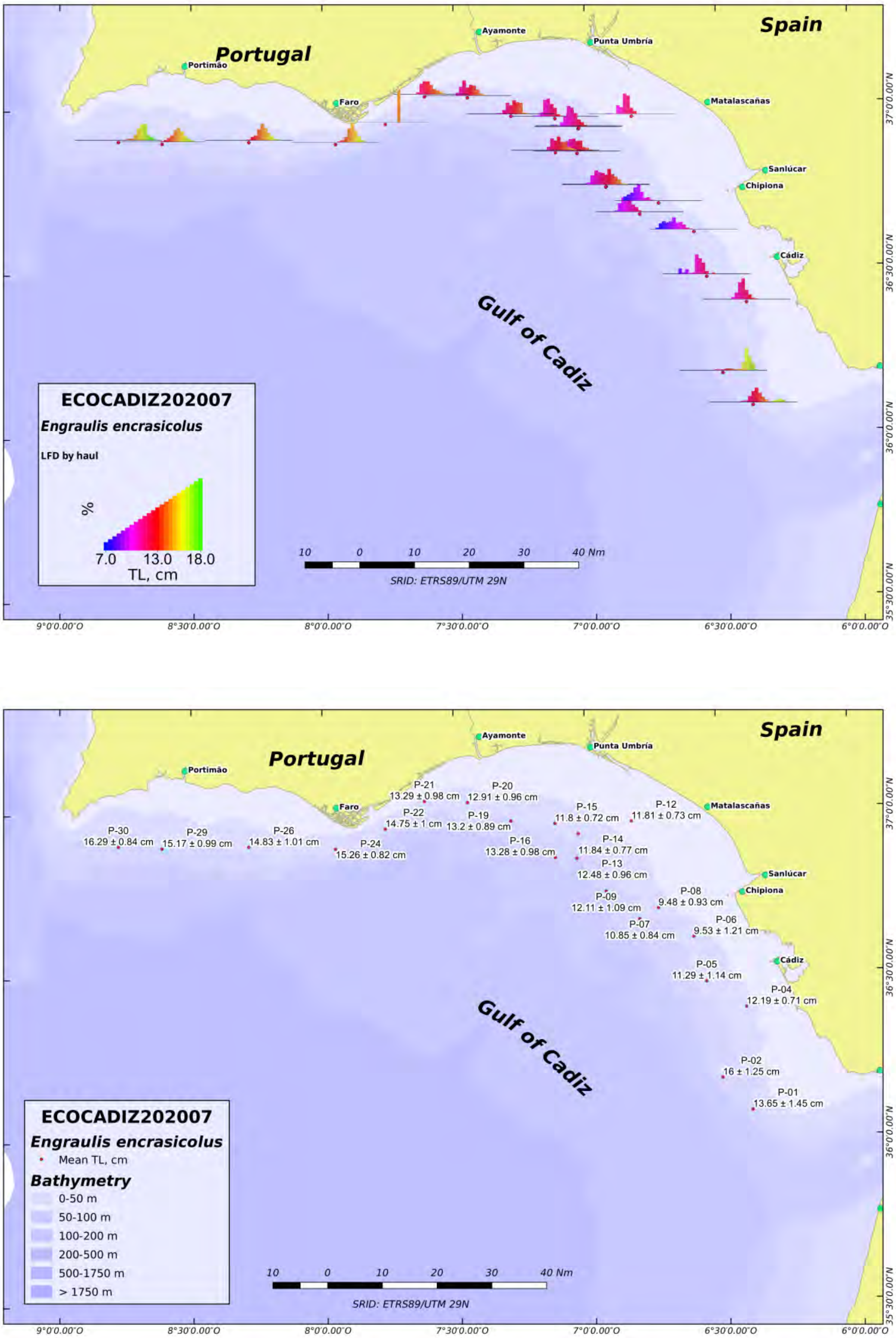
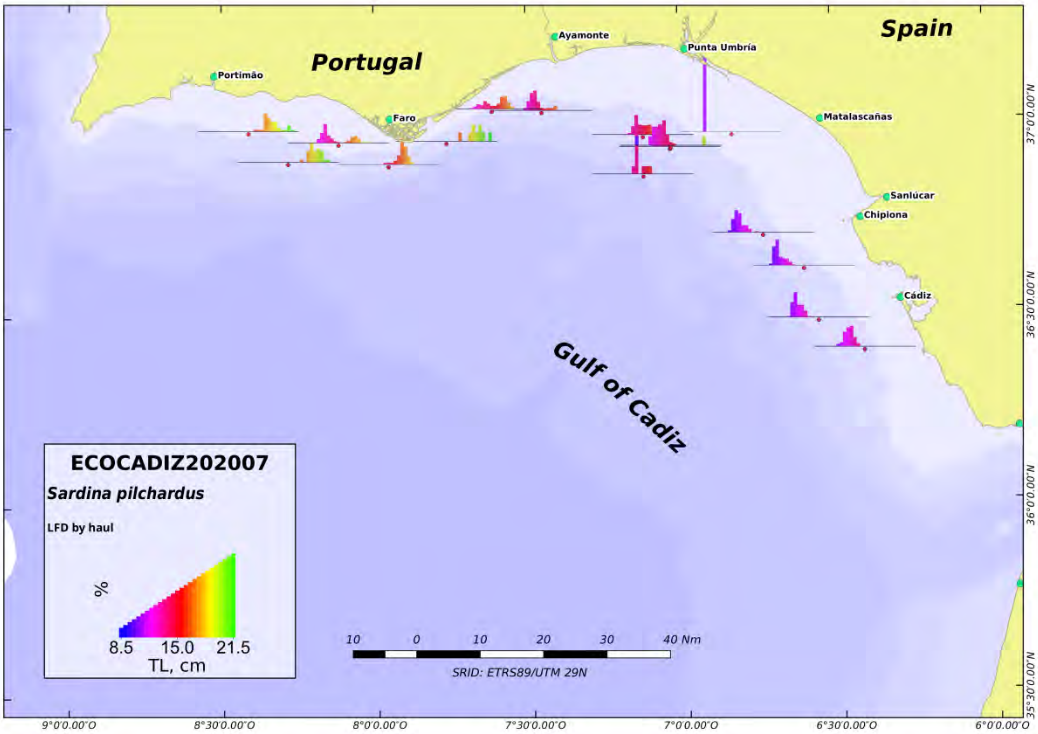


Figure 5. *ECOCADIZ 2020-07* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



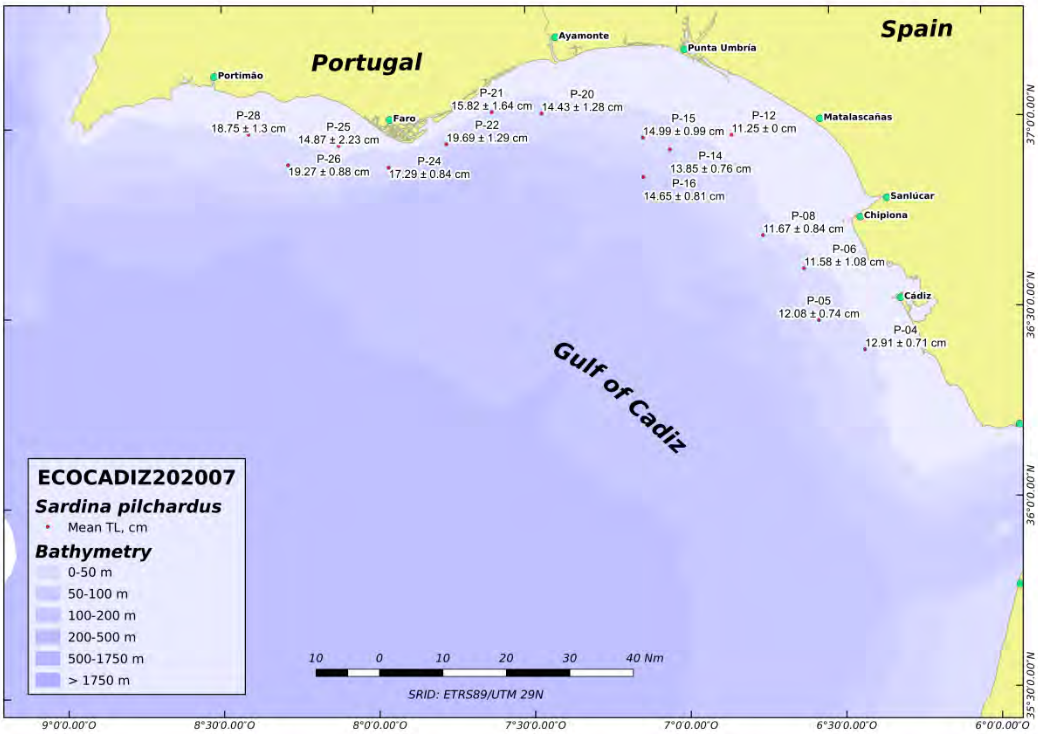


Figure 6. *ECOCADIZ 2020-07* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

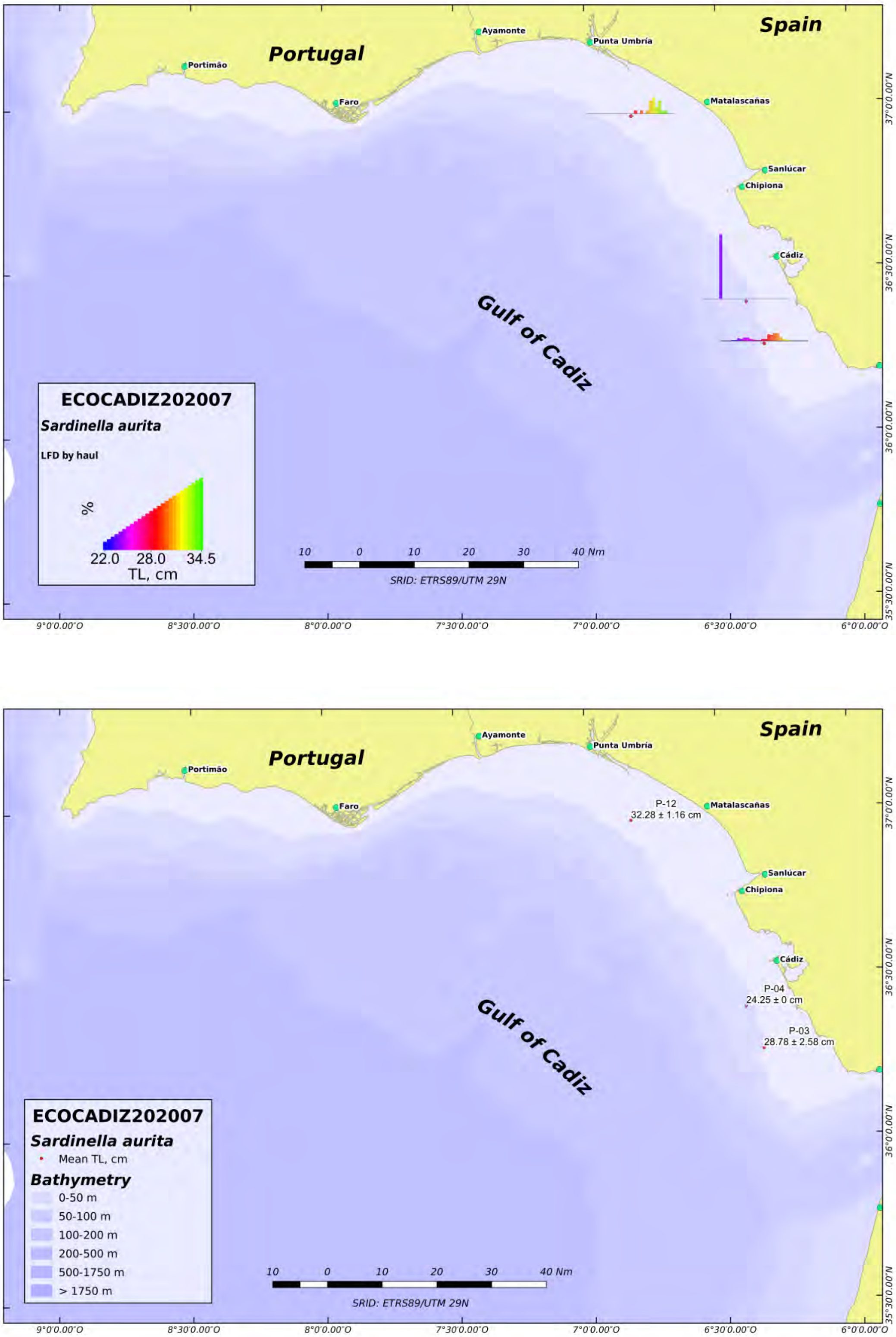
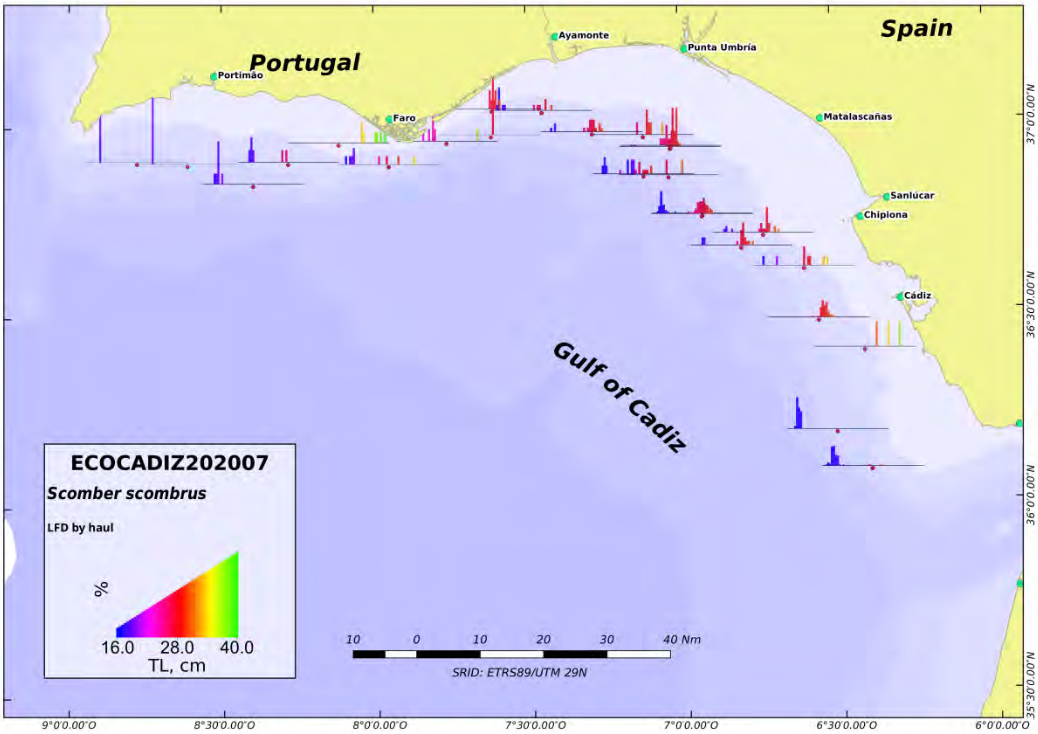


Figure 7. *ECOCADIZ 2020-07* survey. *Sardinella aurita*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



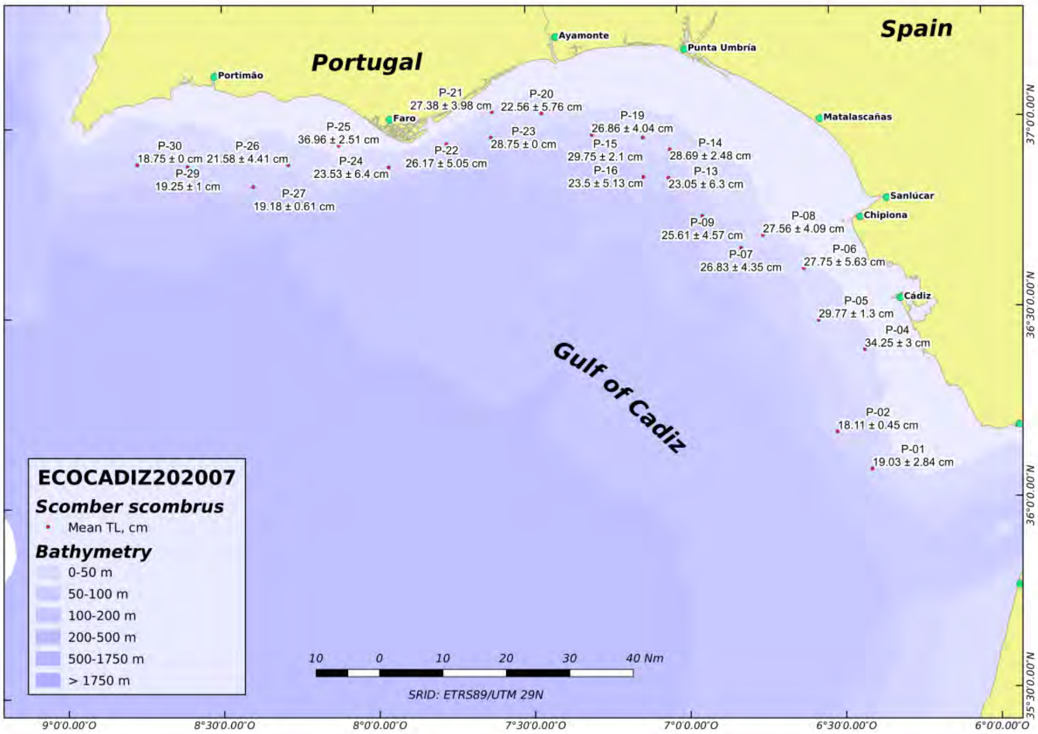
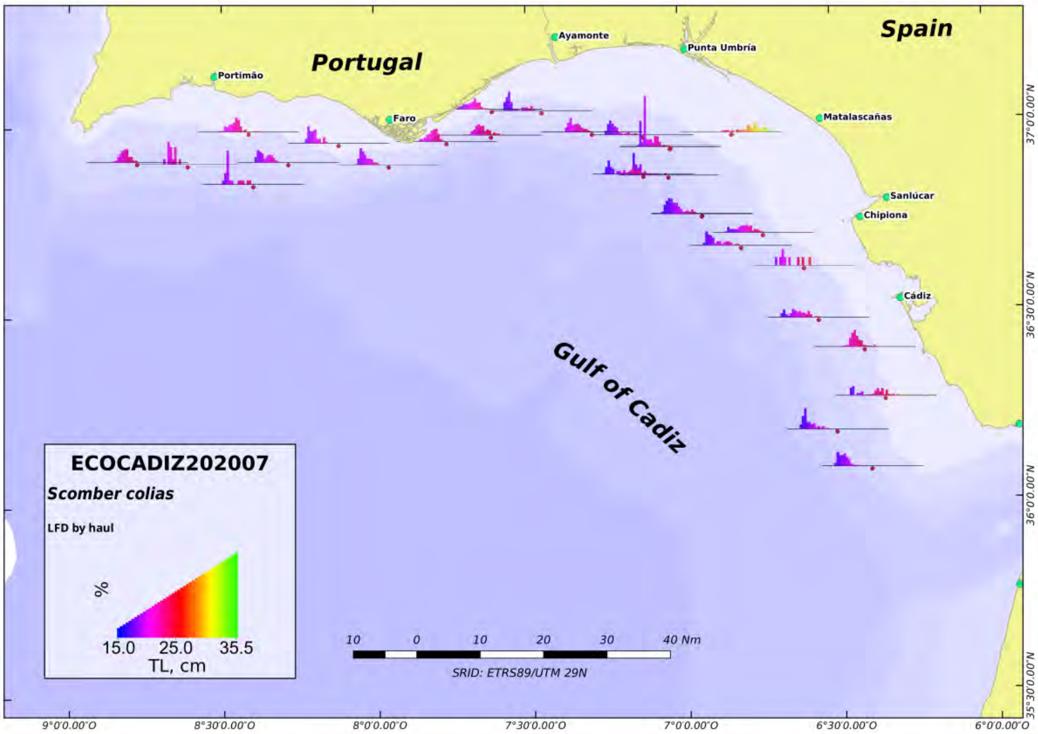


Figure 8. *ECOCADIZ 2020-07* survey. *Scomber scombrus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



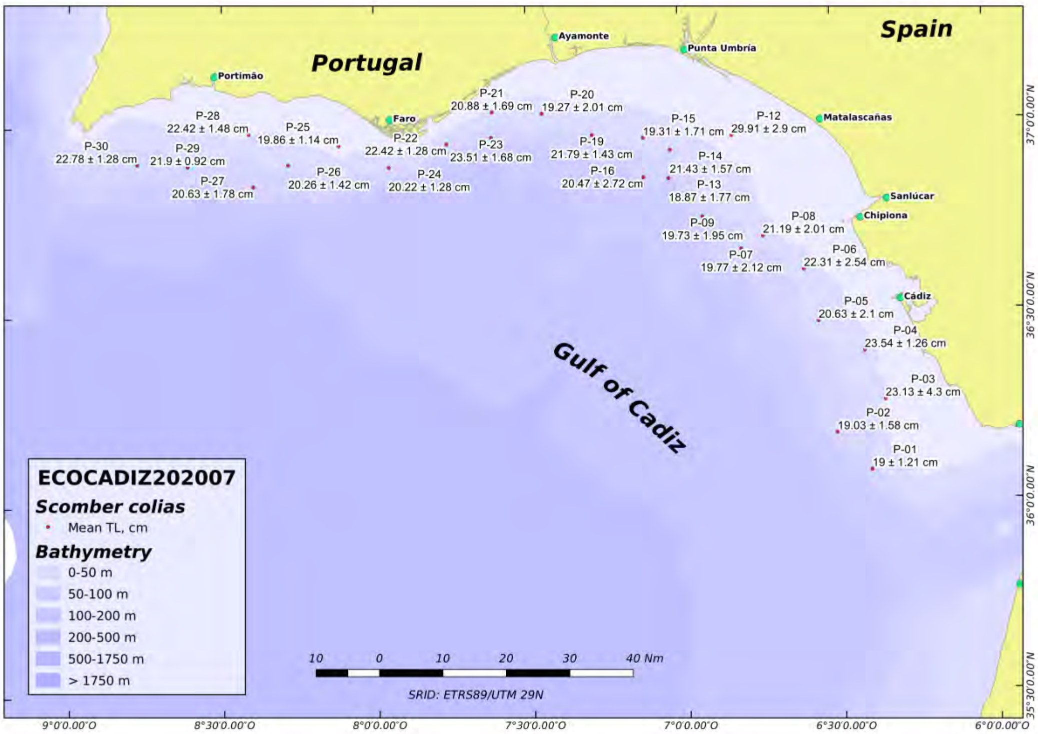


Figure 9. *ECOCADIZ 2020-07* survey. *Scomber colias*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

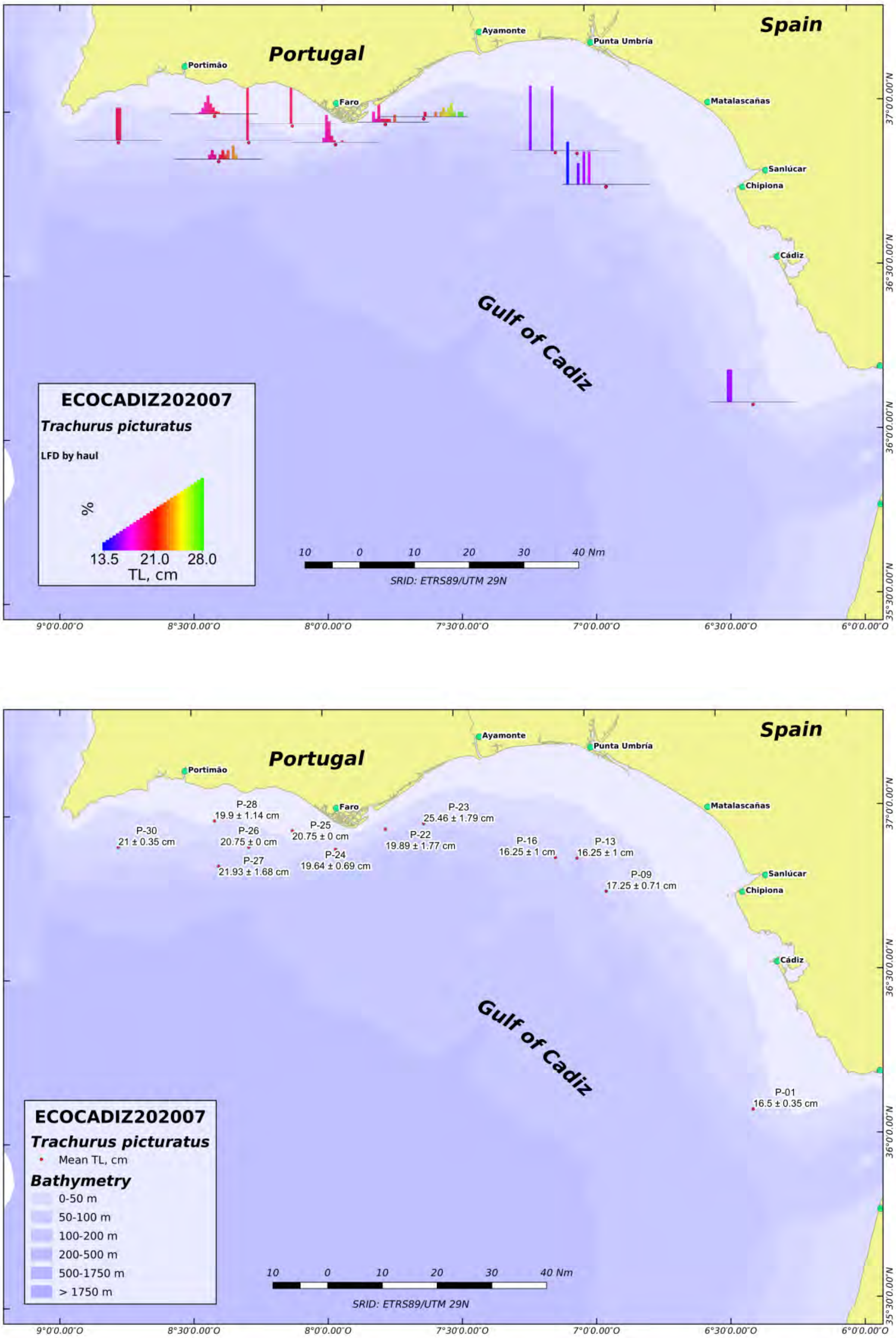
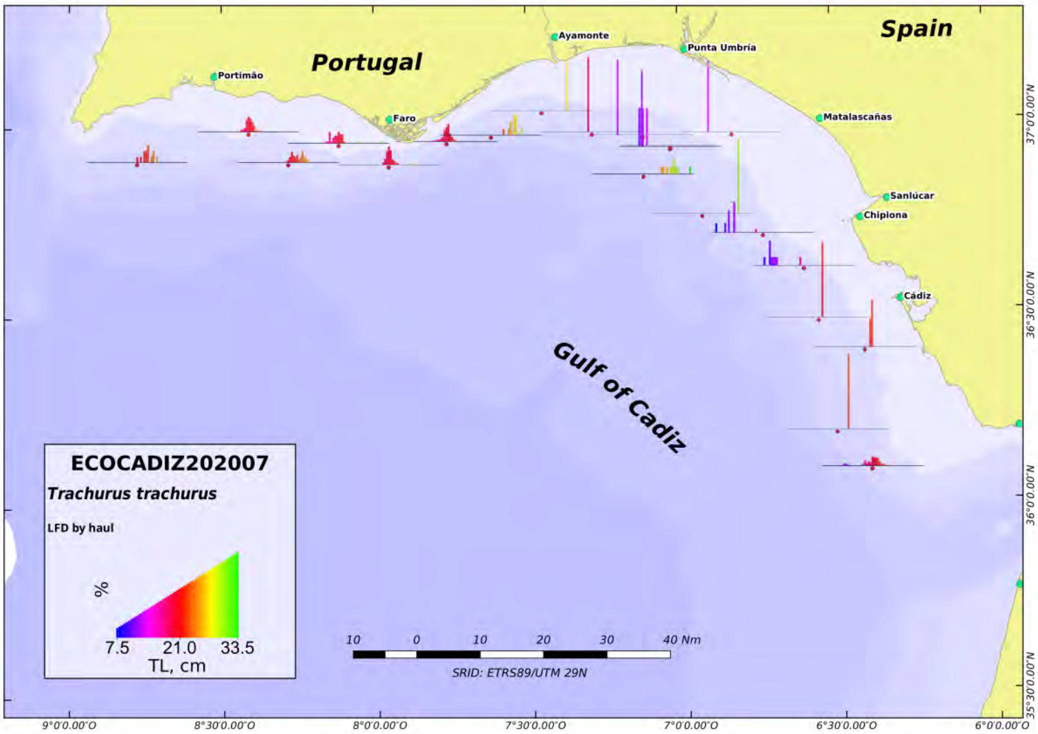


Figure 10. *ECOCADIZ 2020-07* survey. *Trachurus picturatus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



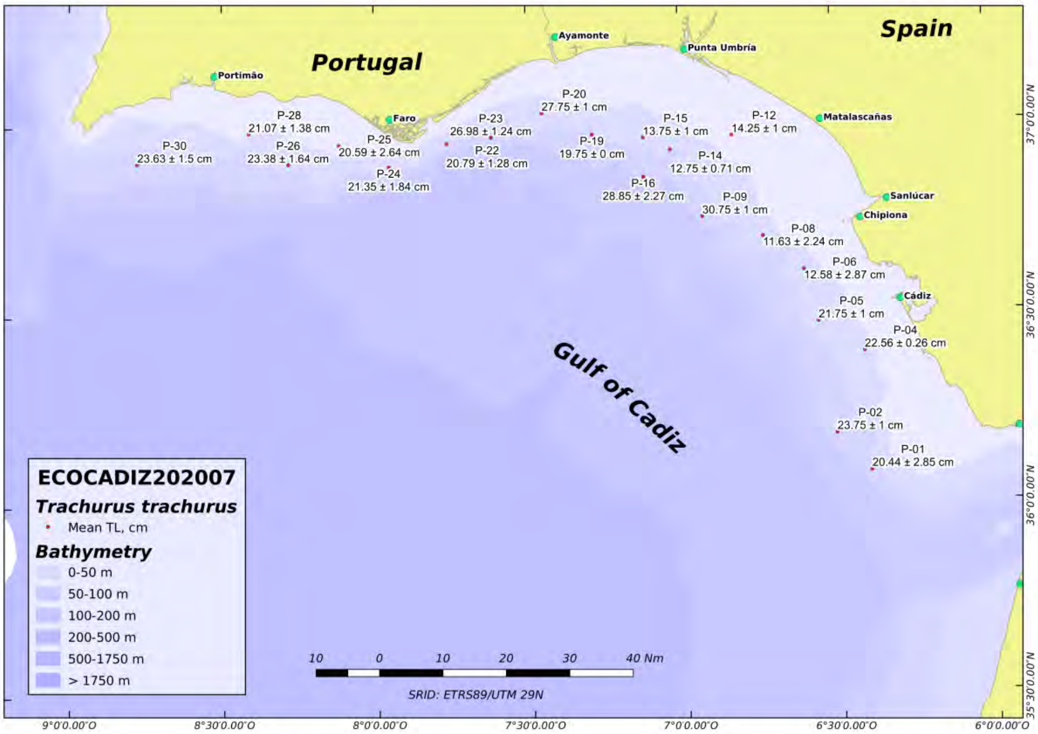
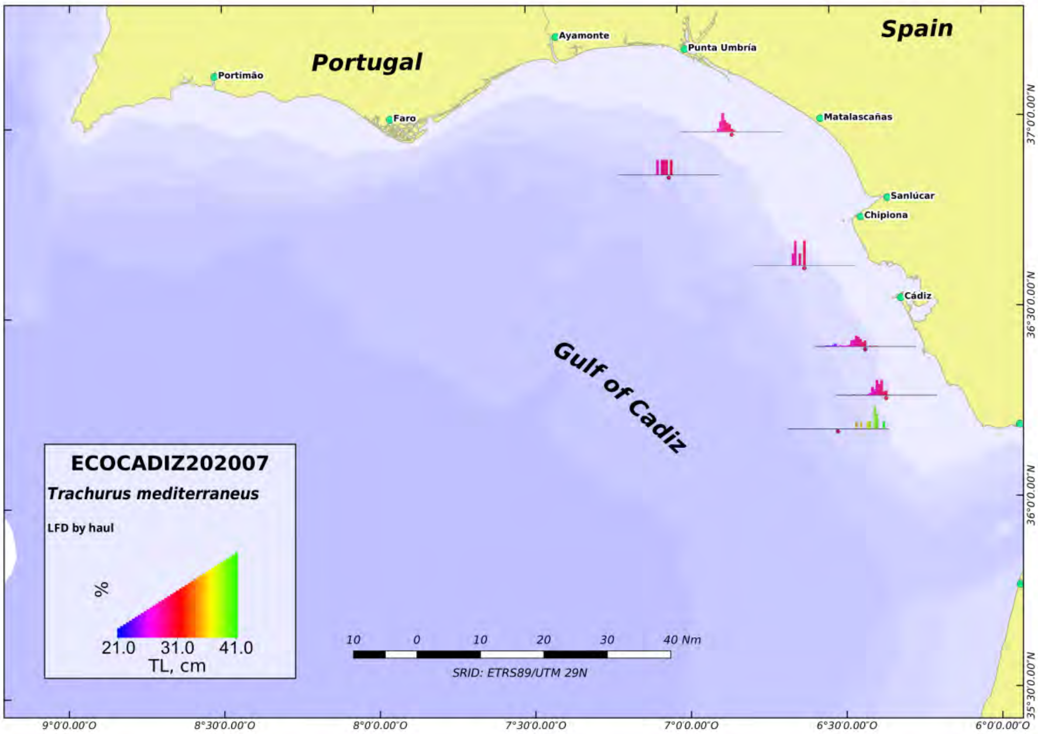


Figure 11. *ECOCADIZ 2020-07* survey. *Trachurus trachurus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



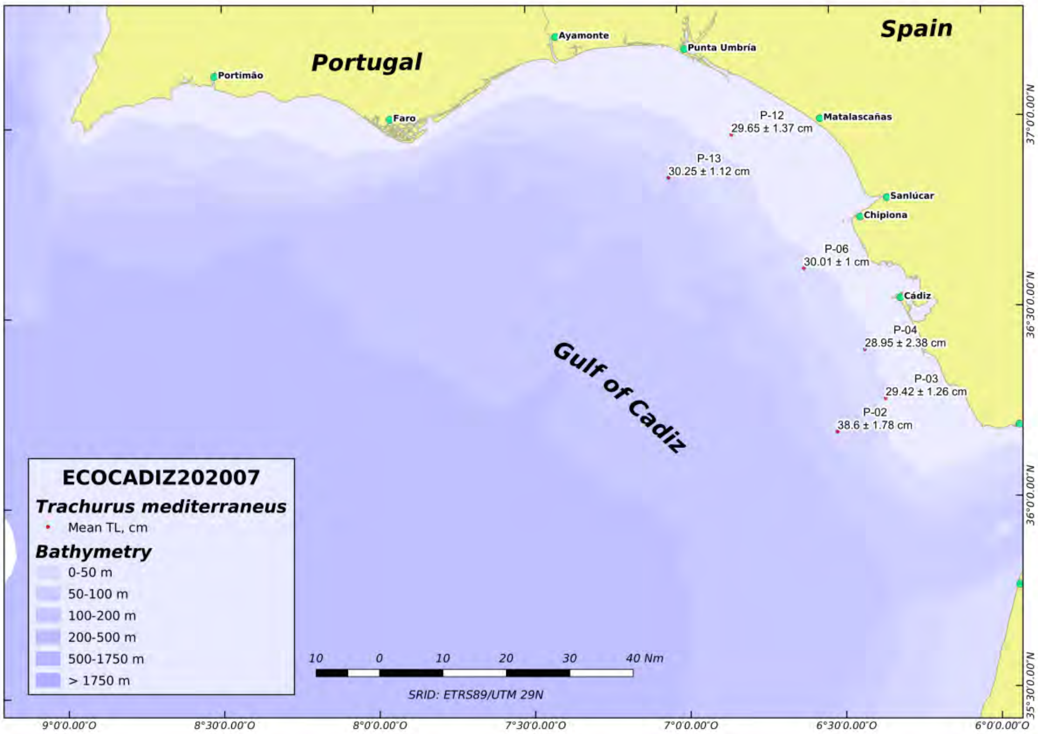
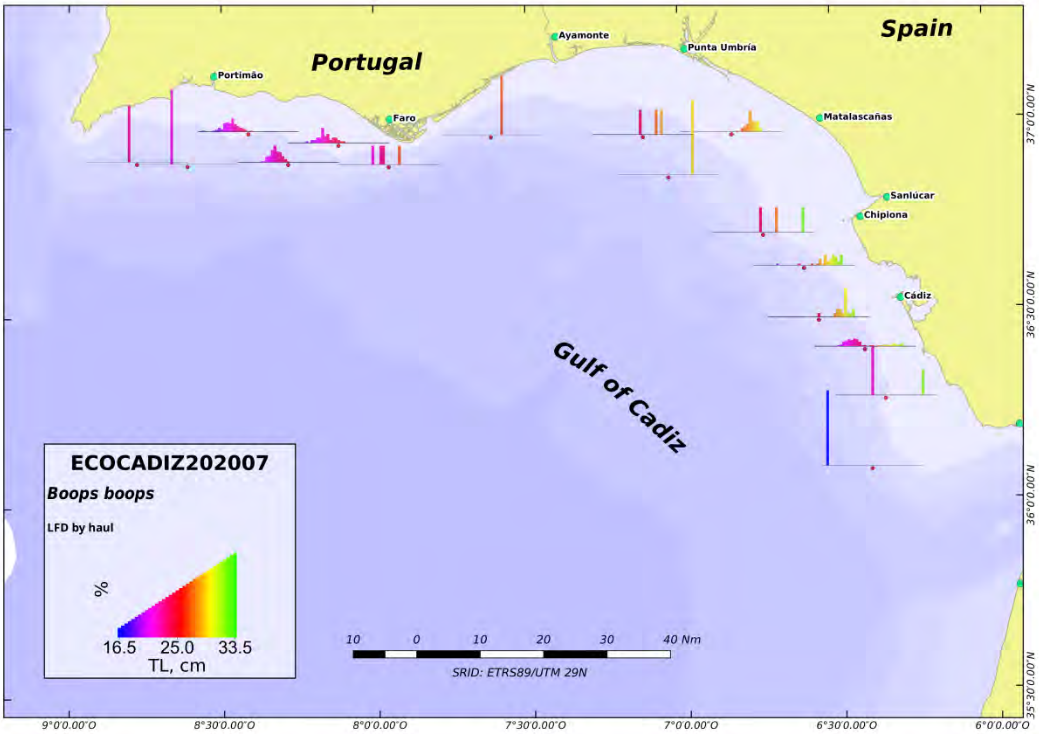


Figure 12. *ECOCADIZ 2020-07* survey. *Trachurus mediterraneus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



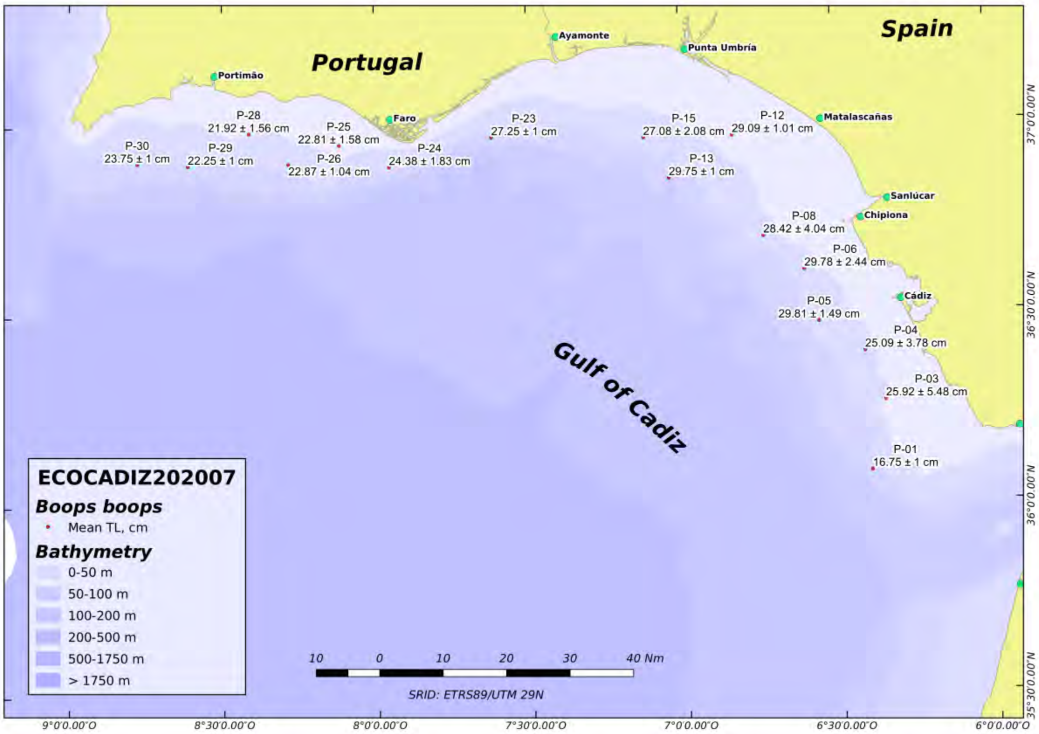
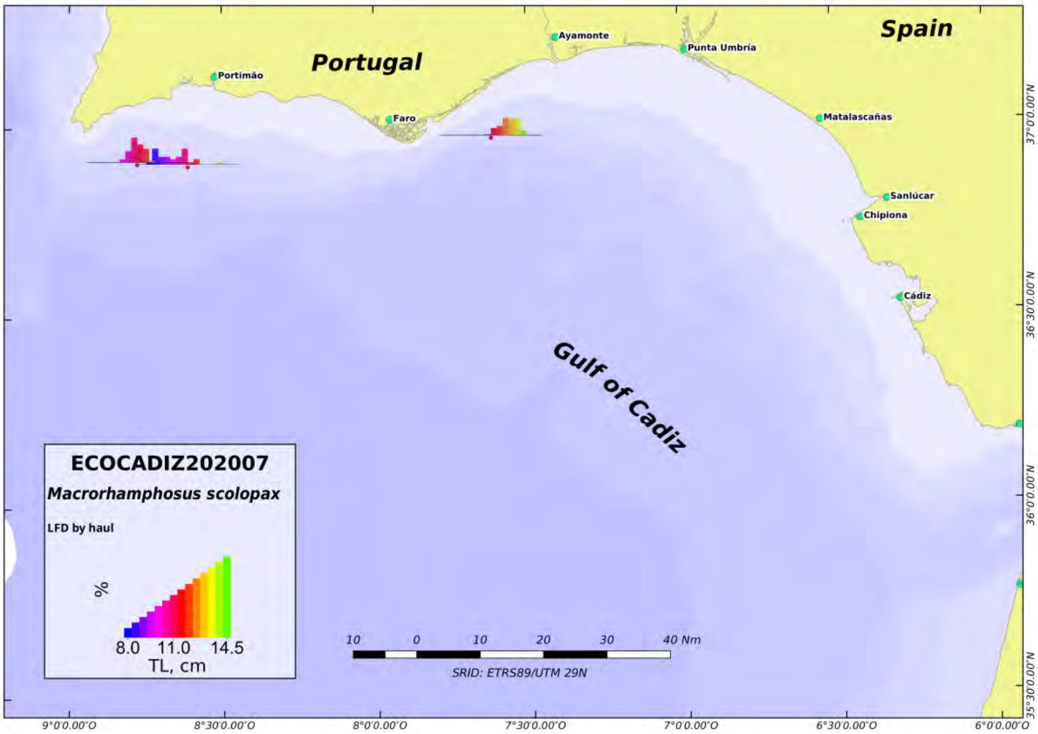


Figure 13. *ECOCADIZ 2020-07* survey. *Boops boops*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



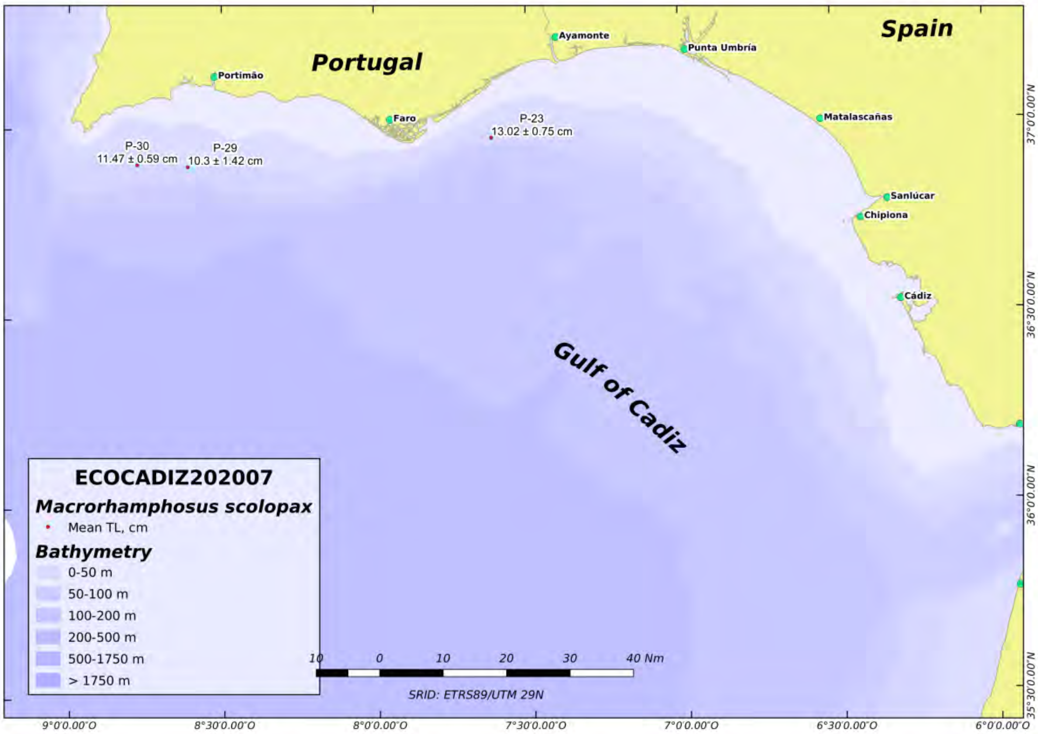
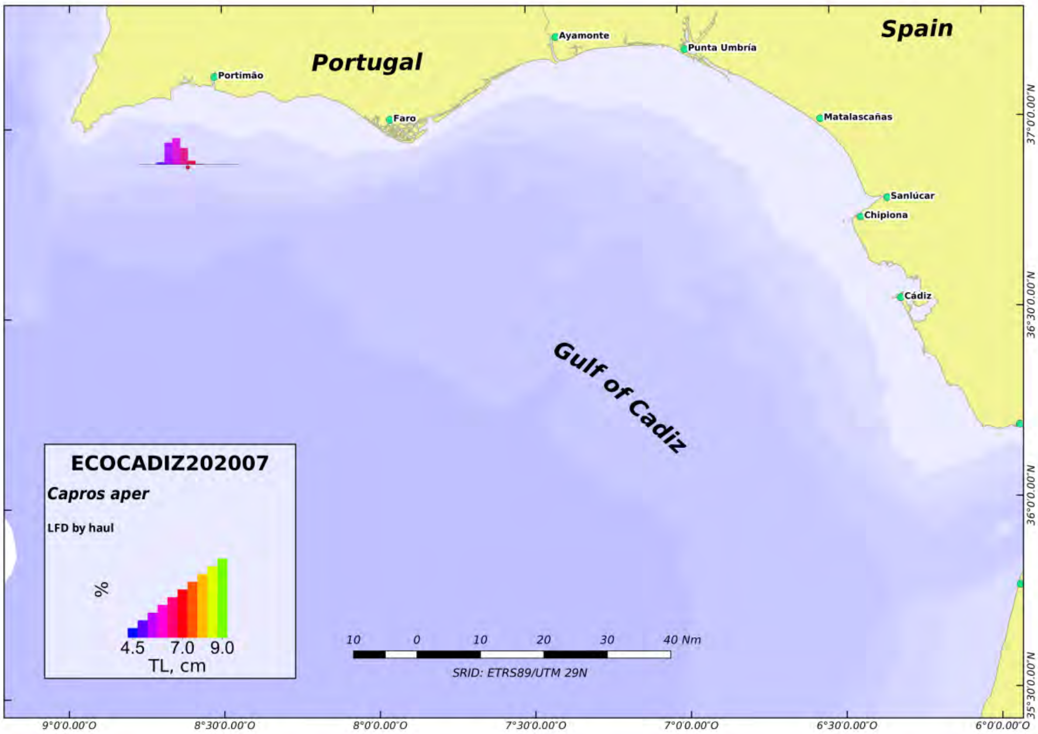


Figure 14. *ECOCADIZ 2020-07* survey. *Macrorhamphosus scolopax*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



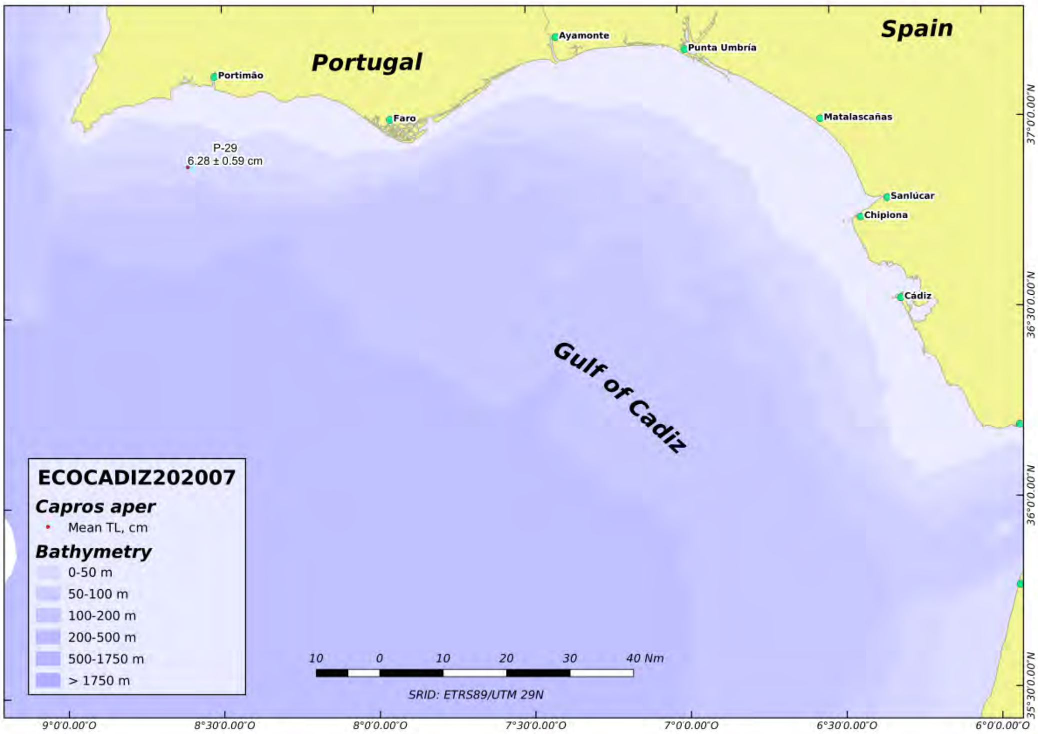


Figure 15. *ECOCADIZ 2020-07* survey. *Capros aper*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

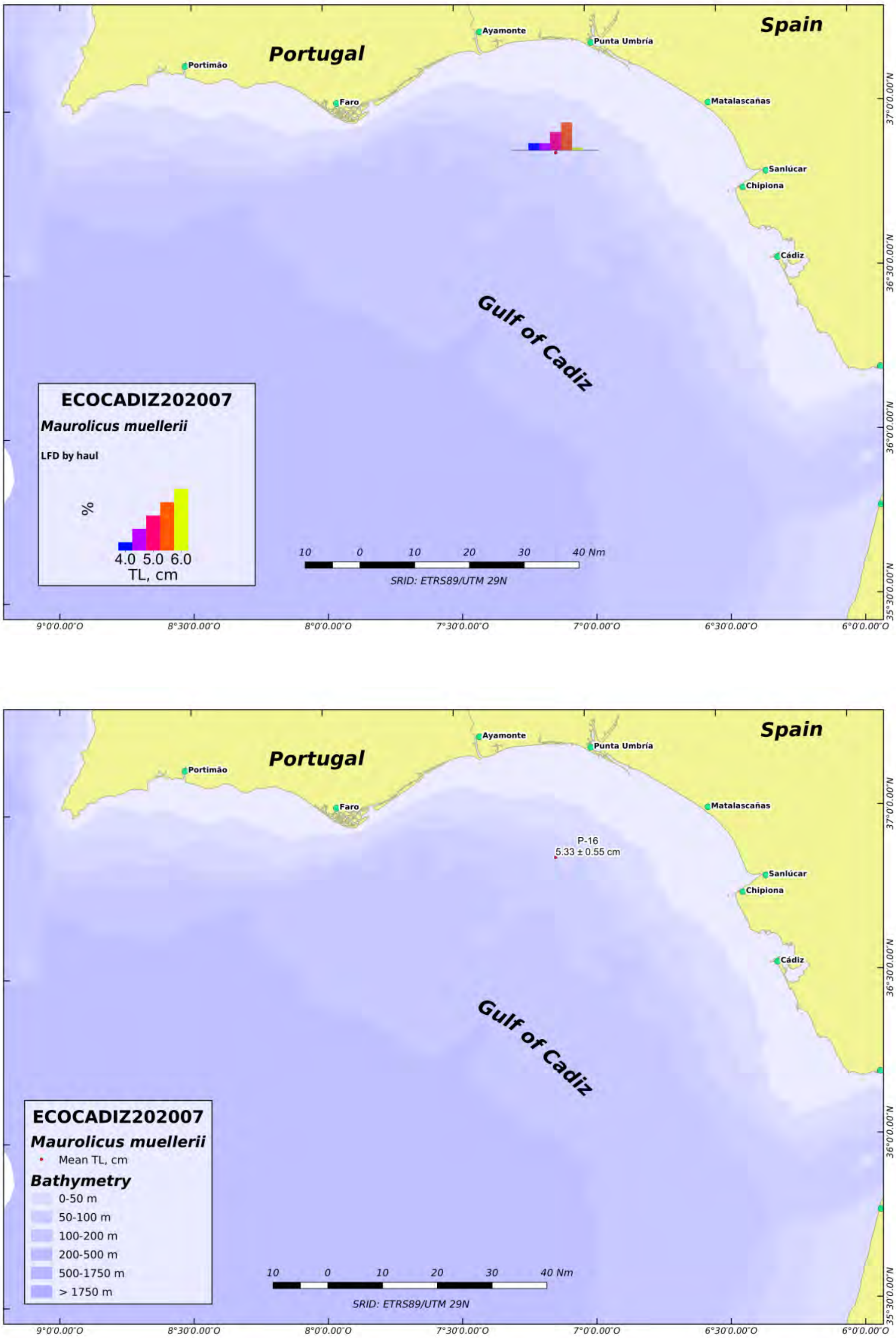
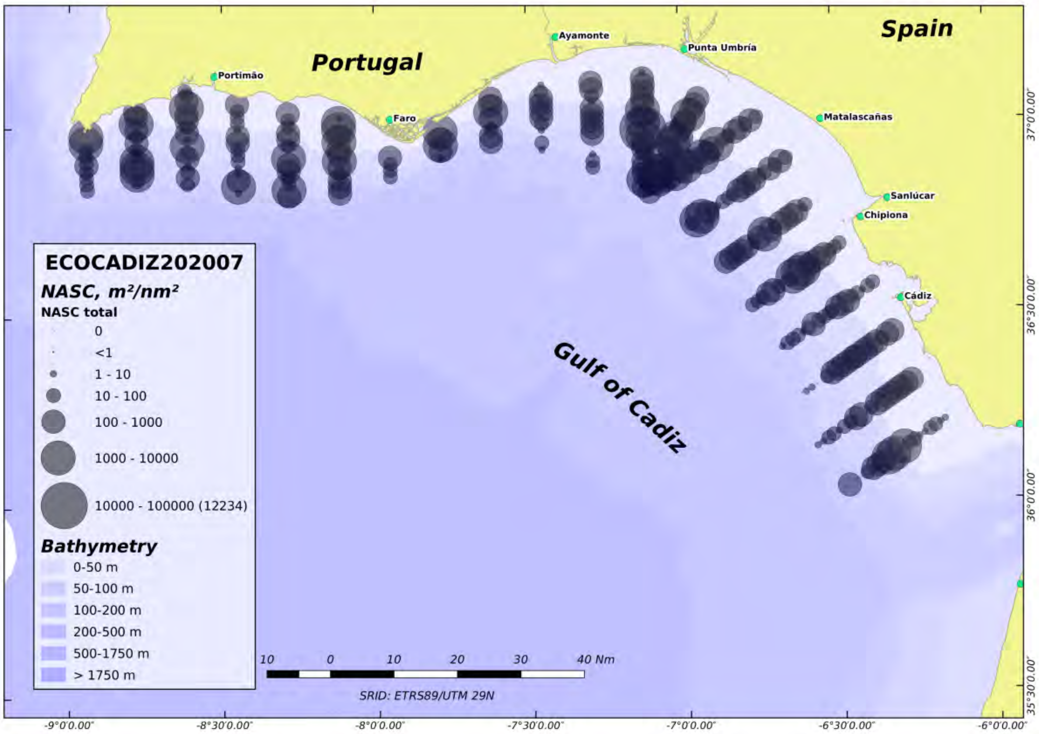


Figure 16. *ECOCADIZ 2020-07* survey. *Maurolicus muelleri*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



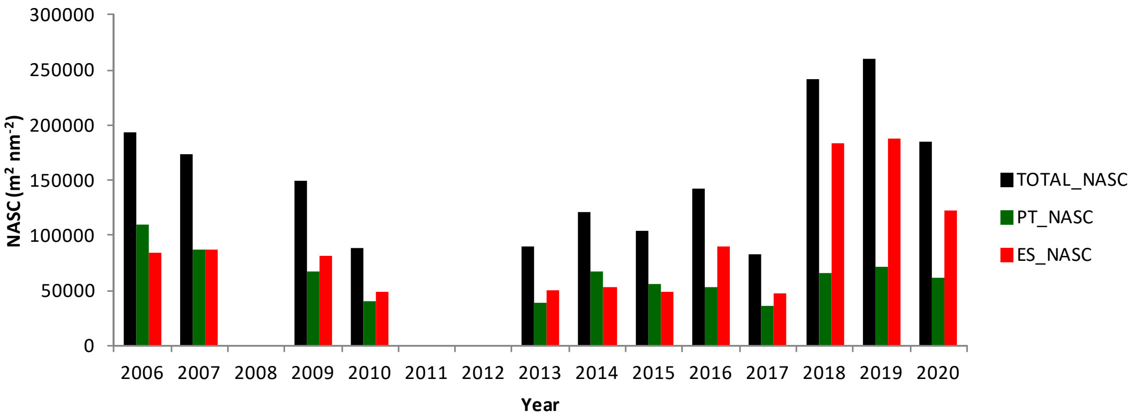
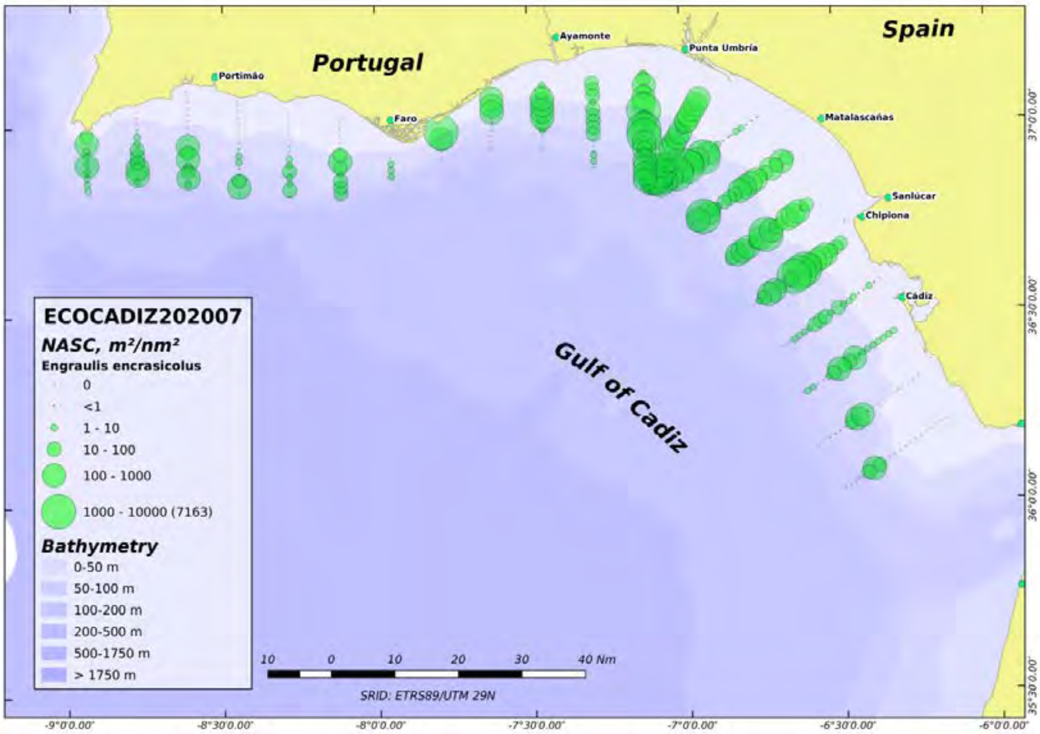


Figure 17. *ECOCADIZ 2020-07* survey. Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage. Bottom: time-series of total NASC estimates per survey.



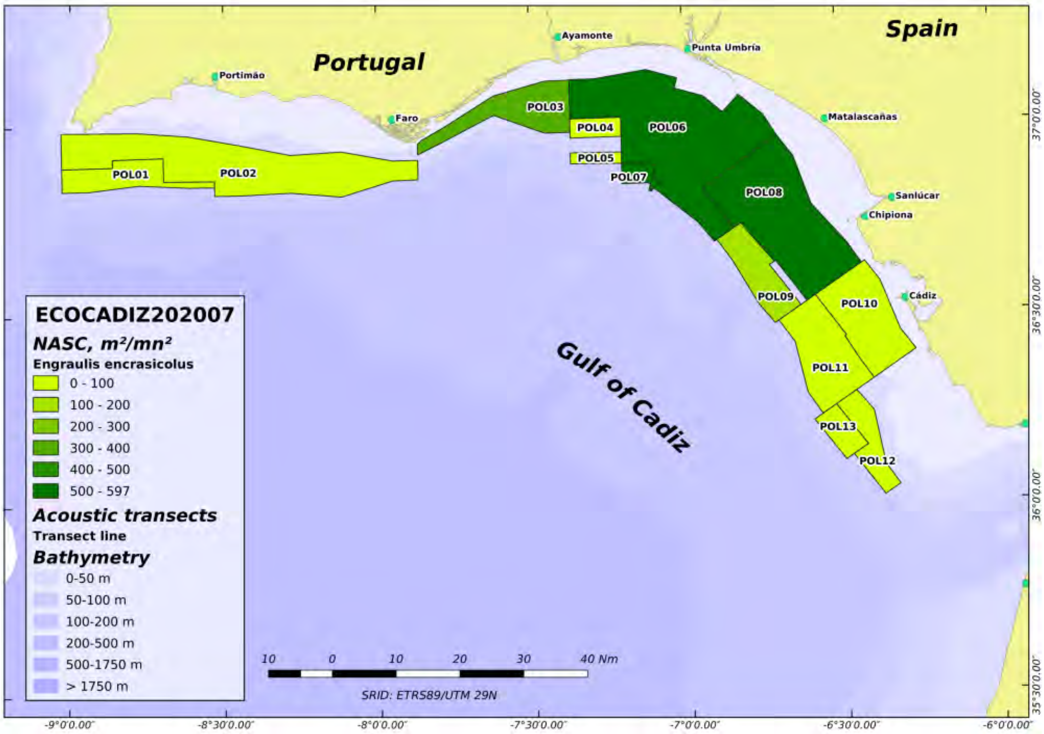


Figure 18. *ECOCADIZ 2020-07* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

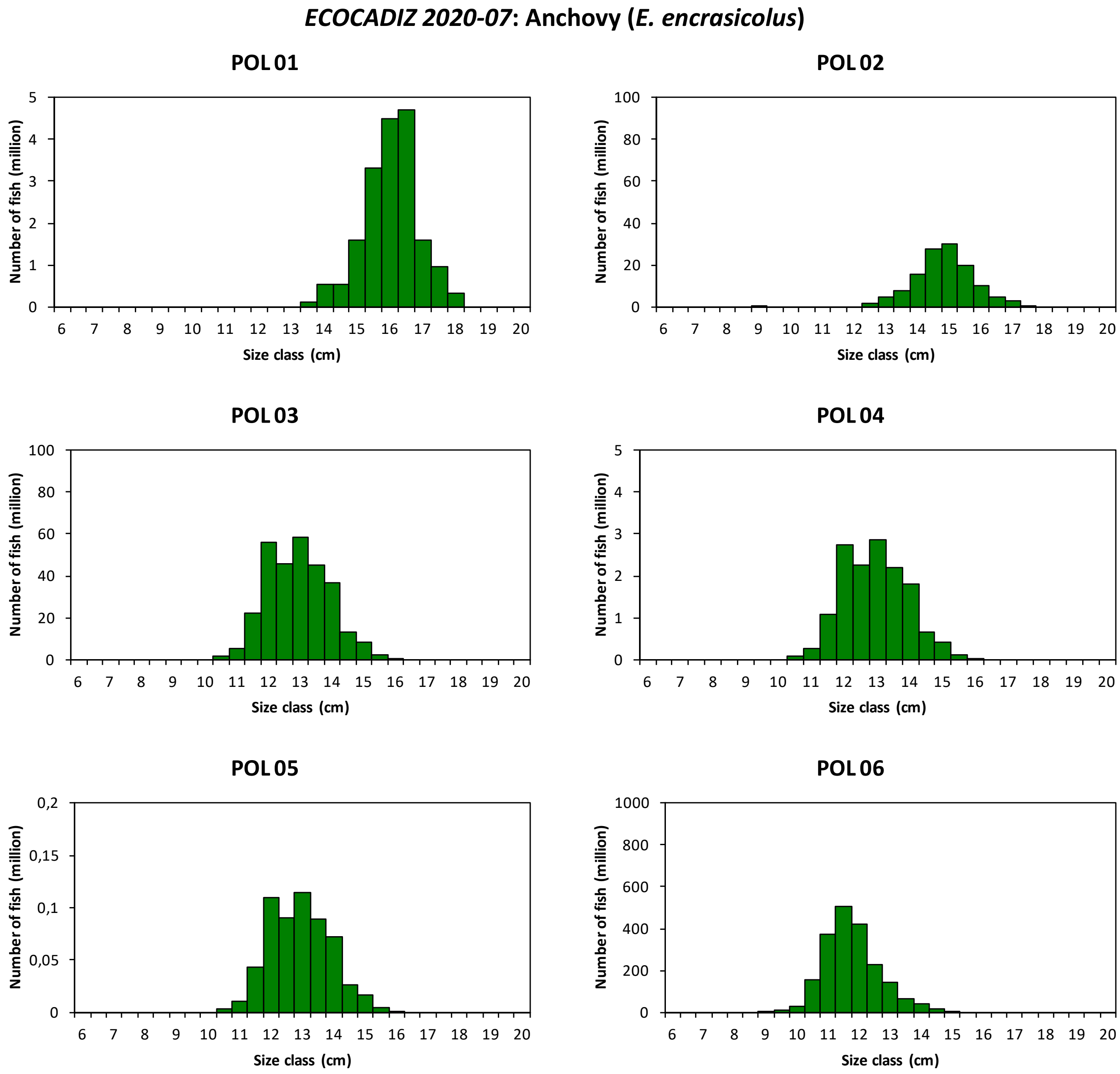


Figure 19. *ECOCADIZ 2020-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 18**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

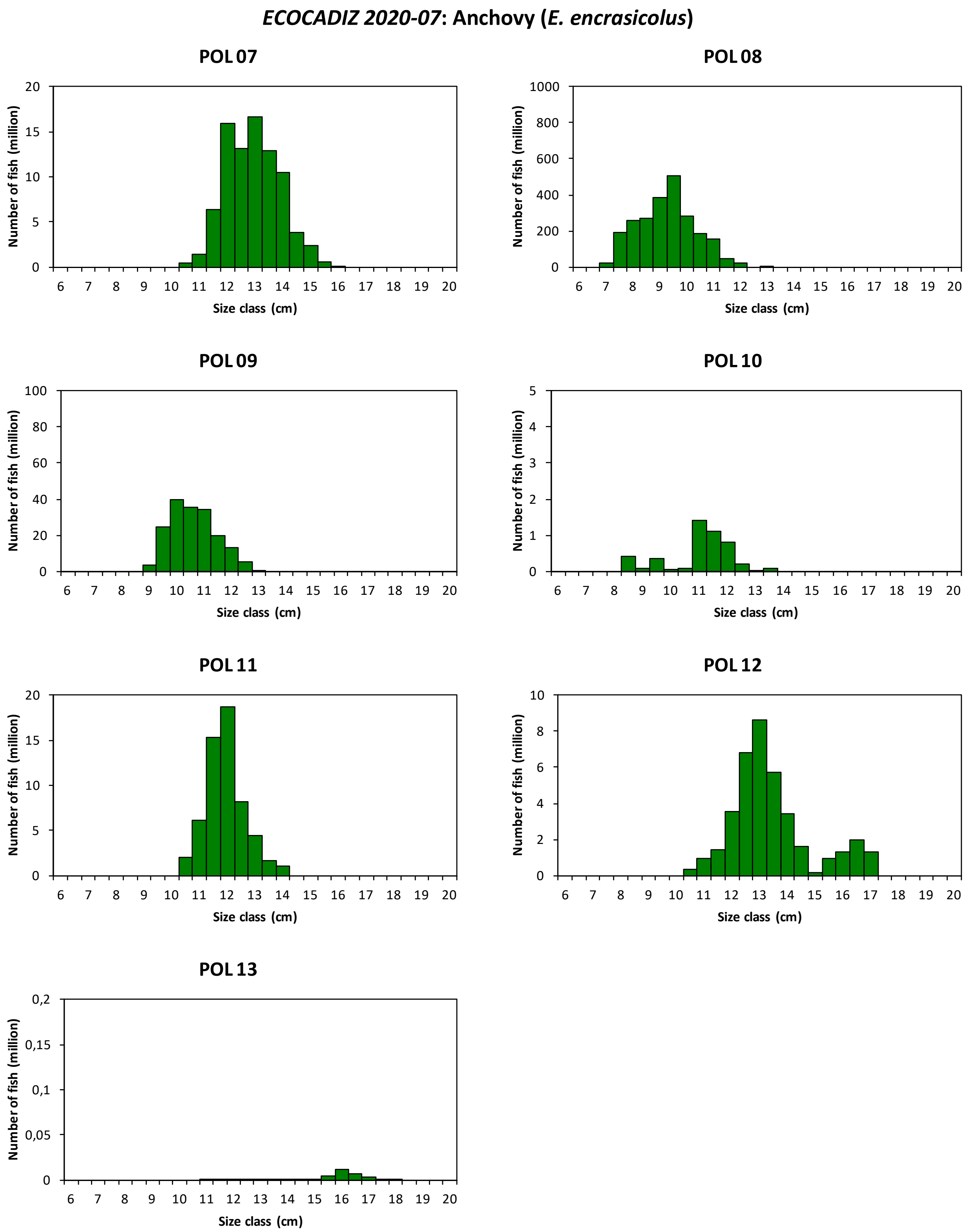


Figure 19. *ECOCADIZ 2020-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

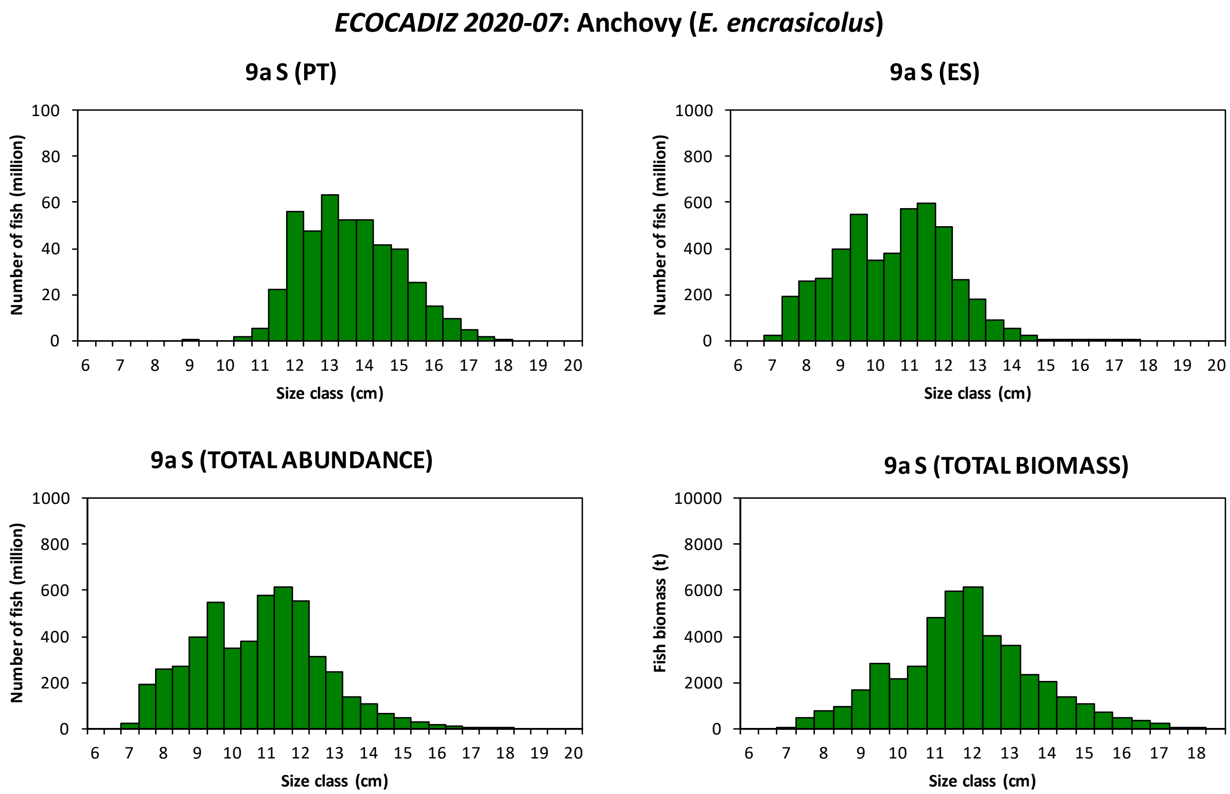


Figure 19. *ECOCADIZ 2020-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

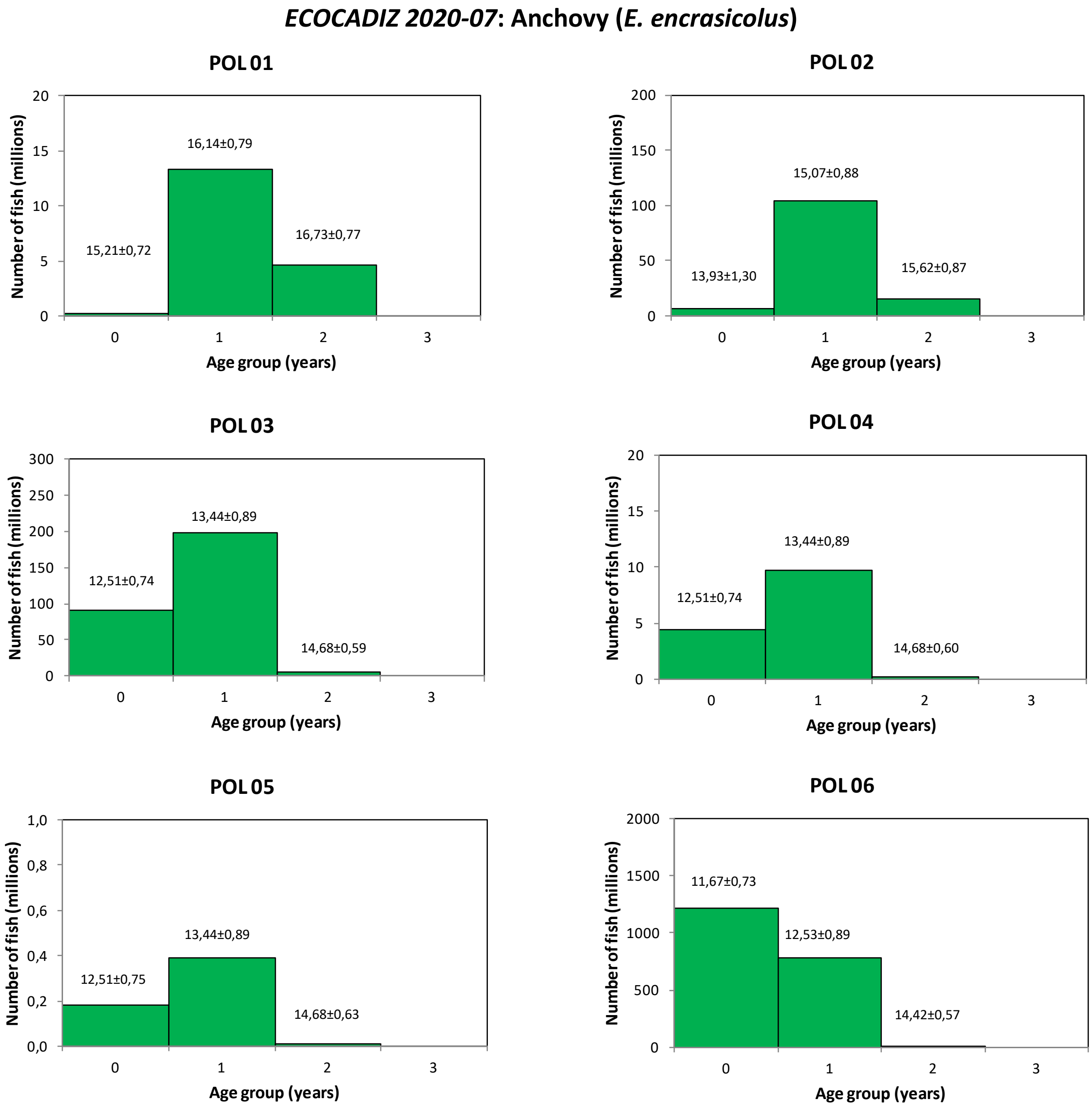


Figure 20. *ECOCADIZ 2020-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 18**) and total sampled area. Post-strata ordered in the W-E direction. Mean (±SD) sizes of age groups are also shown. The estimated biomass (t) by age group for the whole sampled area is shown for comparison. Note the different scales in the y axis.

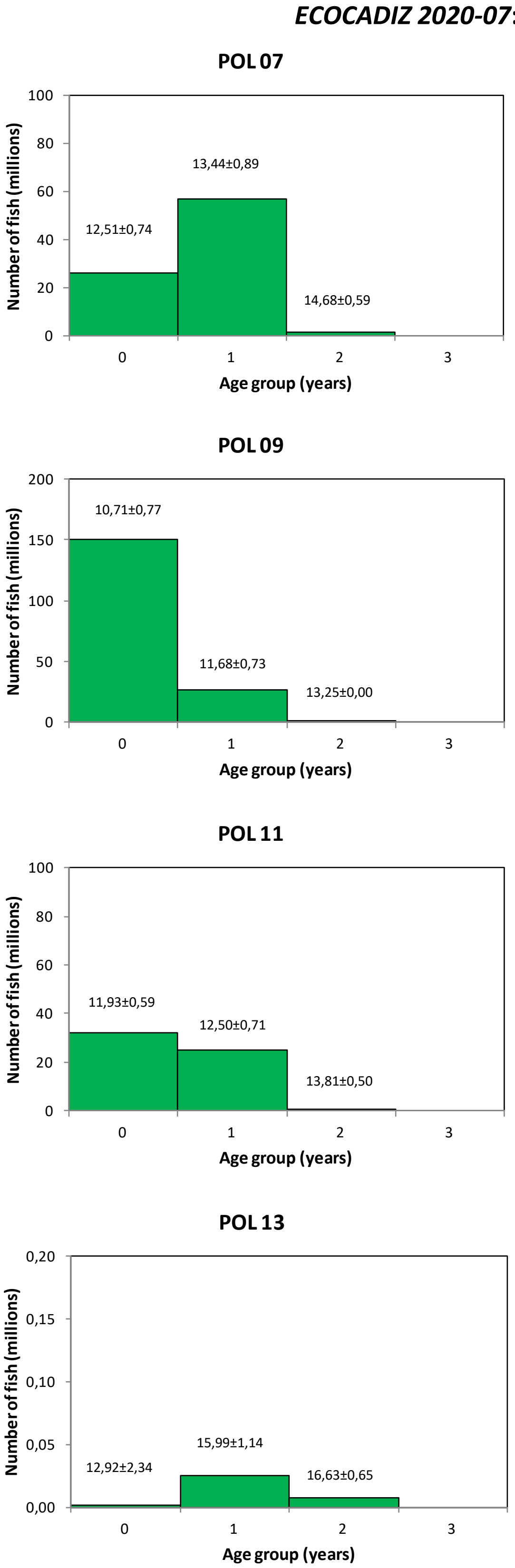


Figure 20. *ECOCADIZ 2020-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

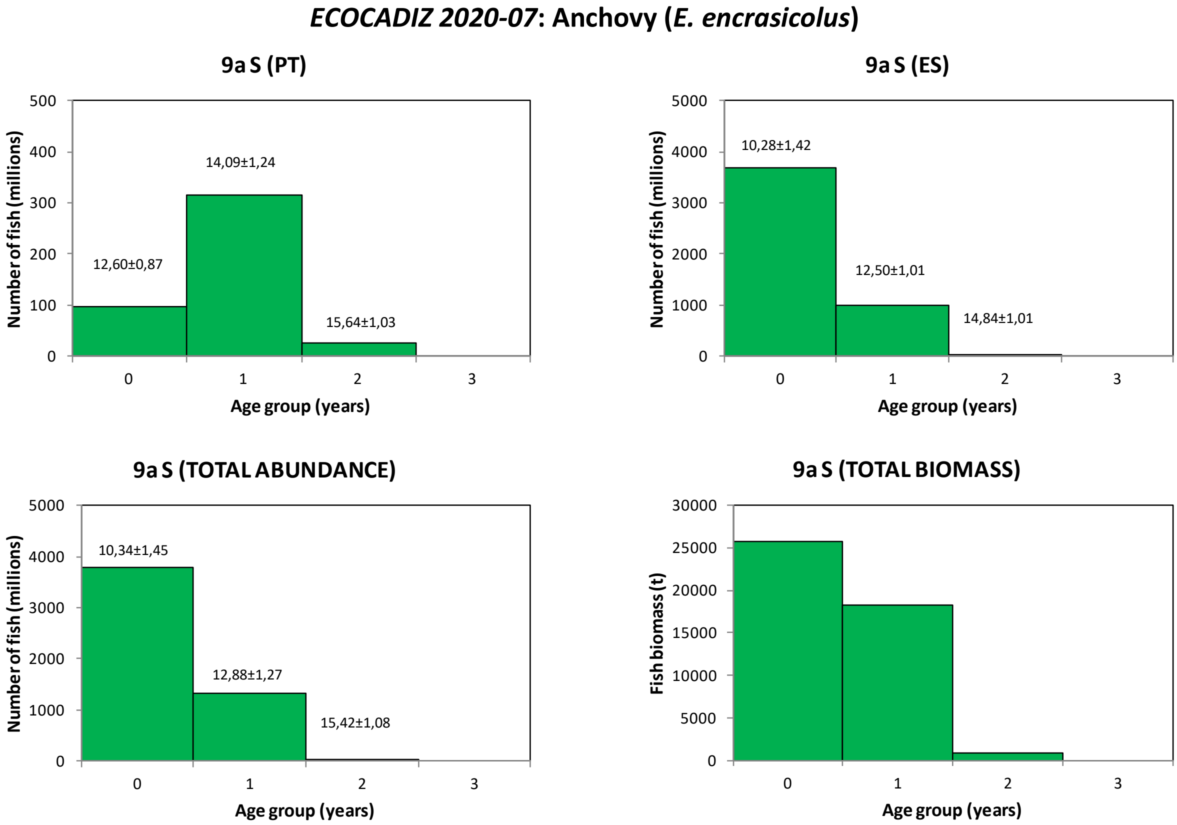


Figure 20. *ECOCADIZ 2020-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

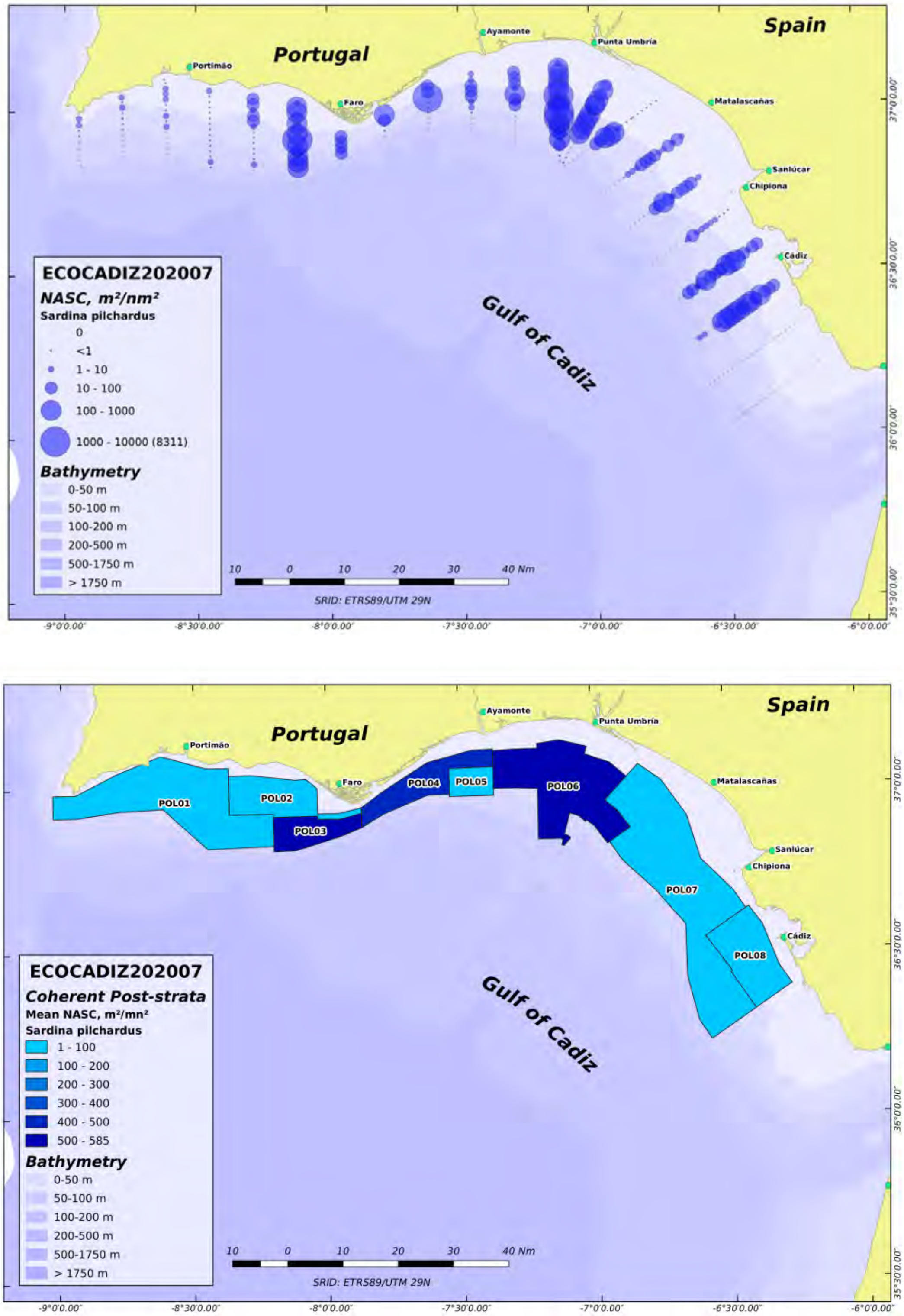


Figure 21. *ECOCADIZ 2020-07* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

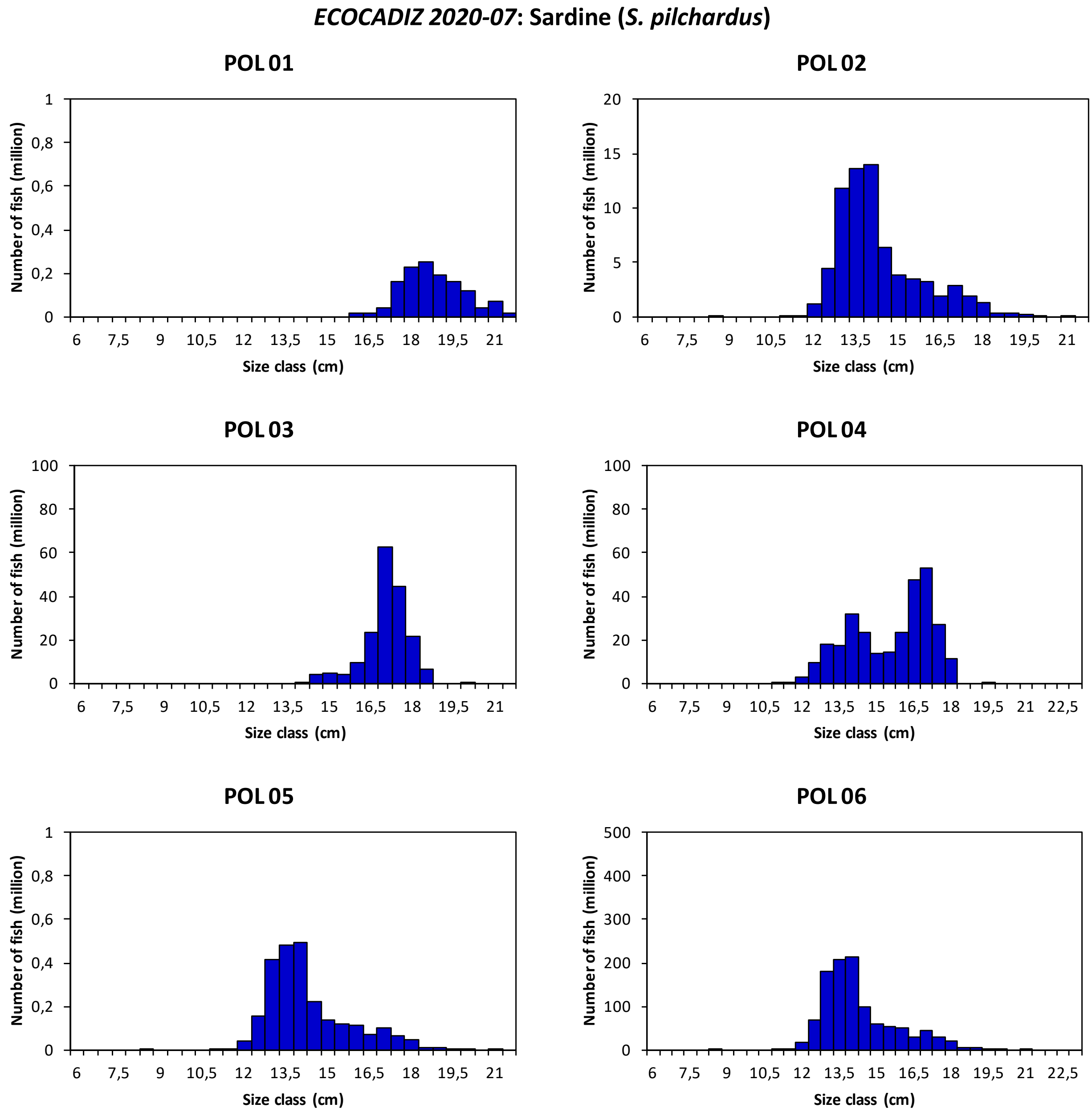


Figure 22. *ECOCADIZ 2020-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

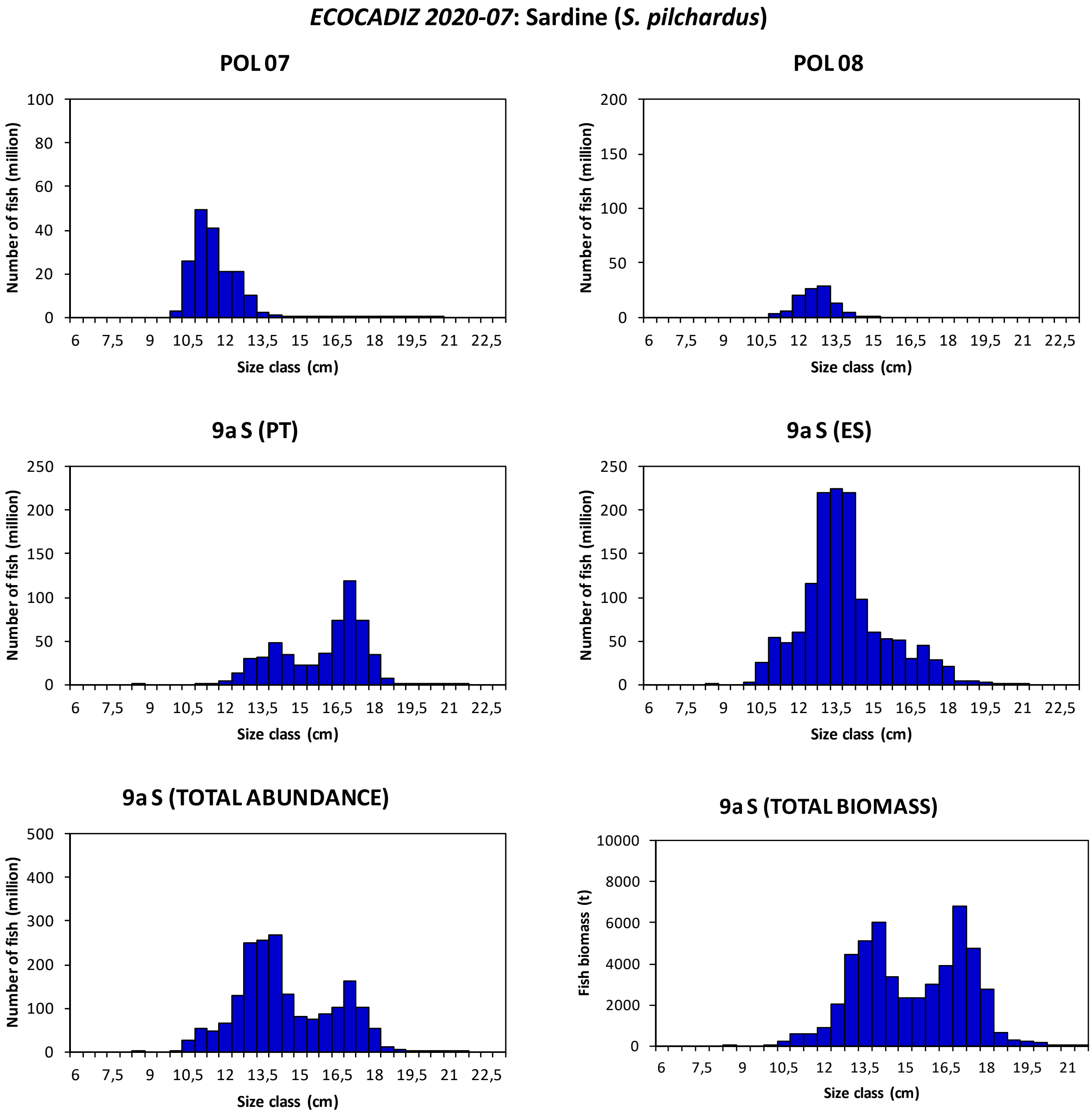


Figure 22. *ECOCADIZ 2020-07* survey. Sardine (*S. pilchardus*). Cont'd.

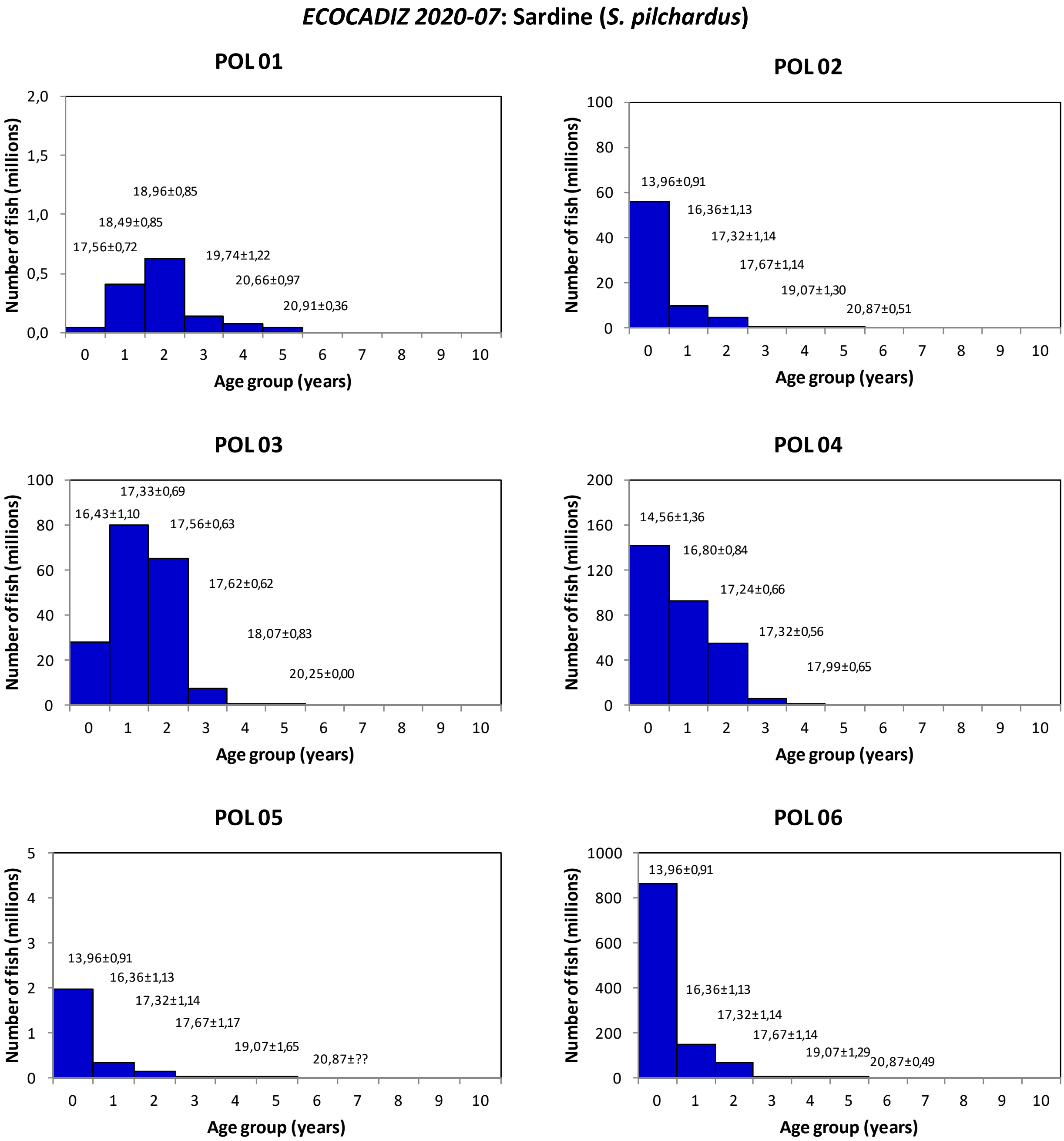


Figure 23. *ECOCADIZ 2020-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. Mean (±SD) sizes of age groups are also shown. The estimated biomass (t) by age group for the whole sampled area is shown for comparison. Note the different scales in the y axis.

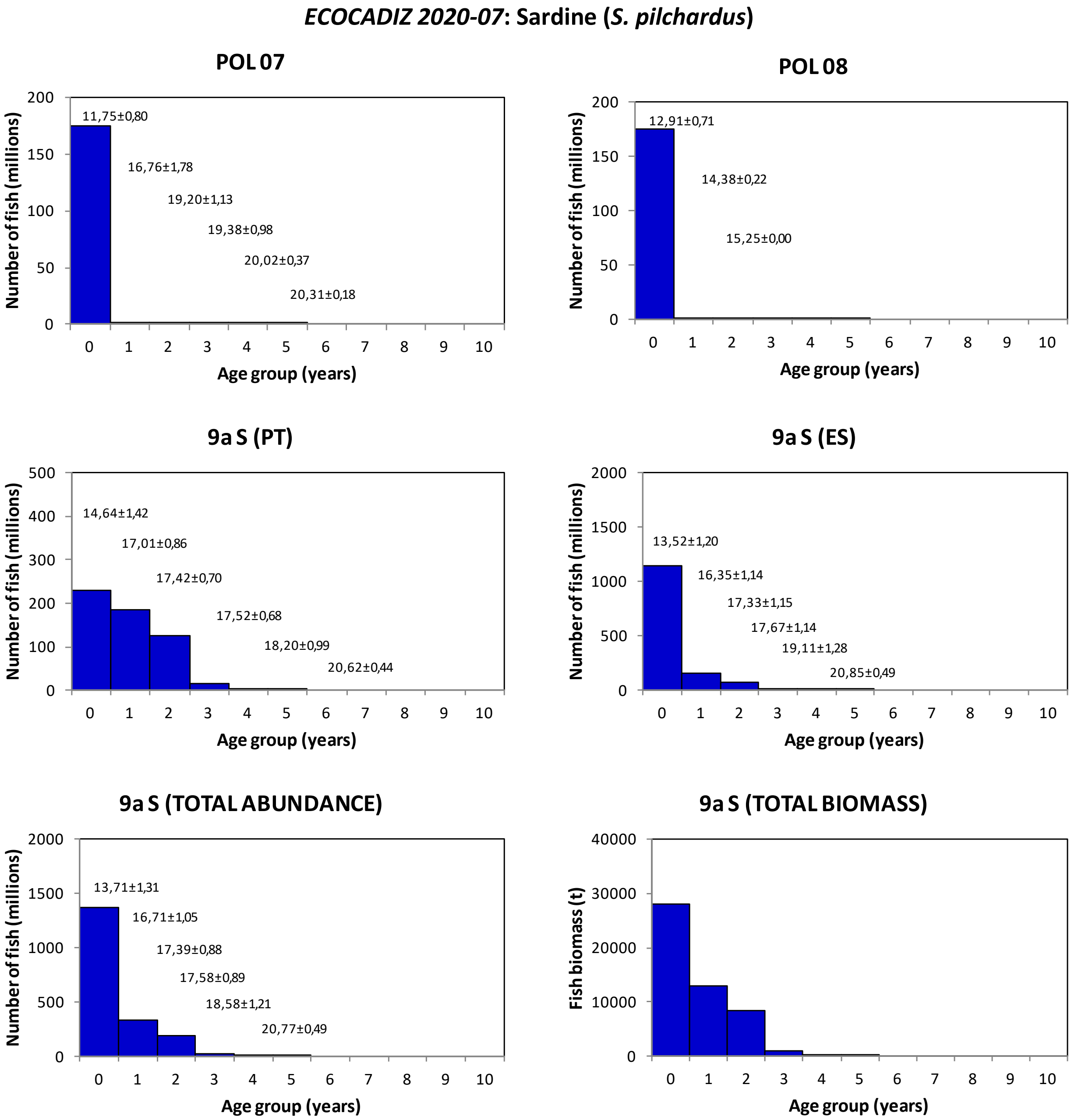


Figure 23. *ECOCADIZ 2020-07* survey. Sardine (*S. pilchardus*). Cont'd.

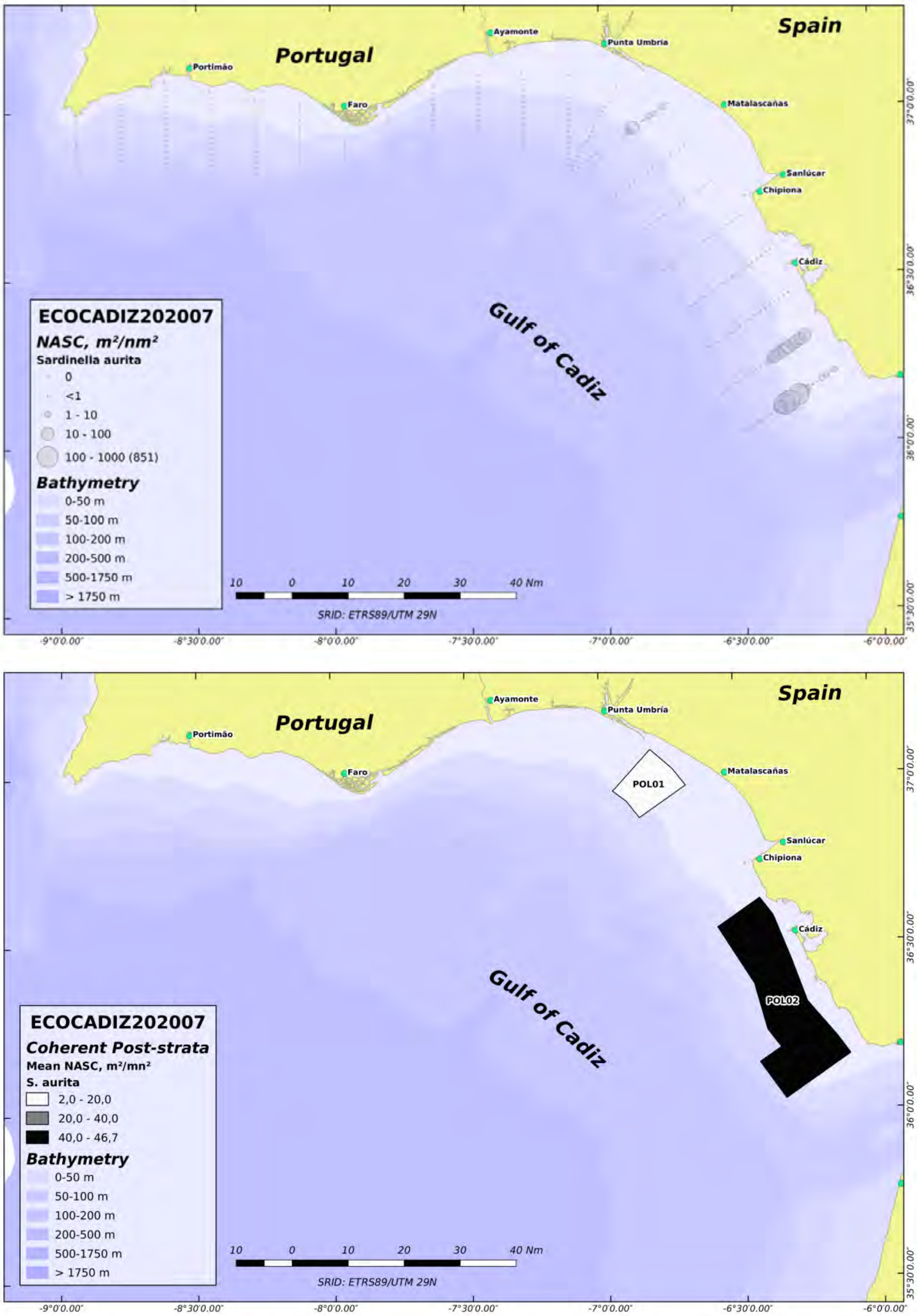


Figure 24. *ECOCADIZ 2020-07* survey. Round sardinella (*Sardinella aurita*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

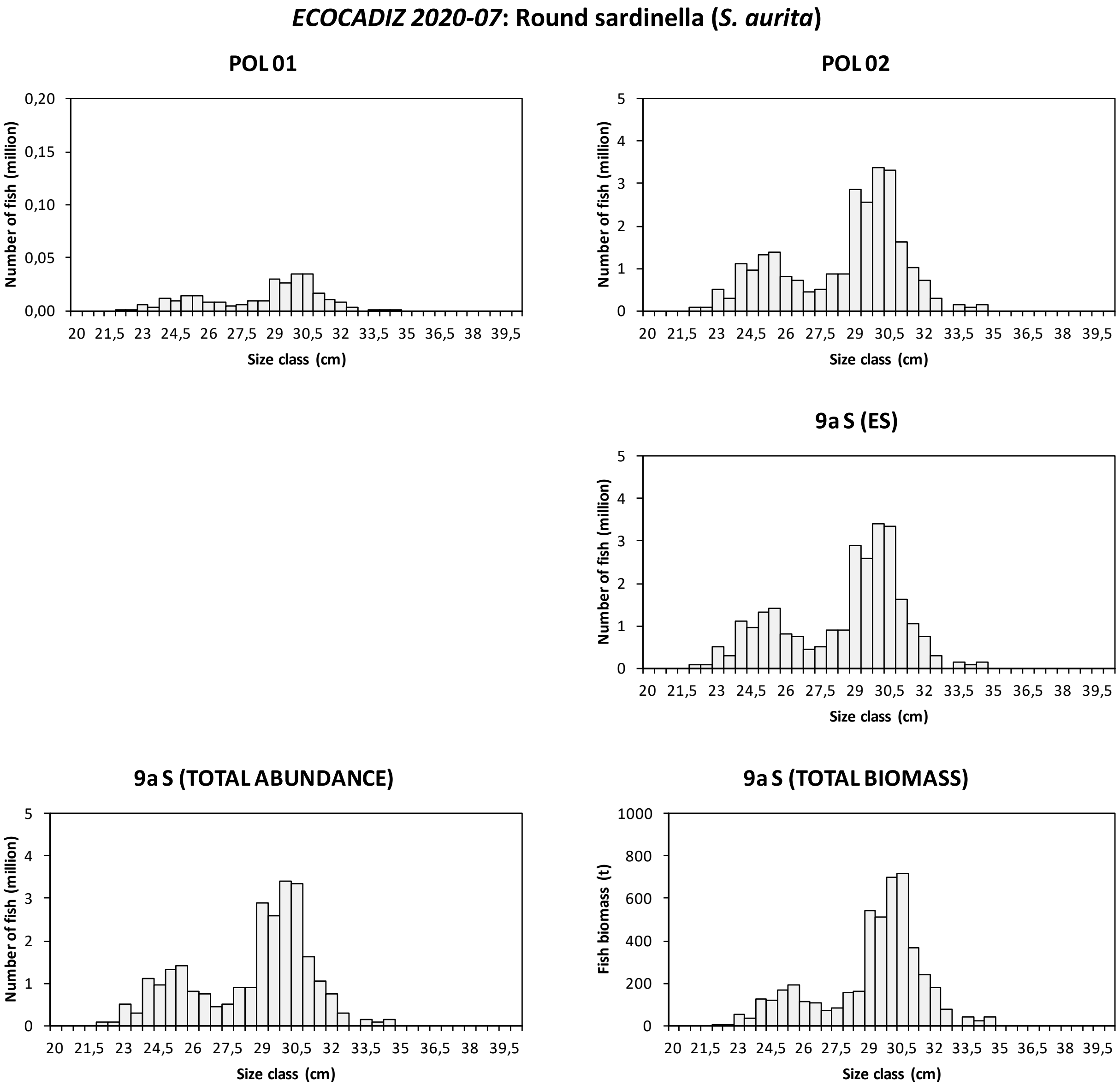


Figure 25. *ECOCADIZ 2020-07* survey. Round sardinella (*Sardinella aurita*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 24**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

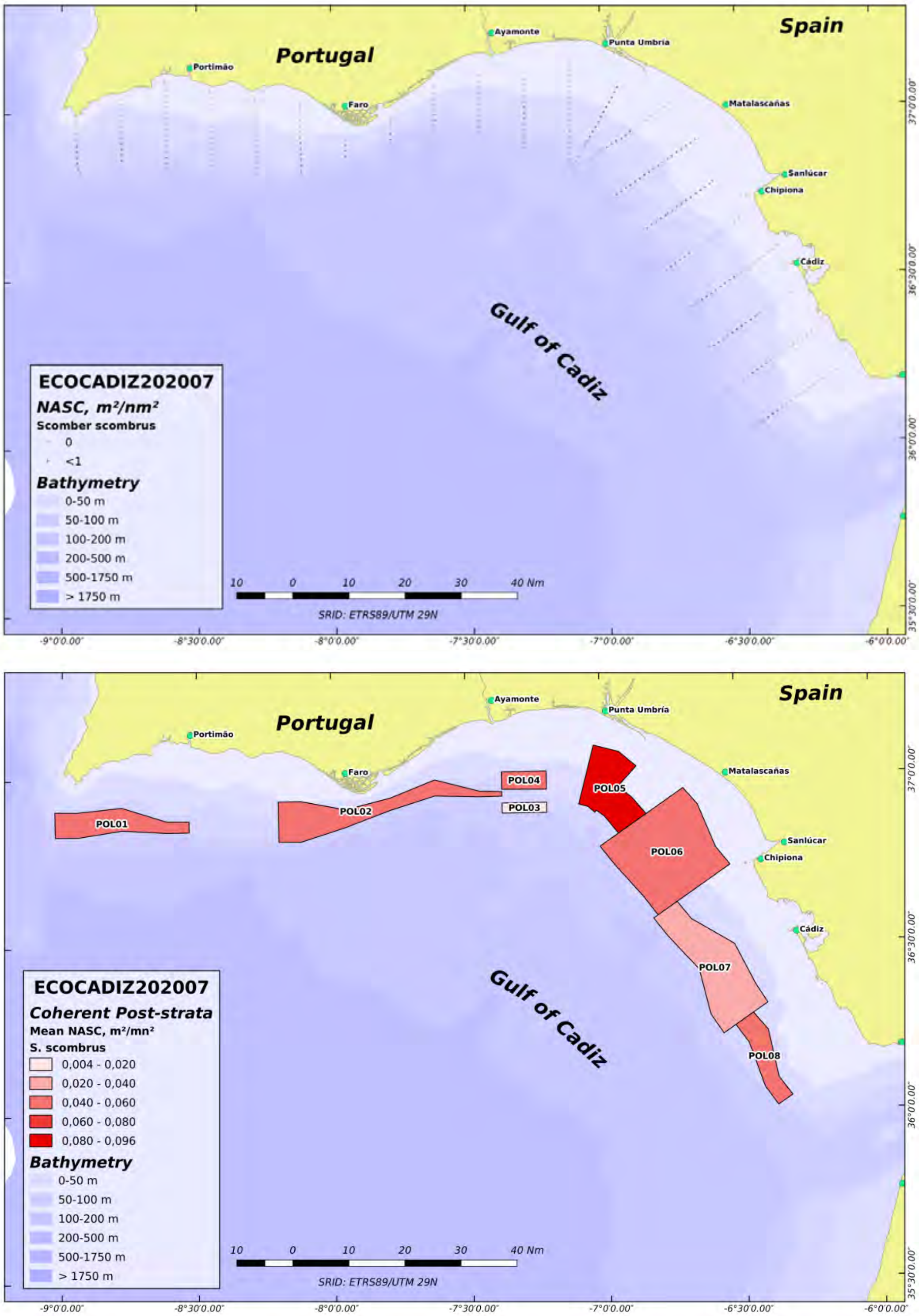


Figure 26. *ECOCADIZ 2020-07* survey. Mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

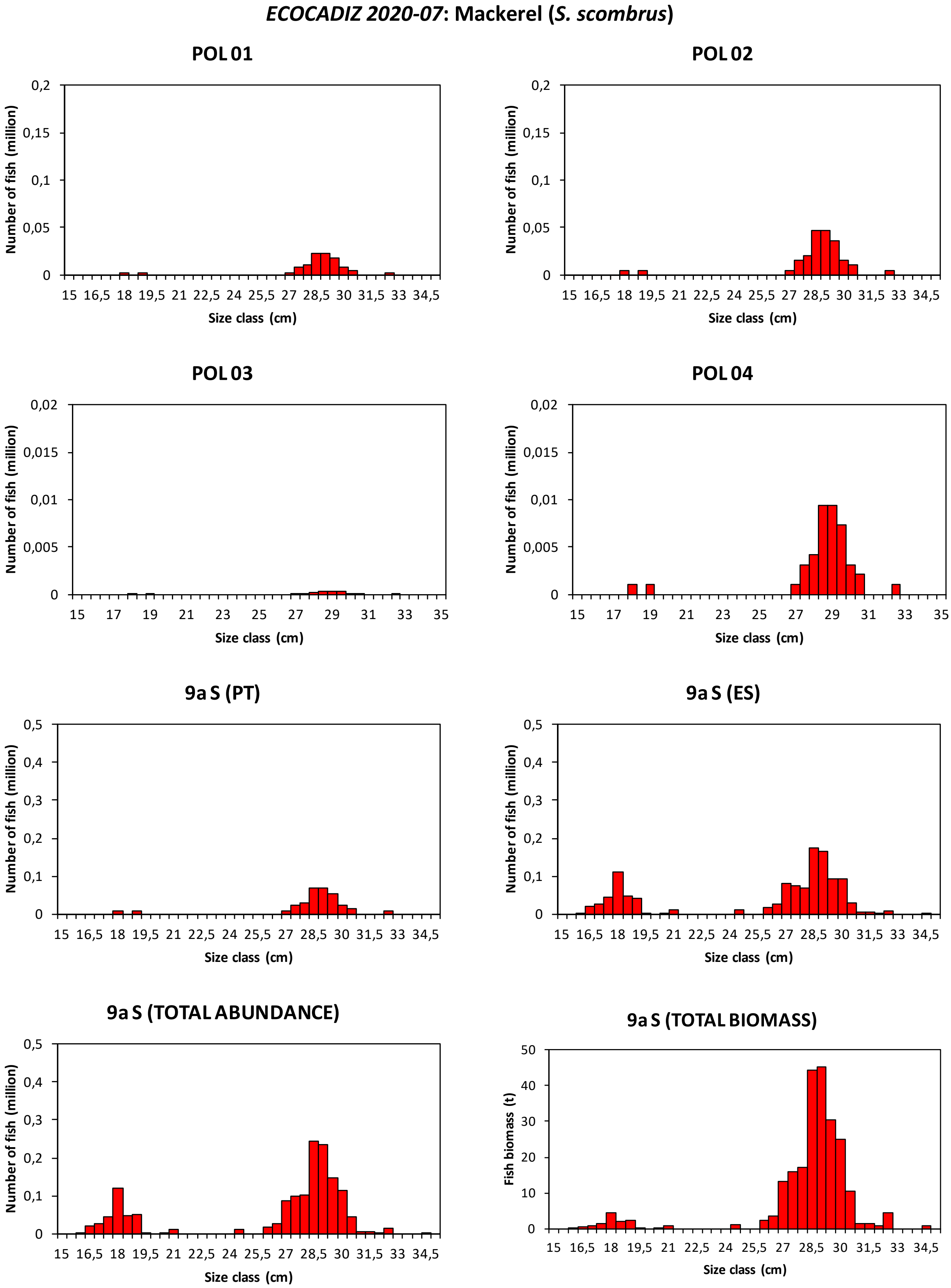


Figure 27. *ECOCADIZ 2020-07* survey. Mackerel (*Scomber scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 26**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

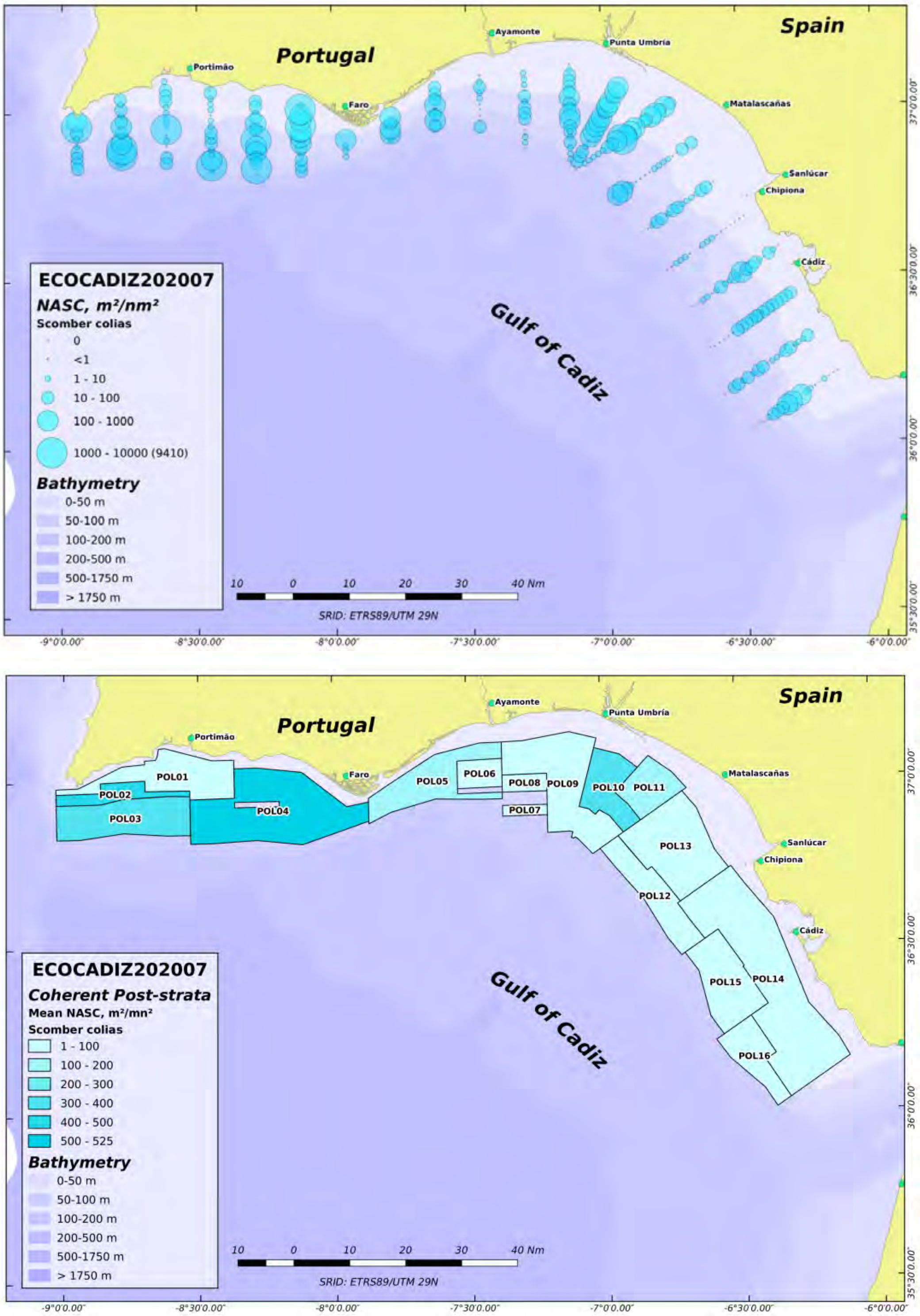


Figure 28. *ECOCADIZ 2020-07* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

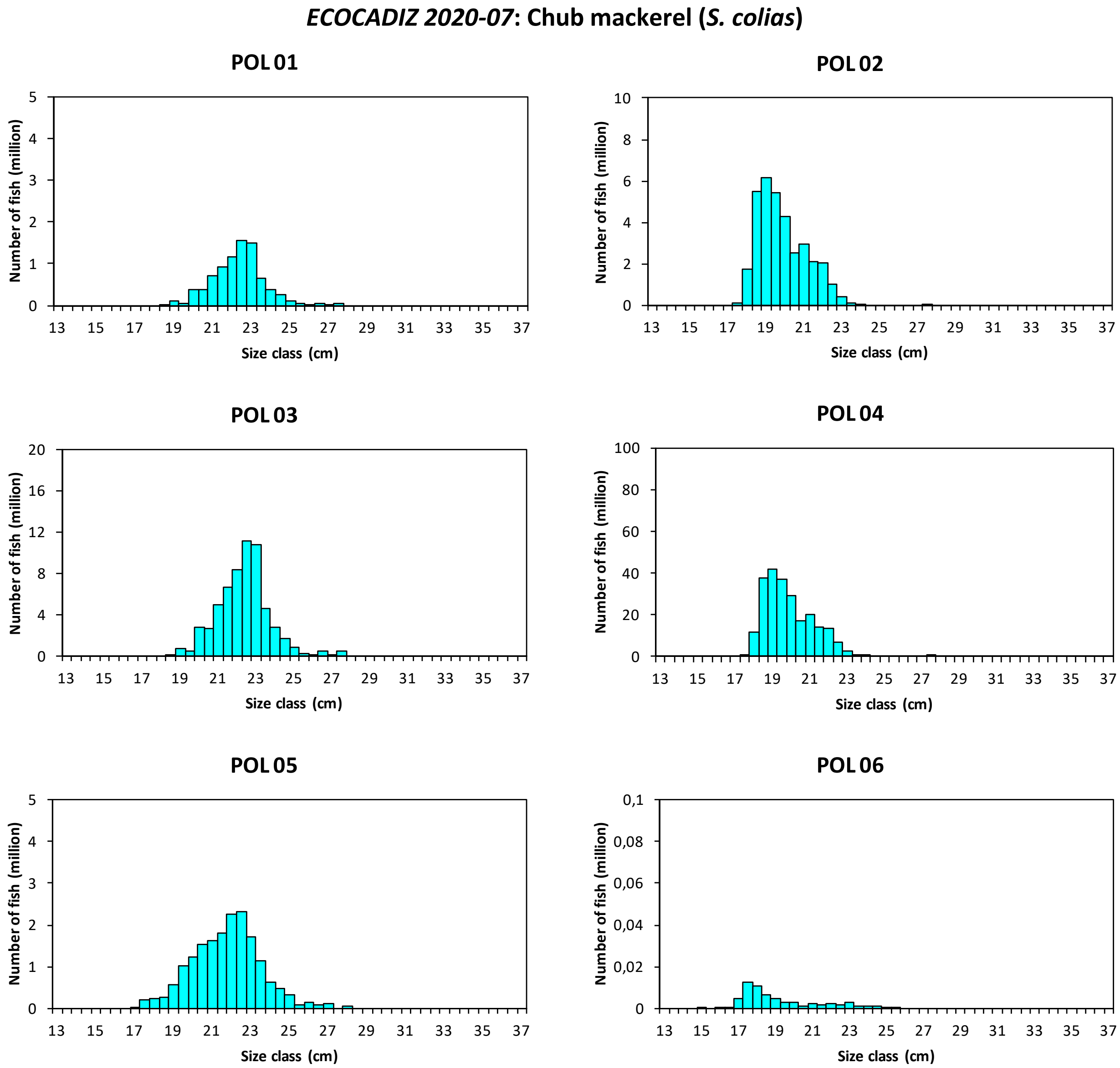


Figure 29. *ECOCADIZ 2020-07* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 28**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2020-07*: Chub mackerel (*S. colias*)**

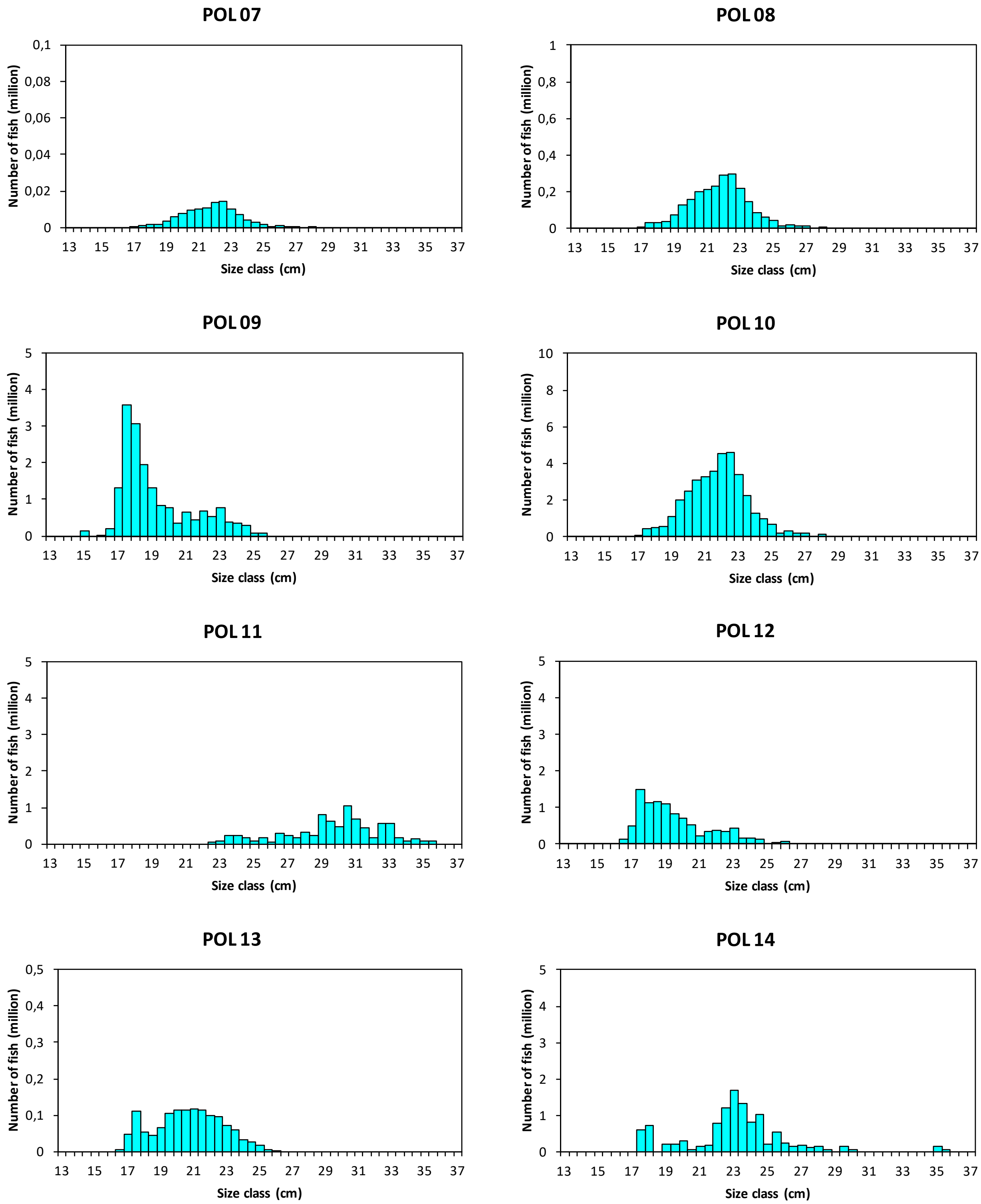


Figure 29. *ECOCADIZ 2020-07* survey. Chub mackerel (*Scomber colias*). Cont'd.

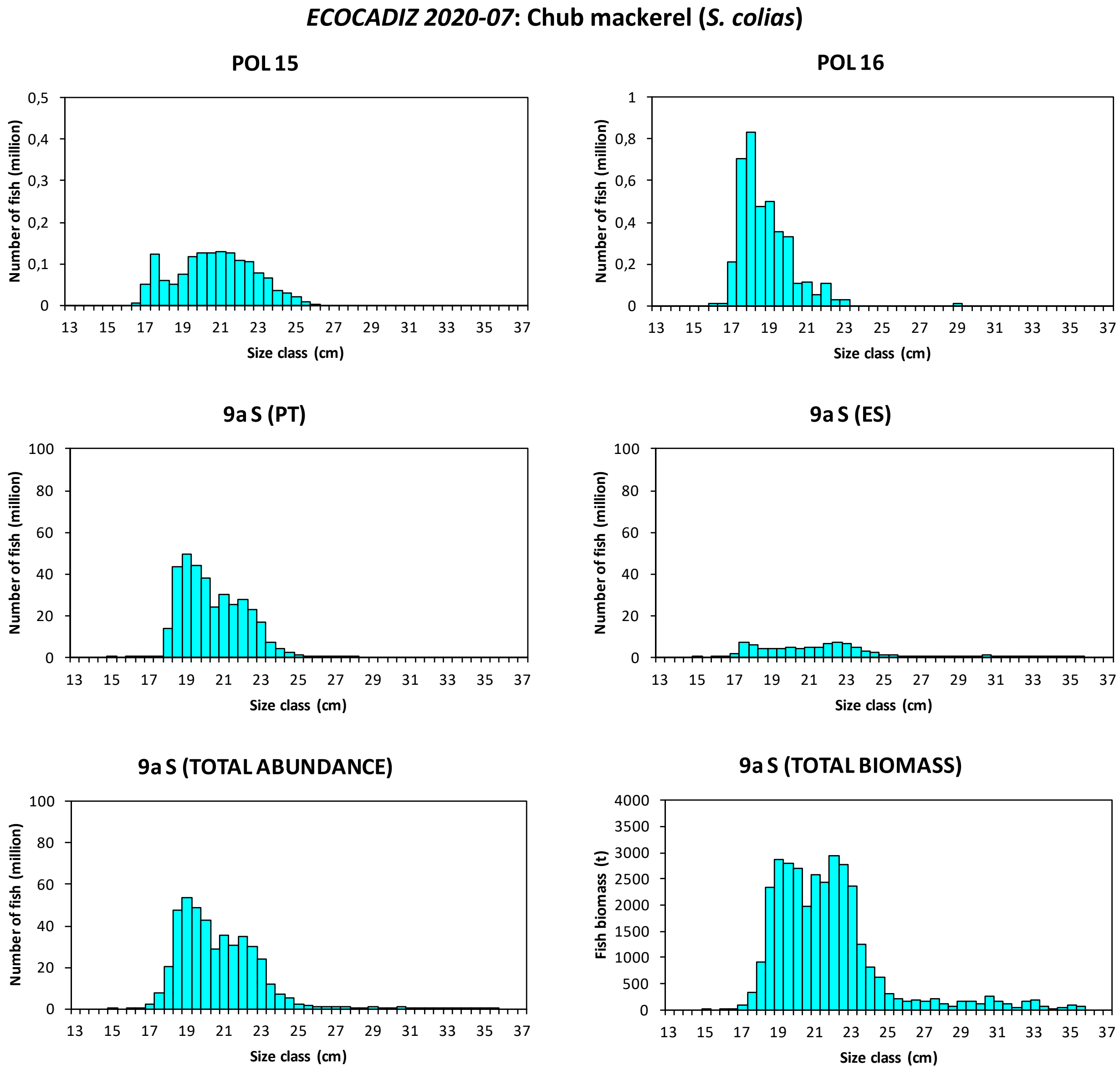


Figure 29. *ECOCADIZ 2020-07* survey. Chub mackerel (*Scomber colias*). Cont'd.

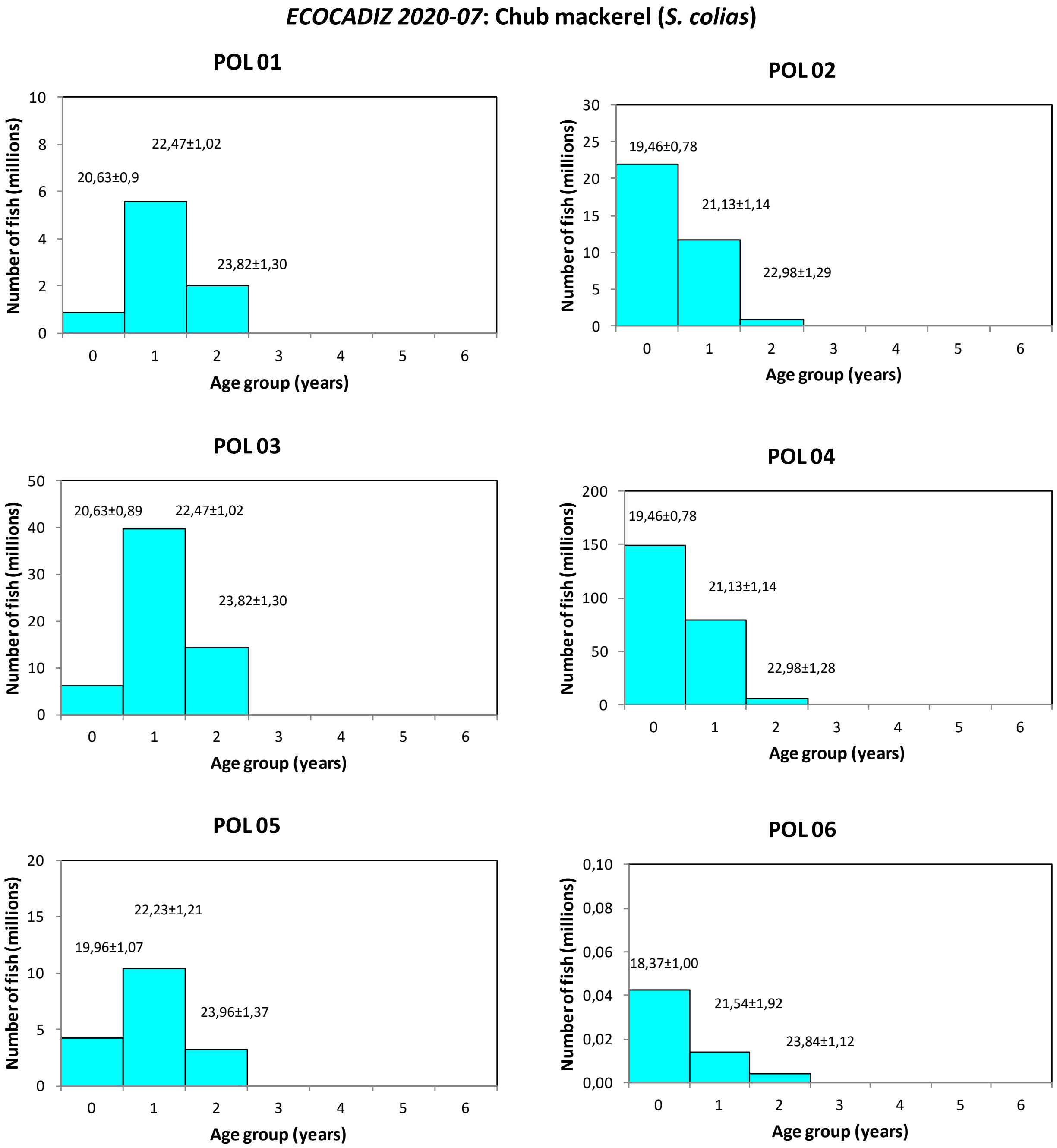


Figure 30. *ECOCADIZ 2020-07* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous stratum (POL01-POLn, numeration as in **Figure 28**) and total sampled area. Post-strata ordered in the W-E direction. Mean (±SD) sizes of age groups are also shown. The estimated biomass (t) by age group for the whole sampled area is shown for comparison. Note the different scales in the y axis.

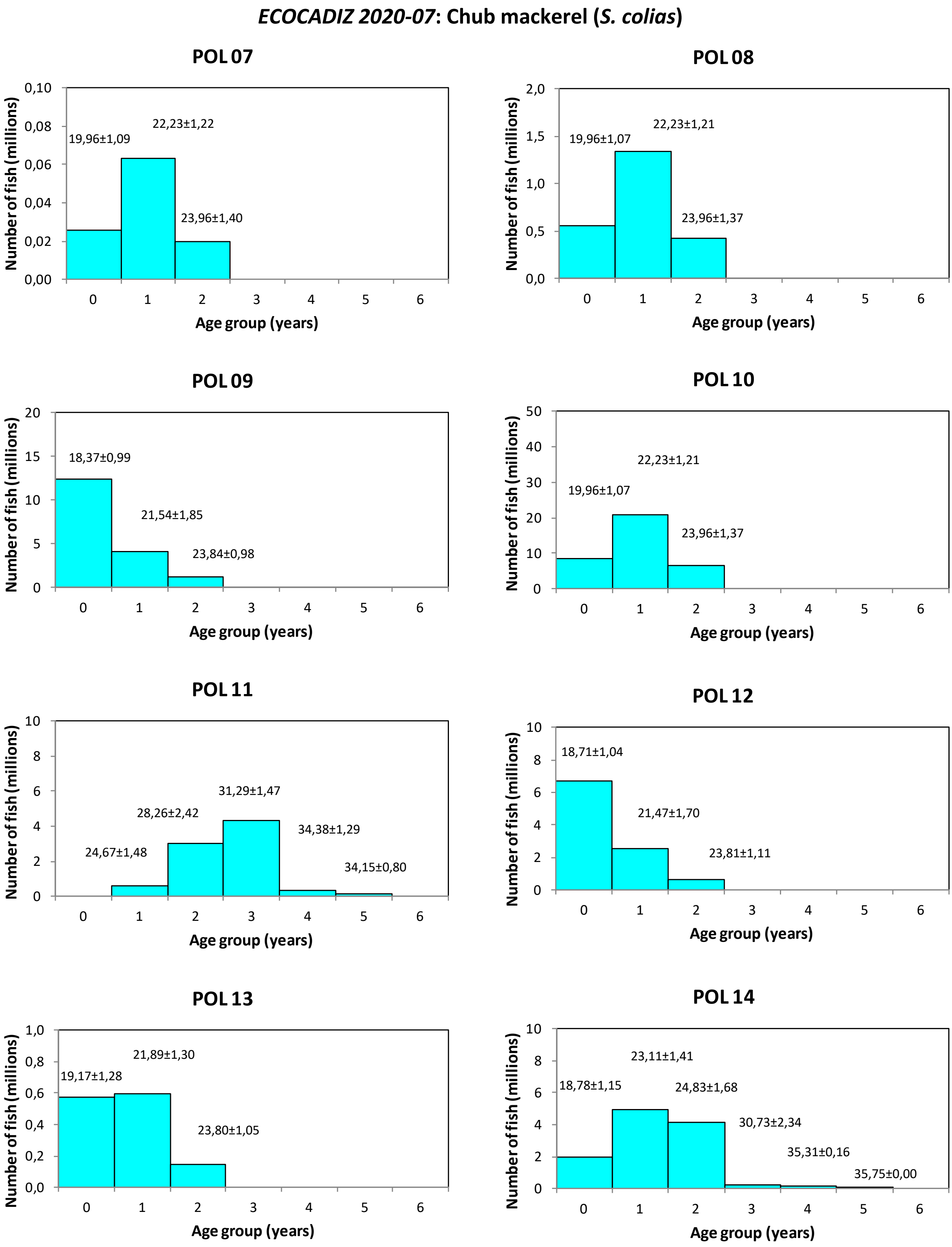


Figure 30. *ECOCADIZ 2020-07* survey. Chub mackerel (*Scomber colias*). Cont'd.

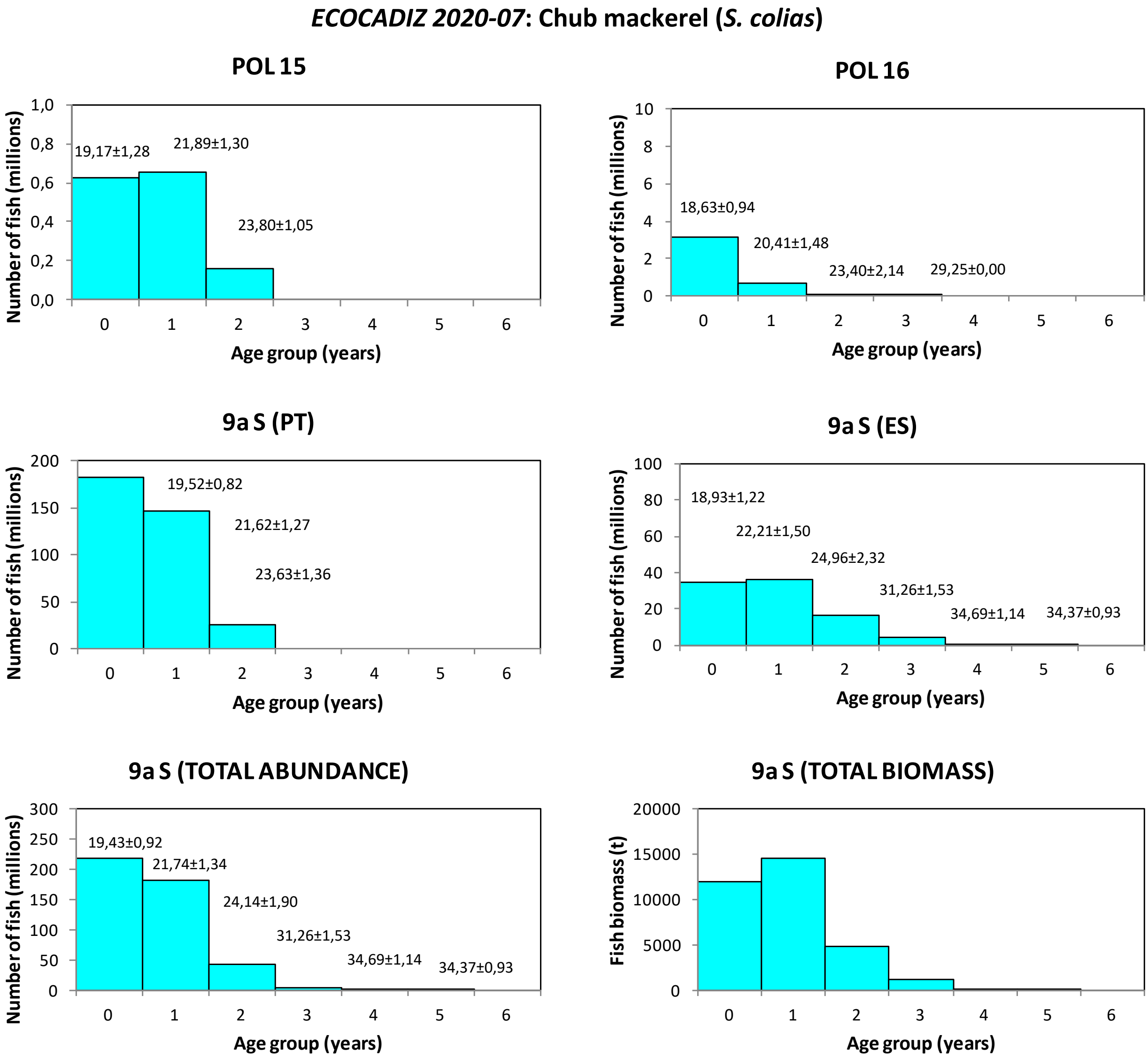
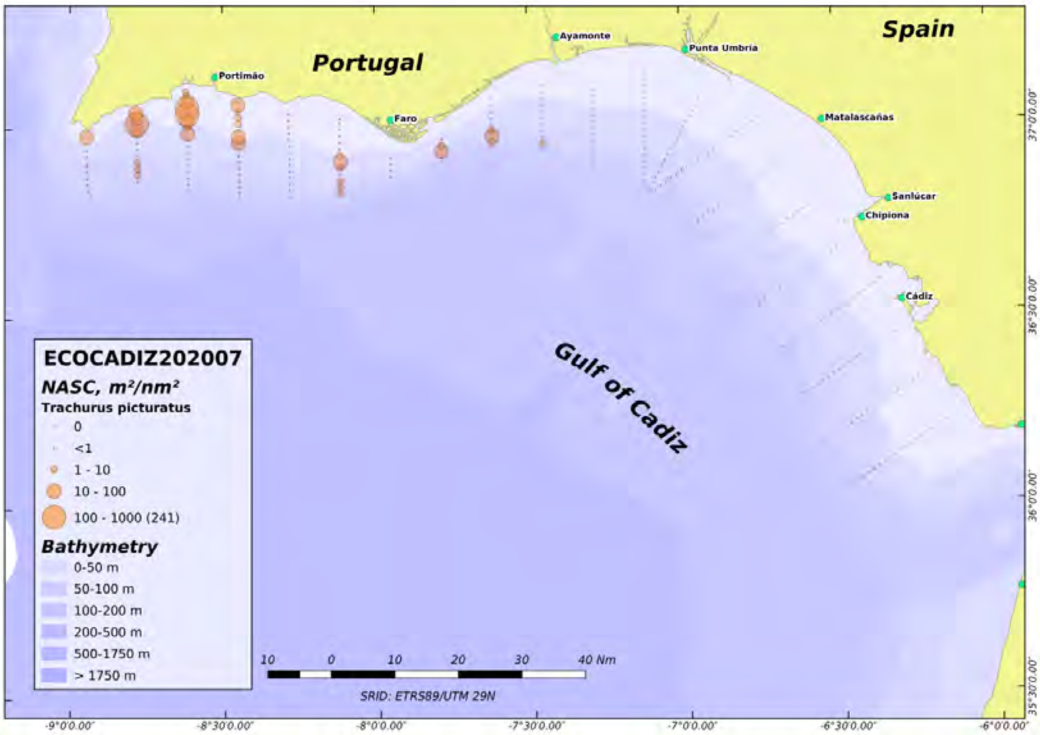


Figure 30. *ECOCADIZ 2020-07* survey. Chub mackerel (*Scomber colias*). Cont'd.



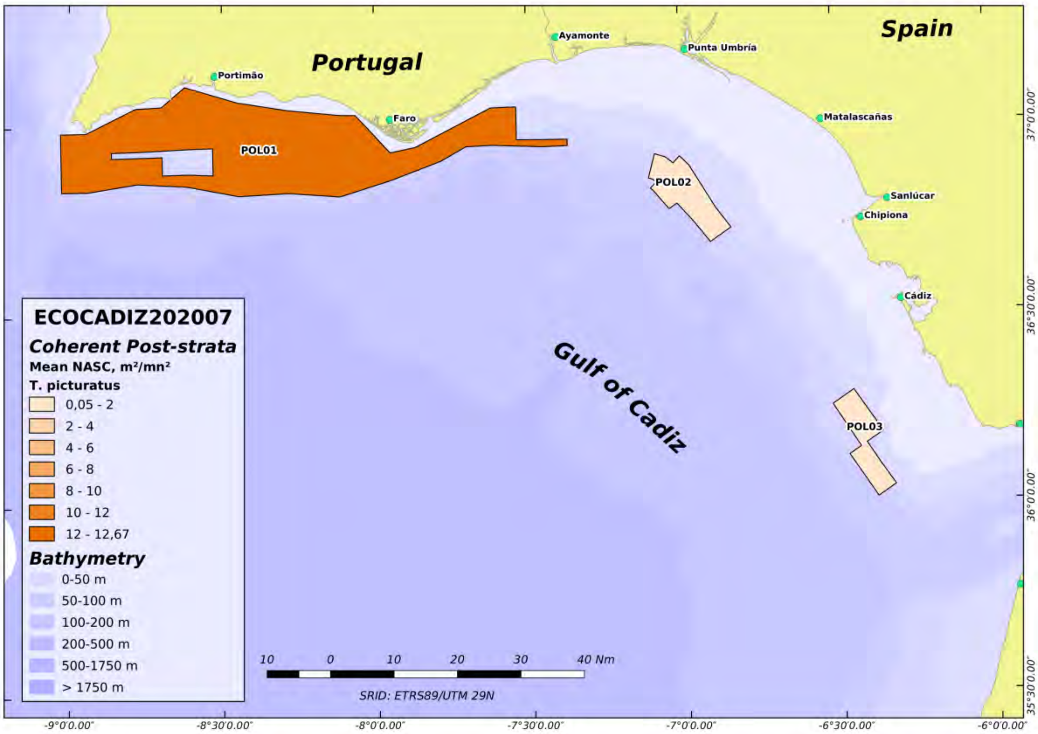


Figure 31. *ECOCADIZ 2020-07* survey. Blue jack mackerel (*Trachurus picturatus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

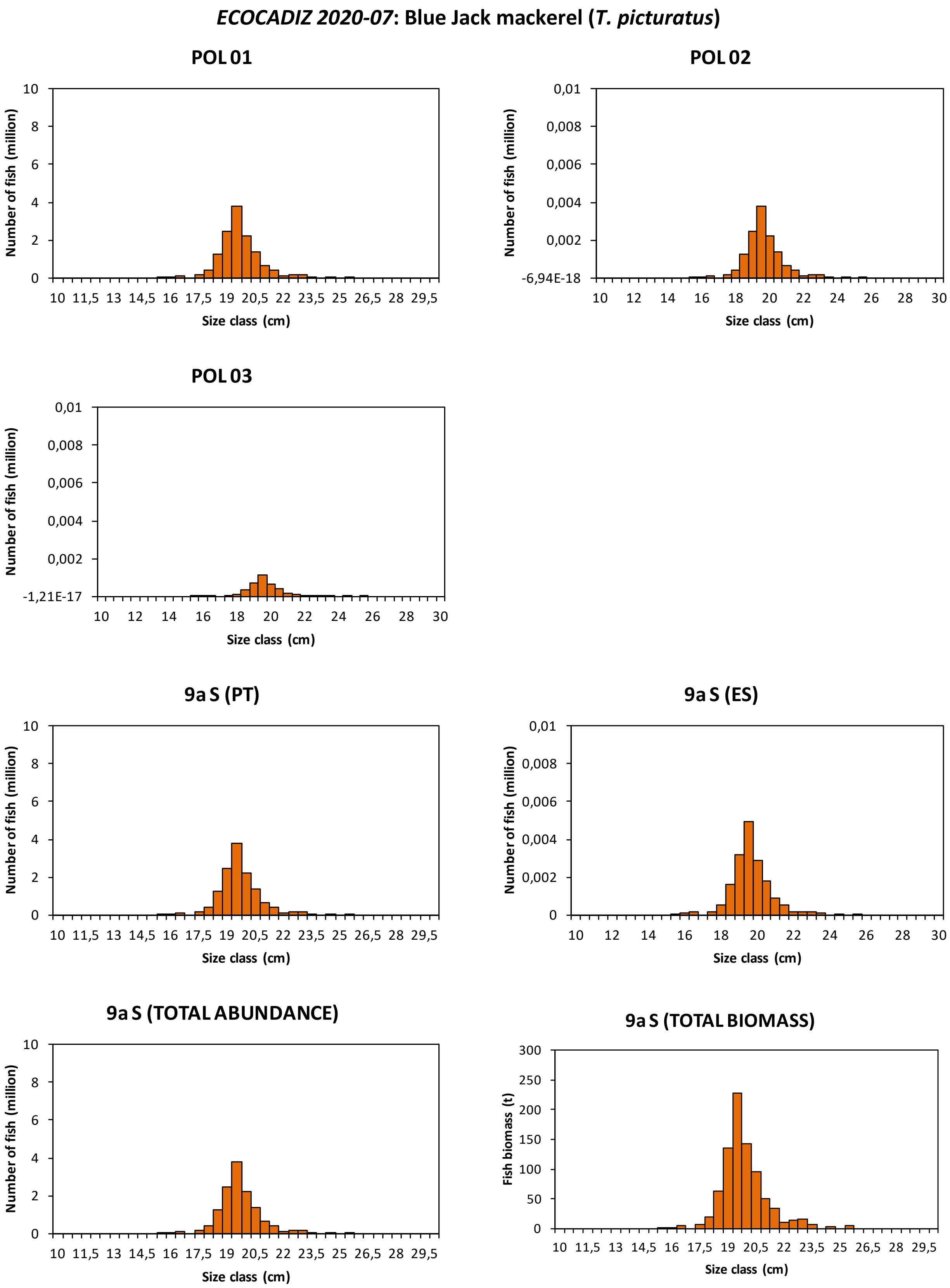


Figure 32. *ECOCADIZ 2020-07* survey. Blue jack mackerel (*Trachurus picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 31**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

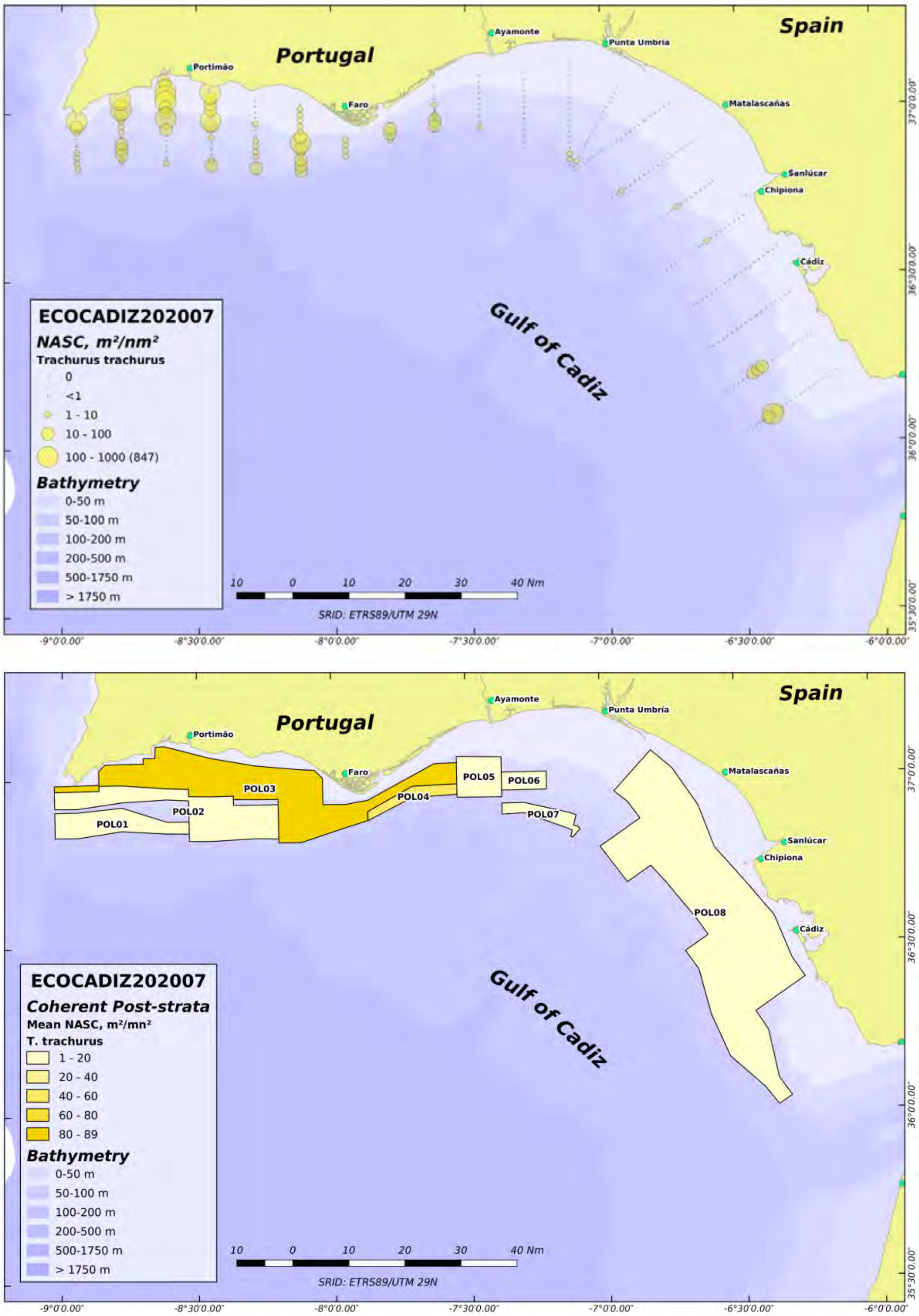


Figure 33. *ECOCADIZ 2020-07* survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

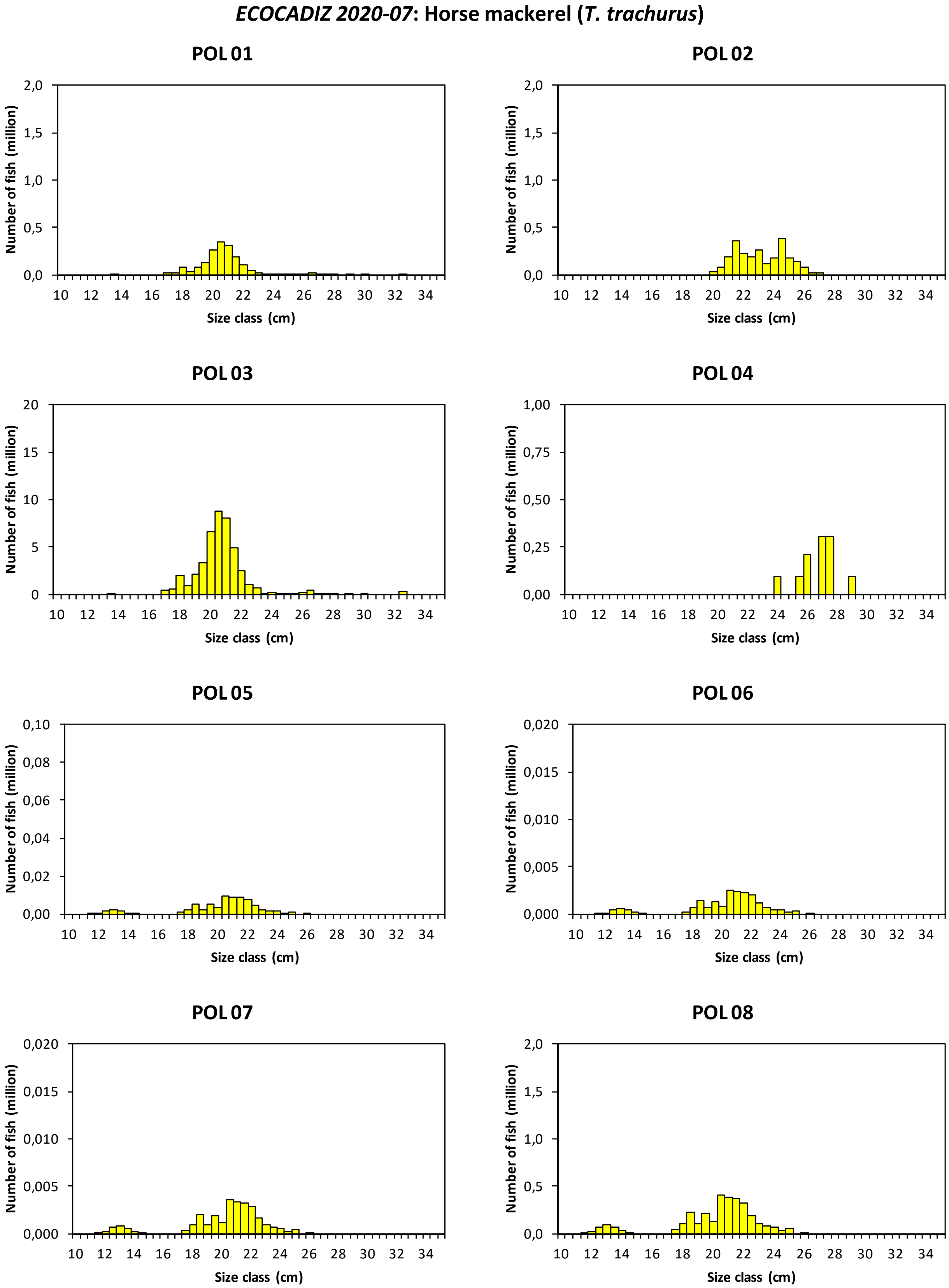


Figure 34. *ECOCADIZ 2020-07* survey. Horse mackerel (*Trachurus trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 33**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

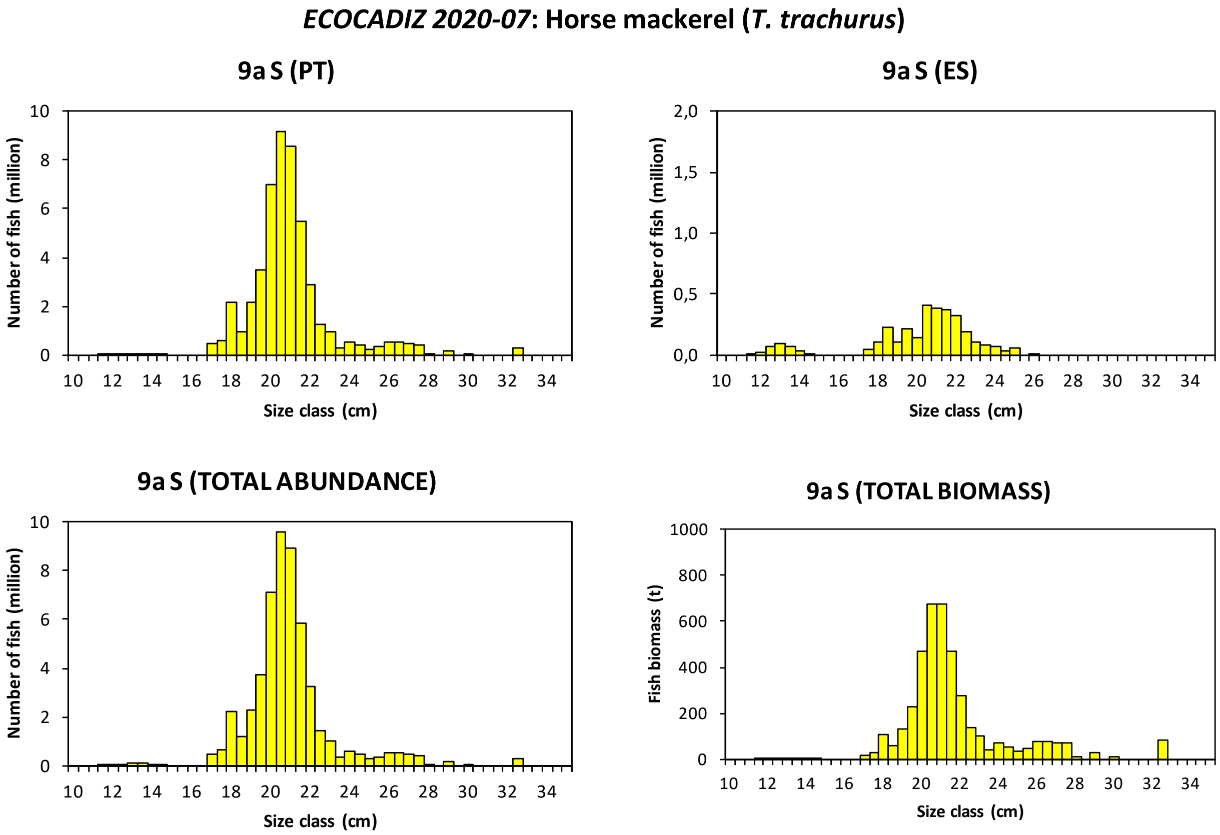


Figure 34. *ECOCADIZ 2020-07* survey. Horse mackerel (*Trachurus trachurus*).Cont'd.

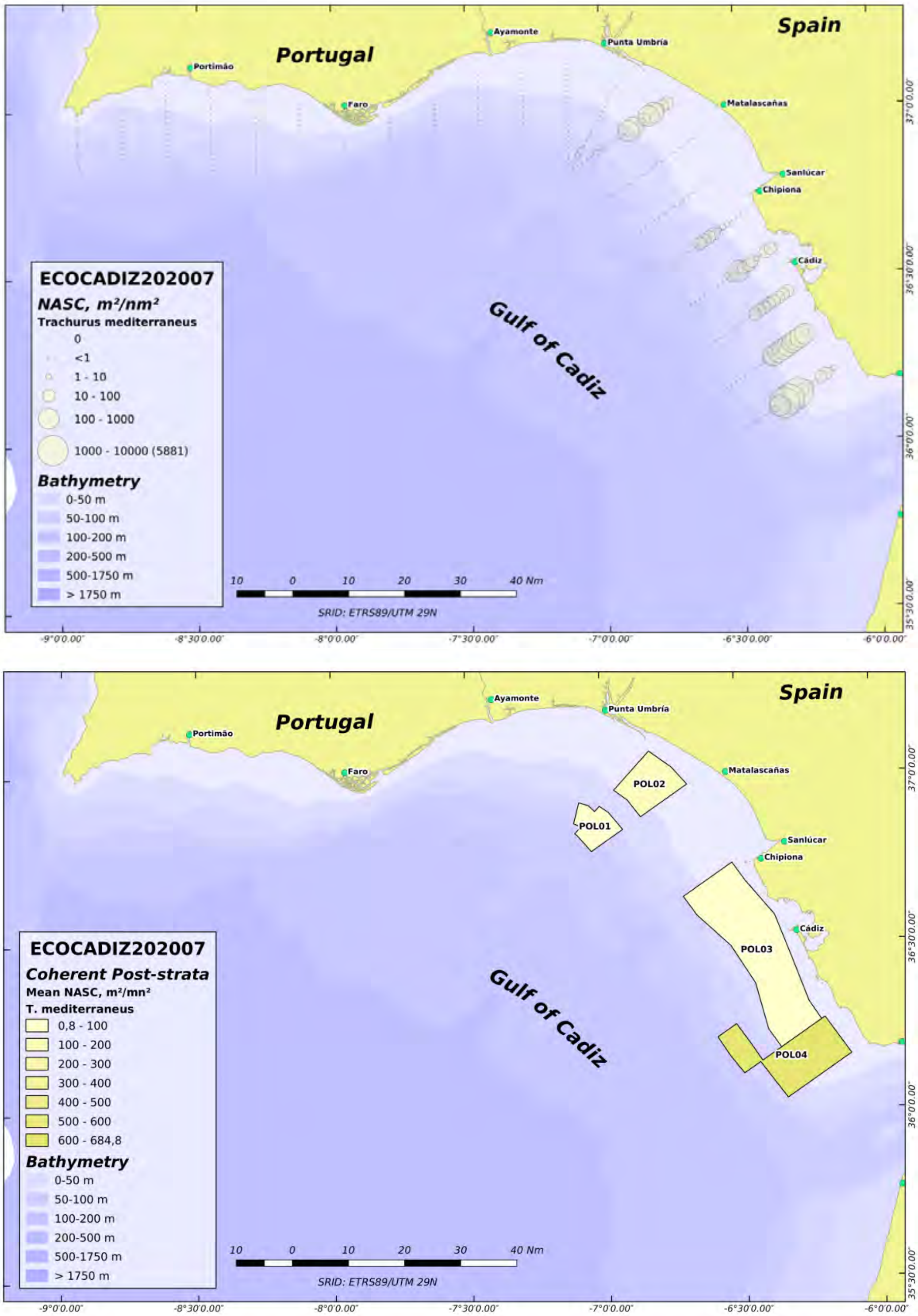


Figure 35. *ECOCADIZ 2020-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2020-07*: Mediterranean horse mackerel (*T. mediterraneus*)**

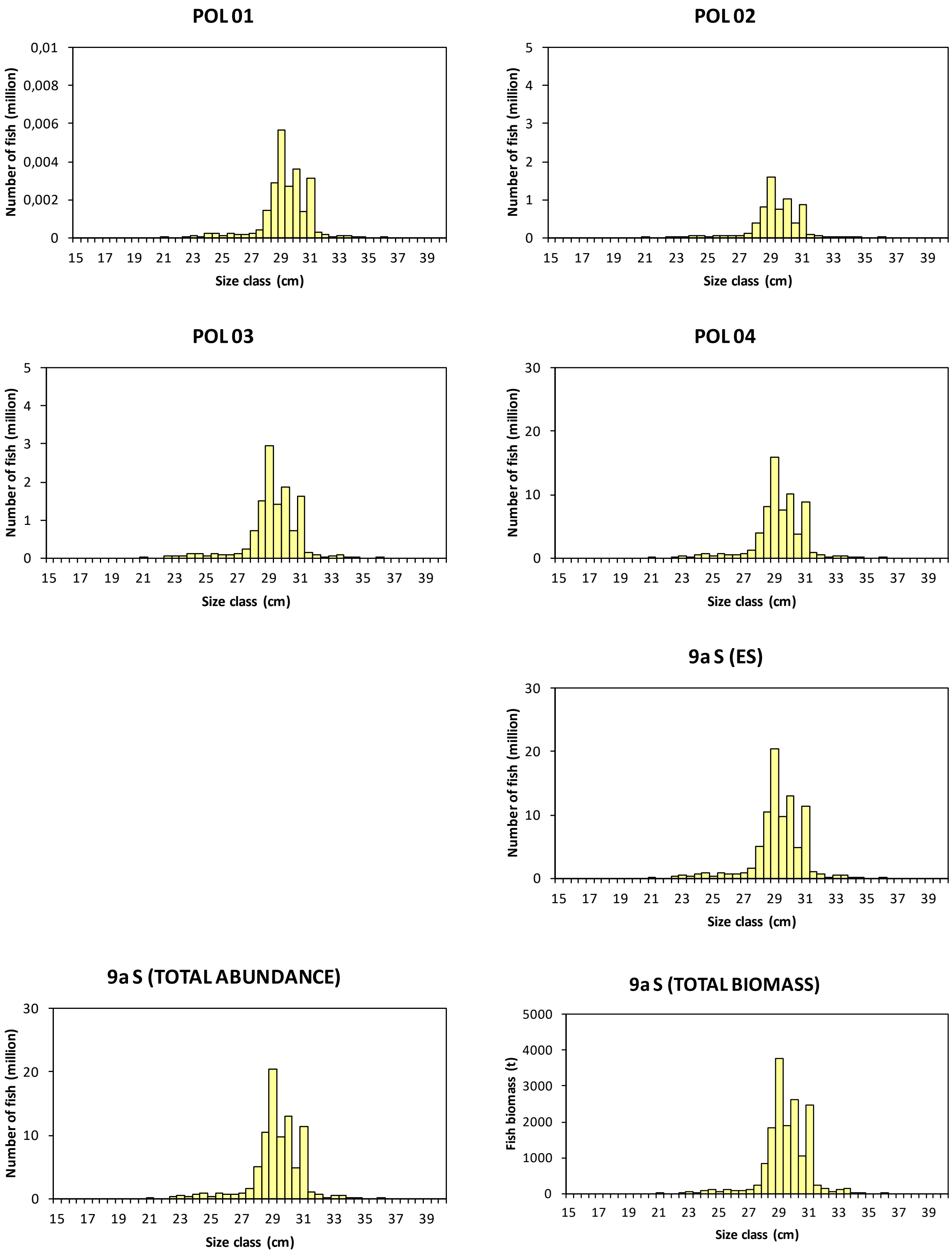


Figure 36. *ECOCADIZ 2020-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 35**) and total sampled area. Post-strata ordered in the W-E direction. 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.

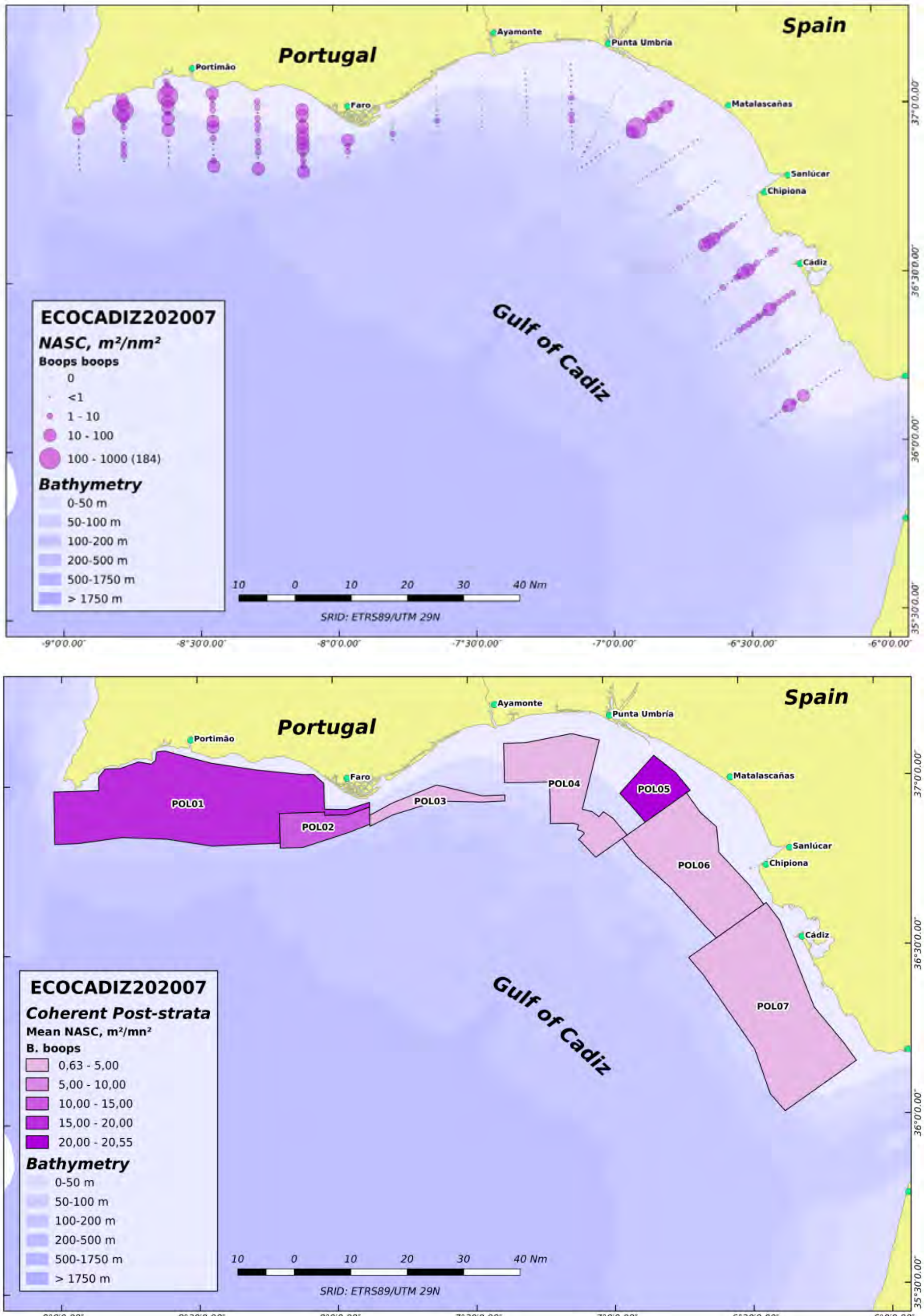


Figure 37. *ECOCADIZ 2020-07* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

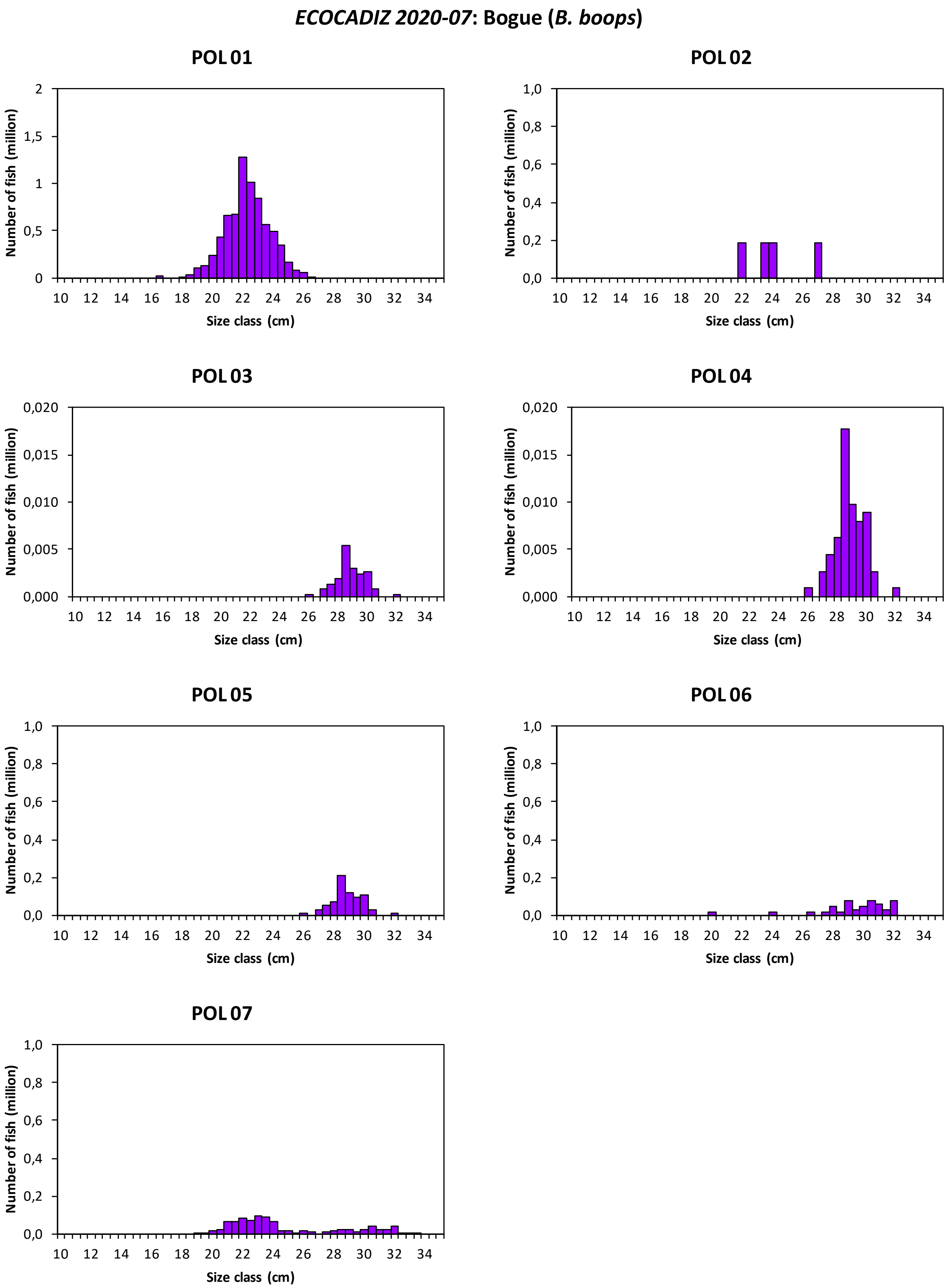


Figure 38. *ECOCADIZ 2020-07* survey. Bogue (*Boops boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 37**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

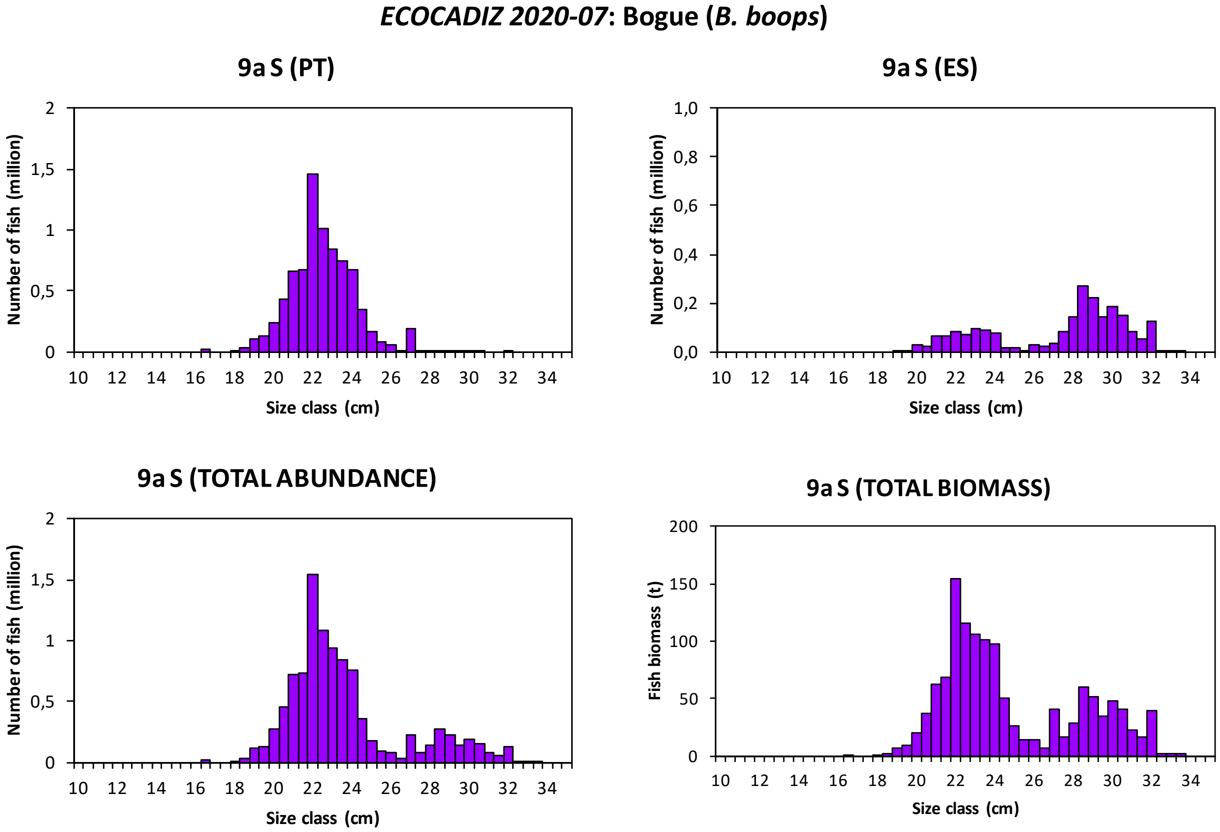


Figure 38. *ECOCADIZ 2020-07* survey. Bogue (*Boops boops*). Cont´d.

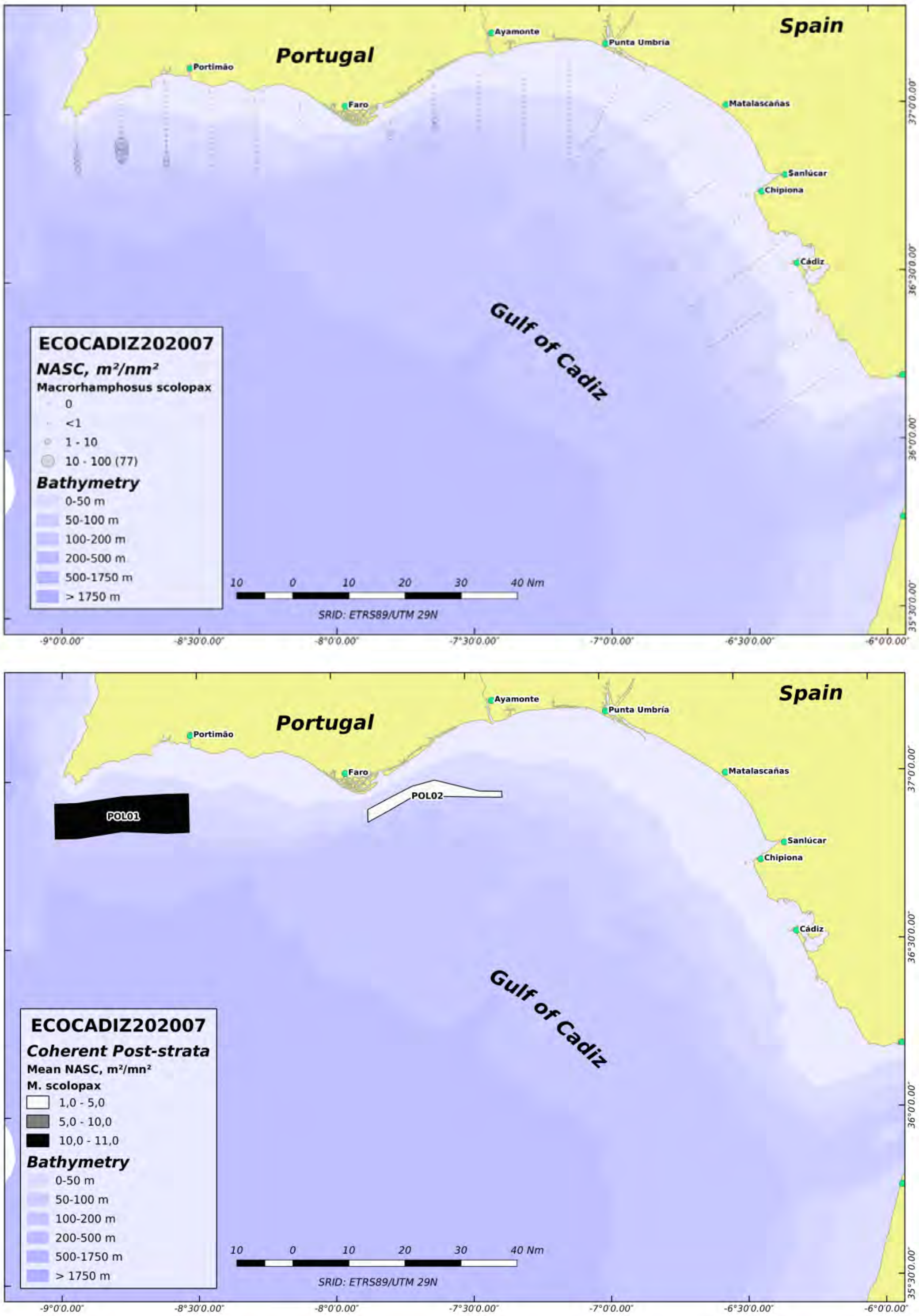


Figure 39. *ECOCADIZ 2020-07* survey. Longspine snipefish (*Macroramphosus scolopax*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

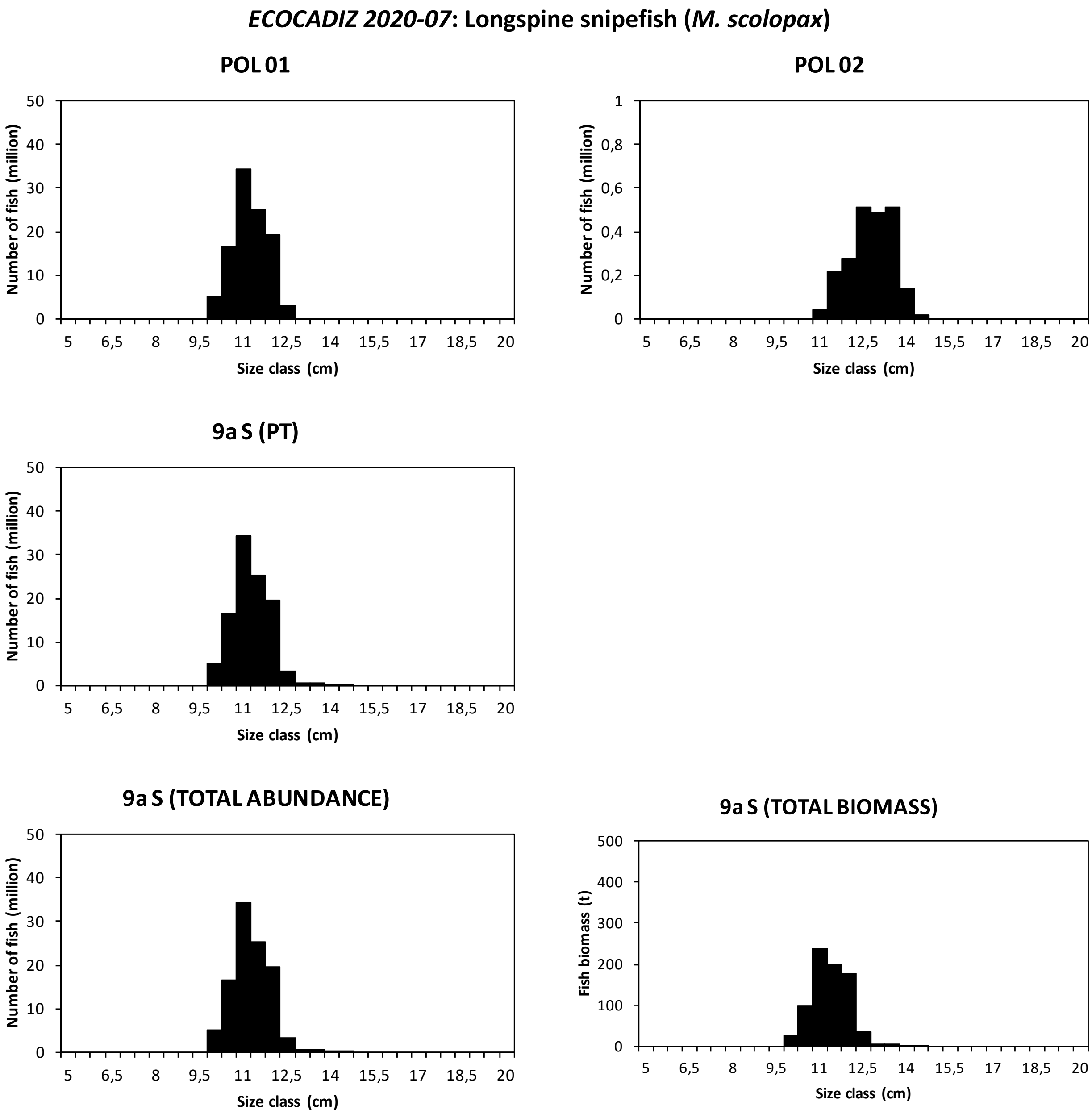


Figure 40. *ECOCADIZ 2020-07* survey. Longspine snipefish (*Macroramphosus scolopax*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 39**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

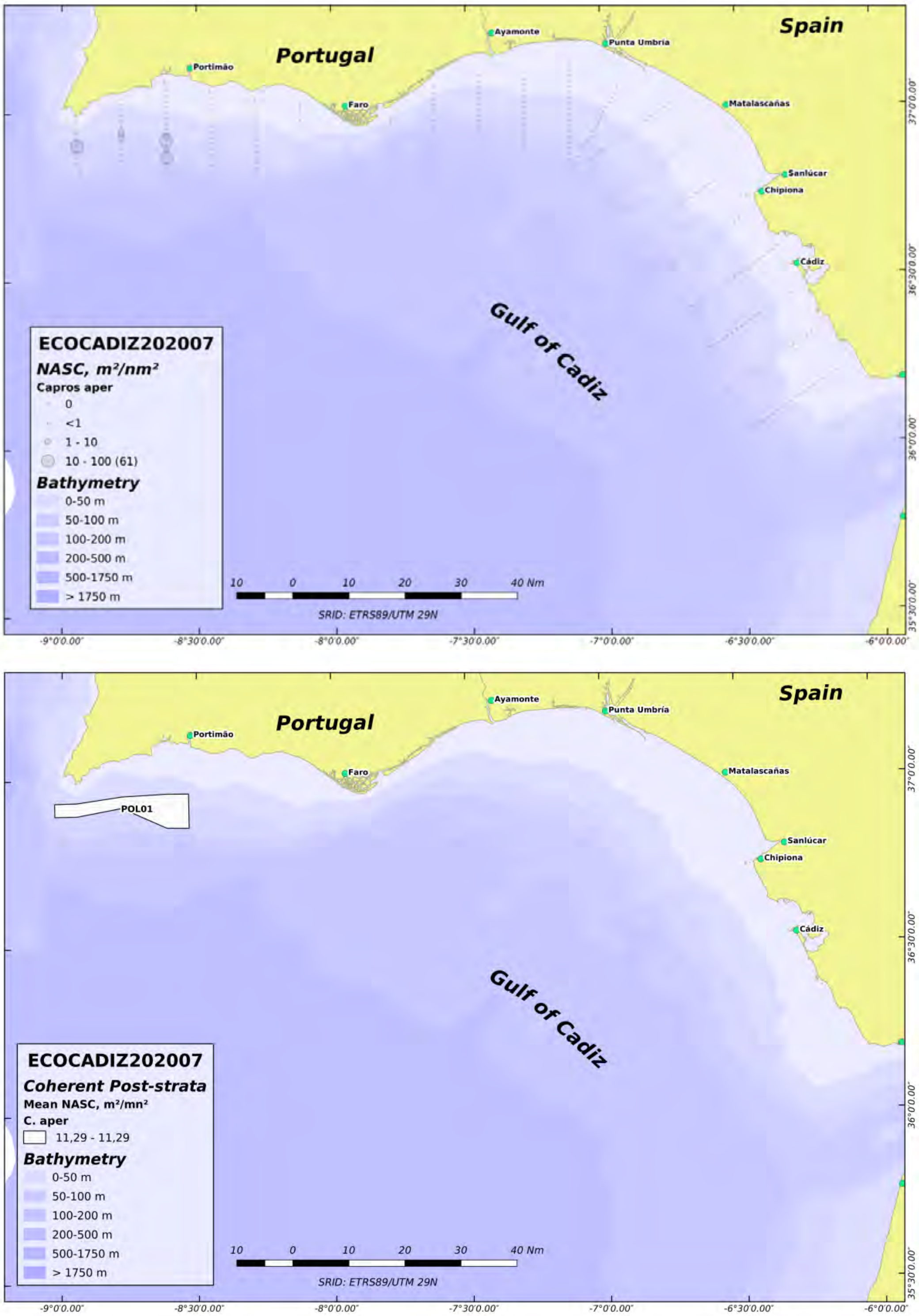


Figure 41. *ECOCADIZ 2020-07* survey. Boarfish (*Capros aper*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

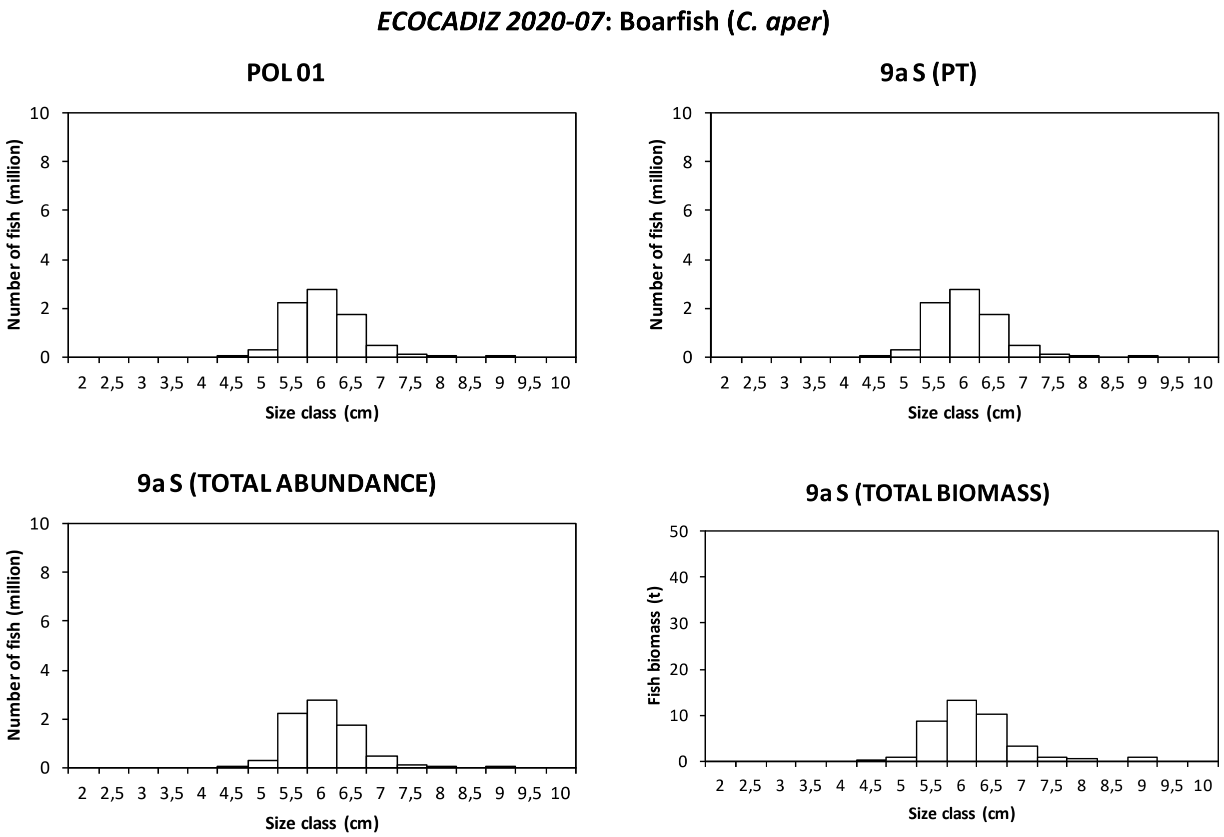


Figure 42. *ECOCADIZ 2020-07* survey. Boarfish (*Capros aper*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 41**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

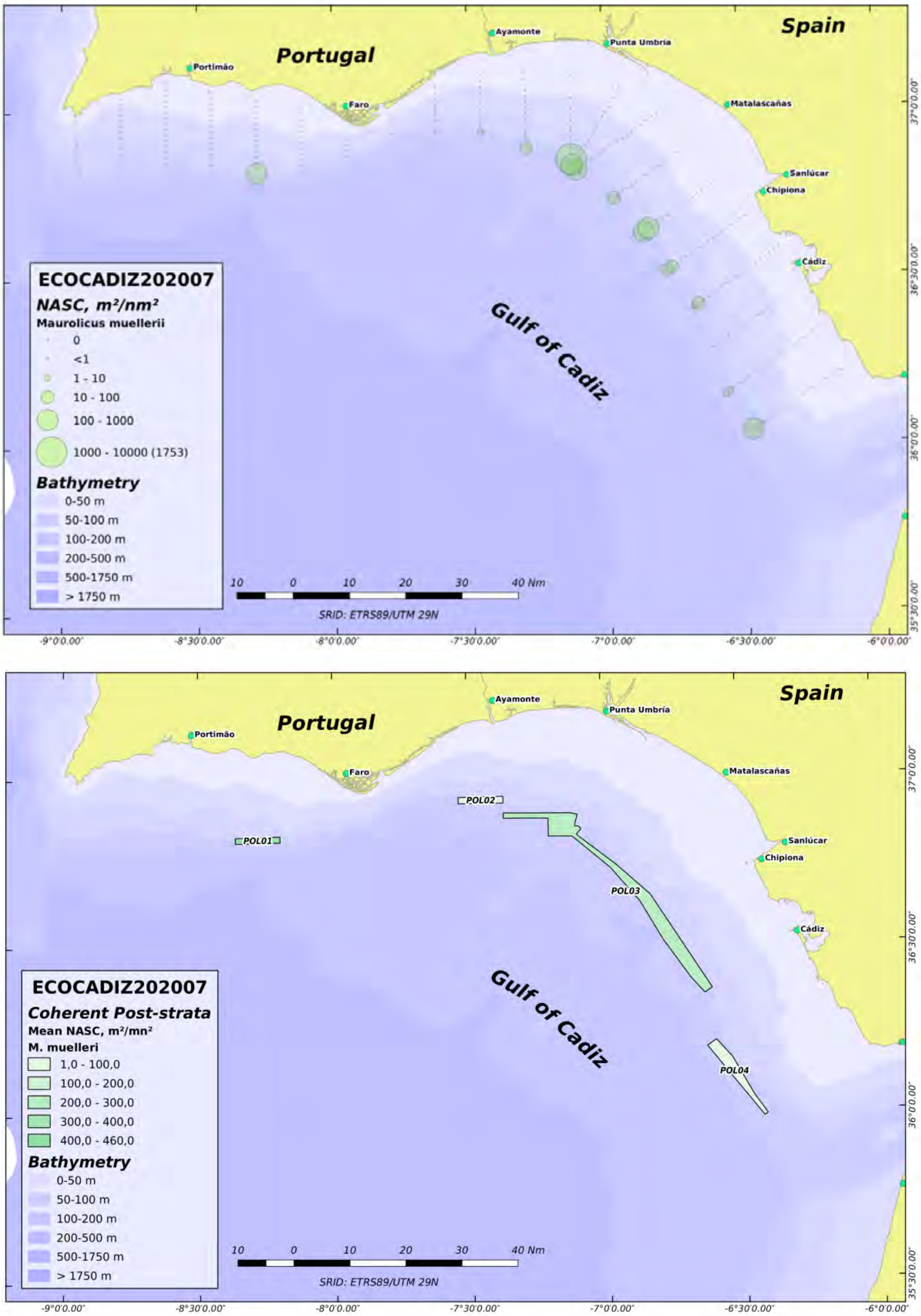


Figure 43. *ECOCADIZ 2020-07* survey. Pearlside (*Maurolicus muelleri*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2020-07*: Pearlside (*M. muelleri*)**

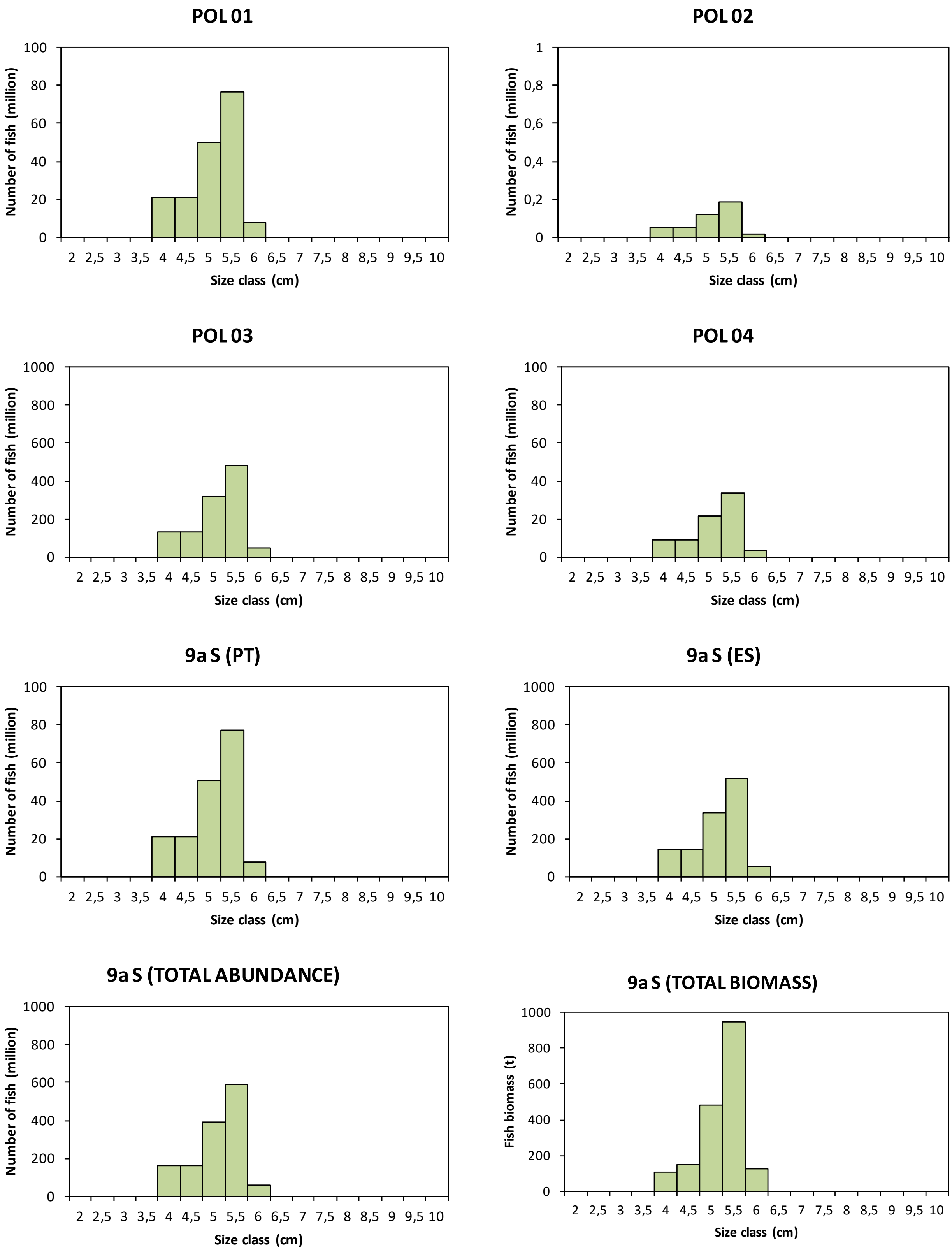
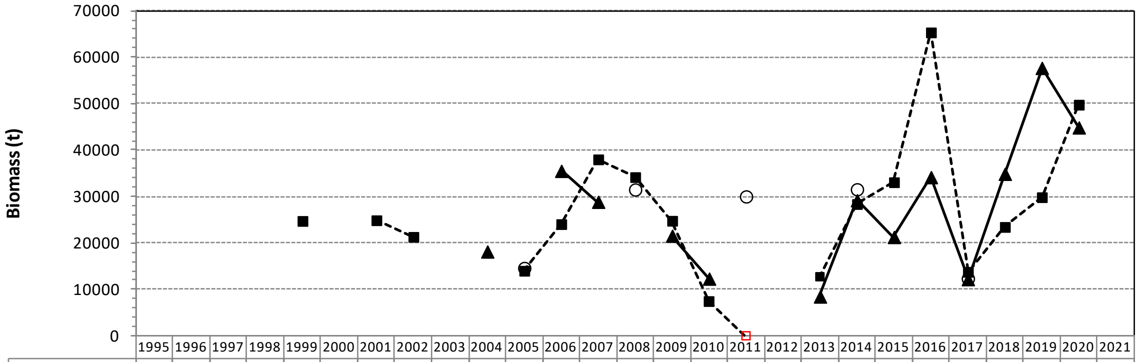


Figure 44. *ECOCADIZ 2020-07* survey. Pearlside (*Maurolicus muelleri*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 43**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

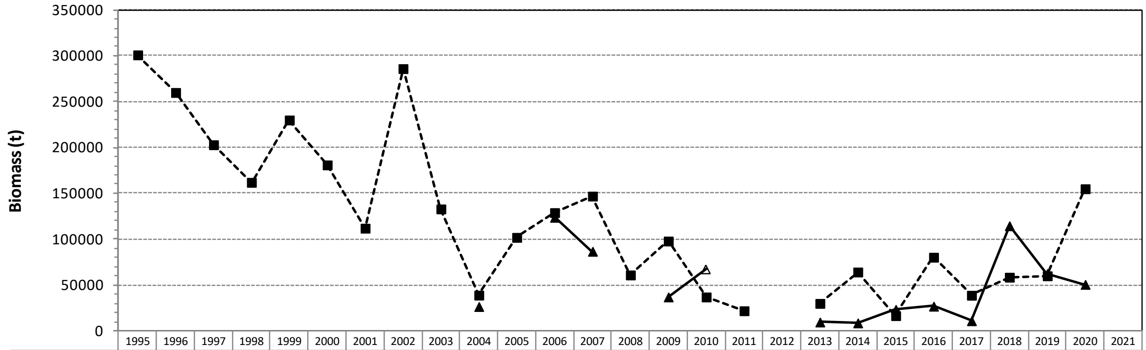
Biomass trends (in tons)

Anchovy biomass estimates



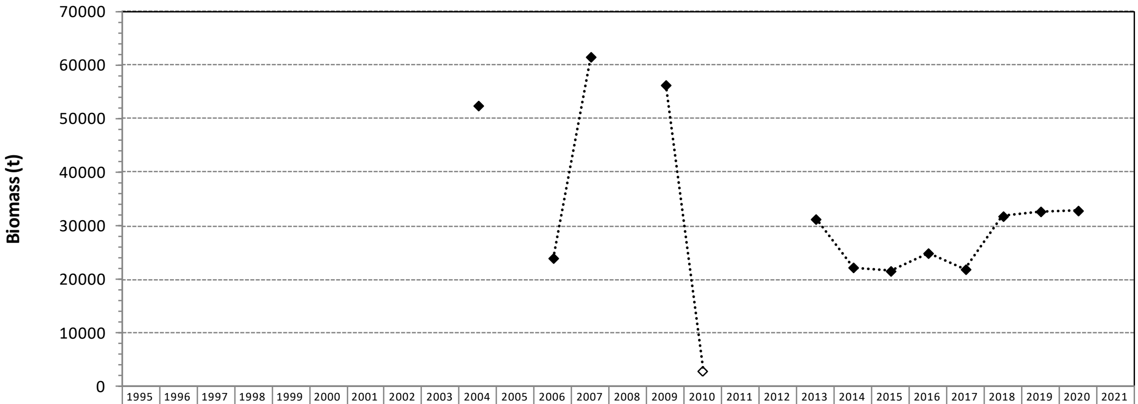
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PELAGO					24763		24913	21335			14041	24082	38020	34200	24800	7395	0		12700	28408	33100	65345	13797	23473	29876	49787	
ECOCADIZ										18177		35539	28882		21580	12339			8487	29219	21305	34184	12229	34908	57700	44887	
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	2019	2020	2021
PELAGO	301000	260000	203000	162000	230000	181000	112000	286000	133000	39000	102000	129000	147000	61000	98000	37000	22000		30000	64227	16663	80356	38873	58561	60088	155017	
ECOCADIZ										26568		123849	86777		37020	66964			9670	8697	23460	26919	11053	114631	62682	50721	

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	2020	2021
ECOCADIZ										52440		23994	61530		56276	2861			31267	22258	21593	24918	21918	31811	32696	32854	

Figure 45. 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, Anchovy and Sardine (WGHANSA). On-line meeting, 24-28 May 2021.

Acoustic assessment and distribution of the main pelagic fish species in ICES Subdivision 9a South during the *ECOCADIZ-RECLUTAS 2020-10* Spanish survey (October 2020).

By

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(2) IEO, Centro Oceanográfico Costero de las Islas Baleares.
(3) IEO, Centro Oceanográfico Costero de Santander.
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ABSTRACT

The present working document summarises the main results obtained from the *ECOCADIZ-RECLUTAS 2020-10* Spanish (pelagic ecosystem-) acoustic-trawl survey conducted by IEO between 02nd and 21st October 2020 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz (GoC) 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 GoC recruitment areas. The 21 foreseen acoustic transects were sampled. A total of 22 valid fishing hauls were carried out for echo-trace ground-truthing purposes. Chub mackerel, anchovy, mackerel and sardine were the most frequent captured species in the fishing hauls, followed by bogue, horse mackerel, Mediterranean horse mackerel and blue jack mackerel. Boarfish, longspine snipefish and pearlside showed an incidental occurrence in the hauls performed in the surveyed area. Sardine, anchovy, chub mackerel and mackerel showed the highest yields. Total and regional estimates of total NASC allocated to the "pelagic fish species assemblage" in this survey become the historical records in their time-series. Such estimates are the result of the relatively high acoustic contributions of sardine (both in Portuguese and Spanish waters), anchovy (in Spanish waters), and chub mackerel (in Portuguese waters). GoC anchovy was widely distributed in the surveyed area, although higher densities were recorded between east of Cape Santa Maria and Bay of Cadiz. Anchovy acoustic estimates in autumn 2020, 36 070 t and 3197 million fish, showed a decrease in relation to the historical peak recorded the last year, but they were either close (abundance) or even higher (biomass) than the time-series average. The population was composed by fishes not older than 3 years. As usual, the bulk of the population, including juveniles, was located in Spanish waters. Age-0 anchovies accounted for 75% (2385 million) and 58% (21 060 t) of the total estimated abundance and biomass, respectively. Age-0 estimates experienced a similar decreasing trend than the one showed by the whole population in relation to the historical peak recorded the year before, but with values close to the time-series average. GoC sardine experienced a huge increase in autumn 2020, rising up to its time-series maximum and yielding 208 400 t and 5451 million fish, with similar regional contributions to the population and with the juveniles being located in the Spanish coastal waters. Age-6 group was the oldest age group in the population, although the occurrence of fishes older than 4 years was incidental. The population was mainly composed by fishes belonging to the age-0 to age-2 groups. Juvenile sardines (age-0 group) were the dominant group, accounting for 45% and 24% of the total abundance (2454 million) and biomass (49 259 t), respectively. This age-group also recorded its historical maximum in 2020. Chub mackerel estimates were of 22 918 t and 295 million fish, representing a slight decrease compared with the last year, but still above the time-series average. The population was composed by fishes not older than 3 years, with the age-1 group being the dominant one (73%, 216 million, and 75%, 17 082 t, of the total abundance and biomass). Age-0 fish was the second most important age group in the estimated population (17%, 51 million fish, and 12%, 2759 t, of the total abundance and biomass estimates). The bulk of the age-0 (73%) and age-1 groups (74%) was recorded in the Portuguese waters.

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 2020-10* survey (the sixth within its series), 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 2020-10* survey was conducted between 2nd and 21st October 2020 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 3rd and 6th October in the Bay of Algeciras following the 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 Small Pelagic Fish in NE Atlantic* (WGACEGG; ICES, 2006a,b).

Fishing hauls 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* trawl sonar, a *Marport™ Narrow Band Trawl Eye* and *Scanmar™*

trawl door sensors for inter-doors distance and depth. 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.

Given a shortage of personnel due to COVID-19 protocols the individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine and chub mackerel only. Otoliths were extracted from these three species.

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.

No continuous recording of SST, SSS and *in-vivo* fluorescence was possible to be carried out during the acoustic tracking because the thermosalinograph was under repair. Vertical profiles of hydrographical variables were also recorded by night from 178 $CTDO_2$ casts over 23 transects 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.

A detailed description of protocols and methods followed in this survey series is reported in Doray *et al*. (2021).

RESULTS

Acoustic sampling

The acoustic sampling was restricted to the period comprised between 8th and 19th 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 Spanish Navy and Army exercises during the survey, which occupied all the Spanish shelf waters. The sampling experienced several "jumps" looking for space-time opportunity windows for the acoustic surveying trying to avoid such military exercises. Thus, the order and/or direction of the realization of the acoustic transects had to be modified on 10th, 12th, 13th, 14th and 18th October. The acoustic sampling was partially interrupted on 12th-13th October in order to satisfy the R/V's refueling and provisioning needs. The arrival of the tropical storm Barbara to the Gulf during the survey's last days (19th-20th October) caused a poor weather and rough sea, entailing losses of the acoustic signal which led to the repetition of the transect RA09 by changing the sailing direction over the transect. In order to perform the acoustic sampling with daylight, the acoustic sampling started at 06:40-06:45 UTC, although this time might vary depending on the duration of the works related with the hydrographic sampling the previous night.

Groundtruthing hauls

A total of twenty two (22) fishing operations for echo-trace ground-truthing (all of them were valid according to a correct gear performance and resulting catches), were carried out during the survey (**Table 2**, **Figure 3**). Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls 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. Five hauls were performed over a determined isobath instead of being conducted over the acoustic transect. According to the above, the sampled depth range in the valid hauls oscillated between 33 and 188 m.

During the survey were captured 2 Chondrichthyan, 35 Osteichthyes, 3 Cephalopod, 2 Echinoderm, and several Cnidarian species. The percentage of occurrence of the more frequent fish species (chondricthyans 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 chub mackerel (86% presence index), anchovy (73%), mackerel (68%) and sardine (64%) were the most frequent species in the valid hauls, followed by bogue (36%), horse mackerel (32%), Mediterranean horse mackerel (23%) and blue jack mackerel (18%). Boarfish, longspine snipefish and pearlside showed an incidental occurrence in the hauls performed in the surveyed area. Round sardinella and blue whiting were absent in the catches.

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, bogue, 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 19 866 kg and 458 thousand fish (**Table 3**). Fifty three per cent (53%) of this "total" fished biomass corresponded to sardine, 17% to chub mackerel, 12% to anchovy, 11% to mackerel, 4% to horse mackerel, and contributions lower than 1% for the remaining species. The most abundant species in ground-truthing trawl hauls was sardine (46%), followed by anchovy (34%), chub mackerel and mackerel (9% and 8%, respectively), and horse mackerel (3%), with each of the remaining species accounting for equal to or less than 1%.

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

Species	OCCURRENCE (Number of valid hauls)	OCCURRENCE (% over Total valid hauls)	Total weight (Kg)	Total number
Scomber colias	19	86,36 %	3437,167	39632
Engraulis encrasicolus	16	72,73 %	2336,636	154483
Scomber scombrus	15	68,18 %	2148,937	38041
Sardina pilchardus	14	63,64 %	10605,051	209268
Merluccius merluccius	13	59,09 %	8,143	58
Boops boops	8	36,36 %	37,454	397
Trachurus trachurus	7	31,82 %	765,933	12967
Spondyliosoma cantharus	6	27,27 %	66,381	560
Mola mola	6	27,27 %	71,955	27
Trachurus mediterraneus	5	22,73 %	163,134	766
Diplodus vulgaris	5	22,73 %	94,929	648
Trachurus picturatus	4	18,18 %	56,546	706
Pagellus bellottii bellottii	4	18,18 %	2,565	25
Pagellus erythrinus	3	13,64 %	10,790	66
Diplodus bellottii	3	13,64 %	11,670	267
Spicara flexuosa	3	13,64 %	0,860	30
Macroramphosus scolopax	2	9,09 %	3,249	196
Pagellus acarne	2	9,09 %	2,417	12
Sarda sarda	2	9,09 %	3,110	2
Stromateus fiatola	2	9,09 %	1,720	4
Maurolicus muelleri	1	4,55 %	0,044	43
Zeus faber	1	4,55 %	1,520	1
Capros aper	1	4,55 %	0,030	5
Liza aurata	1	4,55 %	1,310	1
Remora brachyptera	1	4,55 %	0,010	1
Pomatomus saltatrix	1	4,55 %	0,295	1
Caranx rhonchus	1	4,55 %	16,830	34
Trachinotus ovatus	1	4,55 %	0,340	2
Pomadasys incisus	1	4,55 %	1,280	10
Diplodus annularis	1	4,55 %	0,075	2
Dentex gibbosus	1	4,55 %	2,770	1
Sparus aurata	1	4,55 %	0,430	1
Spicara maena	1	4,55 %	0,050	1
Xiphias gladius	1	4,55 %	8,715	1
Aphia minuta	1	4,55 %	0,001	3

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

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	PIL	ANE	MAC	VMA	HOM	HMM	JAA	BOG	BOC	SNS	MAV
TOTAL AREA	229241	131553	45404	7453	32558	2395	1673	281	146	0	4	7774
%	100	57,4	19,8	3,3	14,2	1,0	0,7	0,1	0,1	0,0001	0,002	3,4
Portugal	99332	57999	2832	7428	22115	1419	0	240	50	0	4	7245
%	43,3	44,1	6,2	99,7	67,9	59,2	0	85,5	34,5	100	100	93,2
Spain	129909	73555	42572	25	10443	976	1673	41	95	0	0	529
%	56,7	55,9	93,8	0,3	32,1	40,8	100	14,5	65,5	0	0	6,8

For this "pelagic fish assemblage" has been estimated a total of 229 241 m^2 nmi^{-2}, the maximum value recorded throughout the time-series. The highest NASC value (13 108 m^2 nmi^{-2}) was recorded in the inner-shelf waters (40 m) in front of Quarteira (transect R16, **Figure 5**), although very close values were also recorded in the inner- and mid-shelf waters (32-69 m depth) of transects R08, R111, R13, R16 and R20. By species, sardine accounted for 57% of this total back-scattered energy, followed by anchovy (20%) and chub mackerel (14%), and the remaining species with relative contributions of acoustic energies lower than 4%.

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, 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 class are given in **Table 5** and **Figure 8**. **Figure 9** shows the acoustic estimates by age group. **Table 6** shows the time-series of estimates for the whole population and Age-0 fish.

Gulf of Cadiz anchovy (20% of the total NASC attributed to fish) was widely distributed in the surveyed area, although higher densities were recorded between east of Cape Santa Maria and Bay of Cadiz (**Figure 7**).

Eight (8) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the representative fishing hauls (**Figure 7**). Overall anchovy acoustic estimates in autumn 2020 were of 3197 million fish and 36 070 tones (**Table 5**; **Figure 8**), entailing 42% and 25% decreases in abundance and biomass, respectively, in relation to the last year's estimates (5518 million, 48 398 t). Notwithstanding the above, the current overall estimates are either close (abundance) or above (biomass) the time-series average (i.e. 3270 million; 23 538 t), (see **Table 6** and **Figure 42**). By geographical strata, the

Spanish waters yielded 95% (3051 million) and 91% (32 780 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 145 million and 3290 t (**Table 5; Figure 8**).

The size class range of the assessed anchovy population in autumn 2020 varied between the 7.5 and 17.5 cm size classes, with two modal classes, the main mode at 9.5 cm and a secondary mode at 13.5 cm. The size composition of anchovy throughout the surveyed area confirms the usual pattern exhibited by the species during the survey 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 (**Figures 6** and **8**).

The population was composed by fishes not older than 3 years. Age 0 fish accounted for 75% (2385 million) and 58% (21 060 t) of the total estimated abundance and biomass, respectively (**Table 6**; **Figure 9**). Spanish waters concentrated the bulk (99%) of this juvenile fraction. The estimates of age-0 fish experienced a similar decreasing trend than the one showed by the whole population in relation to the historical peak recorded the year before, but with values close to the time-series average (**Table 6**). Age 1 fish represented 24% and 40% of the total abundance and biomass (**Figure 9**).

The 2020 autumn estimates of mean size and weight of the whole population (11.9 cm, 11.3 g) were somewhat higher than their respective time-series averages (11.2 cm, 9.2 g).

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 post-strata considered for the acoustic estimation are shown in **Figure 11**. Estimated abundance and biomass by size class are given in **Table 7** and **Figure 12**. **Figure 13** shows the acoustic estimates by age group. **Table 8** shows the time-series of estimates for the whole population and Age-0 fish. No age data are available for the 2020 survey.

GoC sardine recorded a relatively high acoustic echo-integration in autumn 2020 (57% of the total NASC attributed to pelagic fish species assemblage), as a consequence of the occurrence of dense mid-water schools in the coastal fringe of the Spanish central waters of the Gulf (30-63 m depth) and Algarve waters (32-86 m), (**Figure 11**). Sardine was widely distributed all over the surveyed area (avoiding both western- and easternmost waters) and, as a consequence of the abovementioned occurrence of dense schools in coastal waters, with very high densities in the inner-middle shelf waters.

Six (6) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing hauls (**Figure 11**). GoC sardine abundance and biomass in autumn 2020 were estimated at 5451 million fish and 208 400 t, the historical record within its series, as a result of huge increases in abundance and biomass in relation to the last year's estimates (937 million and 36 465 t; **Table 7**, **Figure 12**). Spanish waters concentrated 63% and 49% of the total estimated abundance and biomass, respectively (3445 million and 102 607 t), values that lead to infer the occurrence of the smallest sardines in these waters. The estimates for the Portuguese waters were 2006 million and 105 783 t.

Sizes of the assessed sardine population in autumn 2020 ranged between 10.0 and 22.0 cm size classes. The length frequency distribution of the population was clearly bimodal, with one main mode at 18.0 cm size class and a secondary one at 11.0 cm (**Table 7**; **Figure 12**).

Age-6 group was the oldest age group occurring in the population, although the occurrence of fishes older than 4 years was incidental. The population was mainly composed by fishes belonging to the age-0 to age-2 groups. Juvenile sardines (age-0 group) were the dominant group, accounting for 45% and 24% of the total abundance (2454 million) and biomass (49 259 t), respectively. The bulk of the juvenile fraction (90% of the juvenile total abundance) was recorded in Spanish waters, especially in the relatively shallow waters along the coastal fringe comprised between Matalascañas and the Bay of Cadiz (**Table 8**; **Figures 10** and **13**).

The 2020 autumn estimates of mean length and weight of the whole population (15.9 cm, 38.2 g), are both at the same level that the last year's estimates and are very close to the time-series averages (i.e. 15.6 cm, 37.3 g).

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 post-strata considered for the acoustic estimation are shown in **Figure 15**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 16**.

Atlantic mackerel (3% of the total NASC) showed a main density nucleus in the westernmost Algarve, showing an incidental occurrence in the central zone of the surveyed area (**Figure 15**).

The size range recorded in positive hauls was comprised between 18.5 and 34.5 cm size classes, with a dominant mode at 20.0 cm size class (mainly supported by fish from the Algarve waters) and a secondary mode at 27.5 cm (typical from the Spanish waters), (**Figure 14**).

Two (2) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing stations (**Figure 15**). Mackerel abundance and biomass in autumn 2020 in the GoC shelf waters were estimated at 3469 million fish and 193 870 t (**Table 9**; **Figure 16**). Almost the whole estimated population (99.8% of the total abundance) was located in Portuguese waters (3464 million, 193 008 t). The estimates for the Spanish waters were 5 million and 863 t.

The size range of the estimated population in autumn 2020 varied between 18.5 and 34.5 cm size classes. The size composition was clearly bimodal: the main mode was placed at 20.5 cm size class and the secondary one at 27.5 cm size class (**Table 9**; **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 post-strata considered for the acoustic estimation are shown in **Figure 18**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 19**. **Figure 20** shows the acoustic estimates by age group. **Table 11** shows the time-series of estimates for the whole population and Age-0 fish.

Chub mackerel (14% of the total NASC) was widely distributed in the surveyed area, but showing higher densities between Cape San Vicente and Mazagón (**Figure 18**). The species' positive hauls did not show a clear spatial pattern in (mean) size. However, the smallest fish were recorded in the inner-middle shelf waters between Matalascañas and the Bay of Cadiz (**Table 10**; **Figures 17** and **19**).

Seven (7) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing stations (**Figure 18**). Chub mackerel abundance and biomass in the surveyed area were estimated in 295 million fish and 22 918 t (**Table 10**, **Figure 19**). Portuguese waters accounted for 73%

(216 million) and 72% (16 538 t) of the total abundance and biomass, respectively. Spanish waters yielded a population of 79 million and 6381 t.

The size range recorded for the estimated population was comprised between 17.5 and 36.5 cm size classes, with two equally represented modes at 20.0 and 22.0 cm size classes. A rather similar size composition is also recorded for the estimated biomass, although the mode at 22.0 cm dominates over the smaller mode (**Table 10**, **Figure 19**). Regional size compositions showed very similar shapes.

The population was composed by fishes not older than 3 years, with the age-1 group being the dominant one (73%, 216 million, and 75%, 17 082 t, of the total abundance and biomass estimated in the surveyed area, respectively; **Figure 20**). Age-0 fish was the second most important age group in the estimated population (17%, 51 million fish, and 12%, 2759 t, of the total abundance and biomass estimates). The bulk of the age-0 (73%) and age-1 groups (74%) was recorded in the Portuguese waters.

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 post-strata considered for the acoustic estimation are shown in **Figure 22**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 23**.

Horse mackerel (1% of the total NASC) showed a very scattered distribution, with main density nuclei in both extremes of the surveyed area and around Cape Santa Maria (**Figure 22**).

The size range recorded in positive hauls was comprised between 7.5 and 28.5 cm size classes, with a dominant mode at 18.5 cm size class and a secondary mode at 23.0 cm. Smaller fish were recorded in the Spanish waters (**Figure 21**).

Four (4) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing hauls (**Figure 22**). Horse mackerel abundance and biomass in the surveyed area were estimated in 29 million fish and 2061 t (**Table 12**, **Figure 23**). Portuguese waters accounted for 53% (15 million) and 63% (1307 t) of the total abundance and biomass, respectively. Spanish waters yielded a population of 13 million and 754 t.

The size range recorded for the estimated population was comprised between 14.5 and 28.5 cm size classes, with two distinct modes, the dominant one at 18.5 cm (almost exclusively recorded in Spanish waters) and a secondary mode at 23.0 cm size classes (mainly distributed in Portuguese waters; **Table 12**, **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 post-strata considered for the acoustic estimation are shown in **Figure 25**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 26**.

Mediterranean horse mackerel (1% of the total NASC) was a typically Spanish species in autumn 2020. The species distributed over the Spanish eastern and central waters, not further west than the Tinto-Odiel river mouth, mainly over the inner-mid shelf waters (**Figure 25**). The species showed a wide range of sizes in the positive hauls (5.5-46.5 cm size classes; modes at 29.0, 27.0 and 23.0 size classes in decreasing order of importance), with larger fish occurring in deeper hauls of the easternmost waters of the surveyed area (**Figure 24**).

Four (4) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing hauls (**Figure 25**). Mediterranean horse mackerel abundance and biomass in the surveyed area were estimated in 7 million fish and 1859 t, with the whole population located in Spanish waters, as usual (**Table 13**, **Figure 26**).

The size range recorded for the estimated population was extremely wide and comprised between 5.5 and 46.5 cm size classes, with at least one clearly distinct mode at 33.0 cm size class, and other secondary modes at 40.0 and 44.5 cm size classes. Largest fish occurred in the easternmost waters of the Spanish shelf, as previously evidenced by the positive hauls raw data (**Table 13**, **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 post-strata considered for the acoustic estimation are shown in **Figure 28**. Estimated abundance and biomass by size class are given in **Table 14** and **Figure 29**.

Blue jack mackerel (0.1% of the total NASC) showed very weak acoustic densities. It was restricted almost exclusively to eastern Algarve shelf waters, around Cape Santa Maria, and incidentally in the easternmost Spanish waters (**Figure 28**). The overall size class in positive hauls ranged between 18.5 and 33.5 cm (mode at 20.0 cm size class). Smaller fish were mainly recorded in the Algarve waters (**Figure 27**).

Three (3) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing hauls (**Figure 28**). Blue Jack mackerel abundance and biomass in the surveyed area were estimated in 3 million fish and 233 t (**Table 14**, **Figure 29**). Portuguese waters accounted for 90% (2.6 million) and 82% (190 t) of the total abundance and biomass, respectively. Spanish waters yielded a population of 0.3 million and 43 t.

The size range recorded for the estimated population was comprised between 18.5 and 33.5 cm size classes, with two modes, the dominant one at 20.5 cm and a secondary mode at 25.0 cm size class. As evidenced by positive hauls, the smallest fish occurred in Portuguese waters (**Table 12**, **Figure 23**).

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 post-strata considered for the acoustic estimation are shown in **Figure 31**. Estimated abundance and biomass by size class are given in **Table 15** and **Figure 32**.

Bogue (0.1% of the total NASC) showed a scattered distribution, showing relatively low acoustic densities (**Figure 31**). Although smaller fish seems to occur in the easternmost waters, no clear spatial pattern in size was clearly detected in the surveyed area (**Figure 30**). The overall size range in positive hauls was comprised between 15.5 and 31.5 size classes (mode at 21.5 cm size class).

Five (5) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the representative fishing hauls (**Figure 31**). Bogue abundance and biomass in the surveyed area were estimated in about 1 million fish and 99 t (**Table 15**, **Figure 32**). Spanish waters accounted for

70% of both total abundance (0.6 million) and biomass (69 t), respectively. Portuguese waters yielded a population of 0.3 million and 30 t.

The size range recorded for the estimated population was comprised between 15.5 and 31.5 cm size classes, with two modes, the dominant one at 21.5 cm and a secondary mode at 23.0 cm size class (**Table 15**, **Figure 32**).

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 33**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent post-strata considered for the acoustic estimation are shown in **Figure 34**. Estimated abundance and biomass by size class are given in **Table 16** and **Figure 35**.

The occurrence of boarfish (0.0001%) was incidental and restricted to the outer shelf waters around Cape Santa Maria, co-occurring with longspine snipefish (**Figure 34**). The size range recorded in the only positive haul was comprised between 6.0 and 7.0 cm size classes, without any differentiated mode (**Figure 33**).

One (1) coherent post-stratum has been differentiated according to the S_A value distribution and the size composition in the representative fishing hauls (**Figure 31**). Boarfish abundance and biomass in the surveyed area were estimated in 0.02 million fish and 0.1 t, with the whole population being restricted to the Portuguese waters (**Table 16**, **Figure 35**).

The size range recorded for the estimated population was comprised between 6.0 and 7.0 cm size classes, with a single, but not clearly distinguishable mode, either at 6.0 or 6.5 cm size classes (**Table 16**, **Figure 35**).

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 36**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent post-strata considered for the acoustic estimation are shown in **Figure 37**. Estimated abundance and biomass by size class are given in **Table 17** and **Figure 38**.

Longspine snipefish (0.002%) showed relatively low acoustic densities, which were restricted to the eastern Algarve waters (**Figure 37**). The species showed a concurrent distribution with boarfish. The size range recorded in the positive hauls was comprised between 11.0 and 17.0 cm size classes, with a mode at 14 cm size class (**Figure 36**).

One (1) coherent post-stratum has been differentiated according to the S_A value distribution and the size composition in the representative fishing hauls (**Figure 37**). Longspine snipefish abundance and biomass in the surveyed area were estimated in 1 million fish and 24 t, with the whole population being restricted to the Portuguese waters (**Table 17**, **Figure 38**).

The size range recorded for the estimated population was comprised between 11.5 and 17.0 cm size classes, with a single mode at 14.0 cm size class (**Table 17**, **Figure 38**).

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 39**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent post-strata considered for the acoustic estimation are shown in **Figure 40**. Estimated abundance and biomass by size class are given in **Table 18** and **Figure 41**.

Pearlside (3%) was relatively common over the shelf break, especially in the western Algarve waters (**Figure 40**). The size range in the positive haul varied between 3.0 and 6.0 cm size class (mode at 4.5 cm size class; **Figure 39**).

Four (4) coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the representative fishing hauls (**Figure 40**). Pearlside abundance and biomass in the surveyed area were estimated in 3007 million fish and 3202 t. Portuguese waters accounted for 94% (2820 million, 3003 t) of both the total abundance and biomass, respectively. Spanish waters yielded a population of 187 million and 199 t. (**Table 16**, **Figure 35**).

The size range recorded for the estimated population was comprised between 3.0 and 6.0 cm size classes, with a dominant mode at 4.5 cm size class (**Table 18**, **Figure 41**).

(SHORT) DISCUSSION

The time series of anchovy, sardine and chub mackerel estimates from this survey series are described in **Tables 6**, **8** and **11** and **Figure 42**.

GoC anchovy population in autumn 2020 (3197 million fish, 36 070 t) experienced 42% and 25% decreases in abundance and biomass, respectively, in relation to the last year's autumn estimates (5518 million, 48 398 t; **Table 6**; **Figure 42**). Notwithstanding the above, the current overall estimates are still either close (abundance) or above (biomass) the time-series average (i.e. 3270 million; 23 538 t). Age-0 fish accounted for 75% (2385 million) and 58% (21 060 t) of the total estimated abundance and biomass, respectively. These juveniles were mainly concentrated in the Spanish waters as usual. The estimates of age-0 fish experienced a similar decreasing trend than the one showed by the whole population in relation to the historical peak recorded the year before, but with values close to the time-series average.

GoC sardine abundance (5451 million fish) and biomass (208 400 t) in autumn 2020 peaked at their historical maxima within its series, representing huge increases in abundance and biomass in relation to the last year's autumn estimates (937 million and 36 465 t; **Table 8**; **Figure 42**). Causes for such an increase should be investigated in detail. Interestingly, *PELAGO 20* estimated in spring 2020 6547 million fish and 155 017 t, whereas *ECOCADIZ 2020-07* estimated that summer only 1923 million fish (three times less than in *PELAGO*) and 50 721 t (five times less), suggesting changes in the availability of the species to the surveys or even possible movements between other northernmost sub-areas. Thus, *IBERAS 0920*, conducted one month before than *ECOCADIZ-RECLUTAS*, detected and estimated relatively high densities of sardine in the southernmost waters from the 9a Central-South subarea, a distribution pattern which could be also extended to the westernmost Algarve waters indicating some connectivity. The GoC sardine population was mainly composed by fishes belonging to the age-0 to age-2 groups and in a lesser extent by age-3 fish (incidental occurrence of 4 to 6 year old fishes). Juvenile sardines (age-0 group) were the dominant group, accounting for 45% and 24% of the total abundance (2454 million) and biomass (49 259 t), respectively. This age-group also recorded its historical maximum in 2020. The bulk of the juvenile fraction (90% of the juvenile total abundance) was recorded in Spanish shallow waters.

Chub mackerel abundance (295 million fish) and biomass (22 918 t) in autumn 2020 experienced 20% and 13% decreases respectively in relation to the estimates recorded the last year, although they still are above their respective time-series averages (i.e. 197 million, 14 001 t) (**Table 11**, **Figure 42**).

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Table 1. *ECOCADIZ-RECLUTAS 2020-10* 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	08/10/20	36º 12,890' N	6º 09,00' W	13:15	24	38º 02,0680' N	6º 28,9474' W	15:16	239
R02	Sancti-Petri	09/10/20	36º 19,330' N	6º 14,950' W	06:44	26	36º 08,907' N	6º 14,860' W	14:48	28
R03	Cádiz	13/10/20	36º 26,709' N	6º 19,021' W	13:52	24	36º 17,264' N	6º 36,390' W	15:37	187
R04	Rota	10/10/20	36º 34,735' N	6º 22,146' W	04:49	19	36º 27,739' N	6º 34,930' W	11:09	86
R05	Chipiona	10/10/20	36º 31,217' N	6º 46,299' W	13:45	196	36º 40,389' N	6º 29,462' W	17:36	21
R06	Doñana	11/10/20	36º 46,578' N	6º 35,806' W	06:41	21	36º 38,047' N	6º 51,507' W	09:52	195
R07	Matalascañas	11/10/20	36º 44,009' N	6º 58,357' W	10:47	200	36º 53,949' N	6º 39,976' W	14:30	19
R08	Mazagón	19/10/20	36º 49,401' N	7º 06,042' W	13:59	197	37º 01,111' N	6º 44,645' W	14:08	22
R09	Punta Umbría	19/10/20	36º 49,732' N	7º 06,459' W	08:29	192	37º 04,294' N	6º 56,138' W	10:16	22
R10	El Rompido	18/10/20	36º 50,087' N	7º 07,207' W	11:34	196	37º 07,993' N	7º 07,225' W	17:26	19
R11	Isla Cristina	18/10/20	37º 06,884' N	7º 17,218' W	06:48	21	36º 53,544' N	7º 17,105' W	09:58	188
R12	V.R. do Sto. Antonio	12/10/20	37º 06,457' N	7º 27,201' W	06:42	20	37º 56,277' N	7º 27,100' W	09:19	203
R13	Tavira	12/10/20	36º 57,094' N	7º 37,117' W	10:41	190	37º 05,207' N	7º 37,223' W	13:36	16
R14	Fuzeta	14/10/20	36º 59,133' N	7º 47,102' W	06:40	47	36º 55,4622' N	7º 47,020' W	7:03	197
R15	Cabo Sta. María	14/10/20	36º 55,879' N	7º 57,001' W	12:55	59	36º 52,142' N	7º 56,931' W	13:18	198
R16	Quarteira	15/10/20	37º 01,787' N	8º 06,961' W	06:45	18	36º 49,647' N	8º 06,811' W	11:10	231
R17	Albufeira	15/10/20	36º 49,451' N	8º 16,810' W	13:52	195	37º 01,820' N	8º 17,037' W	17:25	23
R18	Alfanzinha	16/10/20	37º 04,601' N	8º 27,000' W	06:41	19	36º 50,260' N	8º 26,742' W	09:29	200
R19	Portimao	16/10/20	36º 51,914' N	8º 36,743' W	10:52	150	37º 04,297' N	8º 37,0639' W	12:08	38
R20	Burgau	17/10/20	37º 02,564' N	8º 46,947' W	06:47	43	36º 51,954' N	8º 46,661' W	09:52	201
R21	Punta de Sagres	17/10/20	36º 59,601' N	8º 56,610' W	10:50	202	36º 59,166' N	8º 56,826' W	13:52	28

Table 2. *ECOCADIZ-RECLUTAS 2020-10* 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	09-10-2020	36º 15.6561 N	6º 21.6670 W	36º 16.8371 N	6º 19.5417 W	08:05	08:33	48,03	43,22	00:28	00:57	2,084	R02	Sancti-Petri
2	09-10-2020	36º 10.4557 N	6º 31.2778 W	36º 11.5843 N	6º 29.1892 W	11:44	12:12	116,31	104,48	00:28	01:13	2,032	R02	Sancti-Petri
3	10-10-2020	36º 30.6958 N	6º 29.6509 W	36º 32.0930 N	6º 27.1630 W	07:59	08:34	52,38	42,54	00:34	01:09	2,443	R04	Rota
4	10-10-2020	36º 28.7326 N	6º 32.8414 W	36º 27.2053 N	6º 35.8465 W	11:43	12:23	71,03	92,94	00:39	01:21	2,864	R04	Rota
5	10-10-2020	36º 34.1240 N	6º 40.6945 W	36º 32.5679 N	6º 43.5229 W	14:43	15:21	87,63	114,32	00:37	01:26	2,758	R05	Chipiona
6	11-10-2020	36º 42.3433 N	6º 43.4835 W	36º 43.7336 N	6º 41.2683 W	07:52	08:24	63,41	42,76	00:31	01:07	2,258	R06	Doñana
7	11-10-2020	36º 46.0157 N	6º 54.6393 W	36º 44.7045 N	6º 56.9161 W	11:40	12:10	107,62	128,05	00:30	01:16	2,250	R07	Matalascañas
8	11-10-2020	36º 52.1608 N	6º 43.6533 W	36º 50.7808 N	6º 46.1011 W	15:54	16:27	25,64	40,06	00:33	01:46	2,400	R07	Matalascañas
9	12-10-2020	37º 02.5066 N	7º 27.1986 W	37º 03.9725 N	7º 27.1390 W	07:39	07:59	79,3	54,21	00:20	01:01	1,465	R12	Vila R. do Sto Antonio
10	12-10-2020	37º 00.3793 N	7º 37.1516 W	36º 57.6279 N	7º 37.9578 W	11:28	12:09	94,21	156,81	00:41	01:30	2,823	R13	Tavira
11	14-10-2020	36º 56.8597 N	7º 47.6118 W	36º 57.4938 N	7º 45.6502 W	08:03	08:26	84,3	88,53	00:23	01:12	1,695	R14	Fuzeta
12	14-10-2020	36º 59.2888 N	7º 44.9026 W	36º 58.2829 N	7º 47.7953 W	11:08	11:42	72,11	68,23	00:34	01:20	2,526	R14	Fuzeta
13	15-10-2020	36º 58.0247 N	8º 08.4612 W	36º 56.7755 N	8º 06.0614 W	08:37	09:08	42,77	44,09	00:31	01:08	2,293	R16	Quarteira
14	15-10-2020	36º 52.3596 N	8º 06.7448 W	36º 54.7944 N	8º 06.9393 W	11:43	12:16	100,89	64,09	00:33	01:15	2,437	R16	Quarteira
15	15-10-2020	36º 50.1007 N	8º 16.9764 W	36º 49.7740 N	8º 19.0655 W	14:54	15:17	122,97	166,09	00:23	01:17	1,709	R17	Albufeira
16	16-10-2020	36º 54.1264 N	8º 26.7725 W	36º 56.6928 N	8º 26.7991 W	08:07	08:42	115,3	91,23	00:34	01:18	2,563	R18	Alfanzina
17	16-10-2020	37º 02.9482 N	8º 38.2395 W	37º 03.4007 N	8º 36.4118 W	14:04	14:24	41,9	41,57	00:20	00:58	1,531	R19	Portimao
18	17-10-2020	36º 54.0899 N	8º 46.5827 W	36º 56.6435 N	8º 46.7312 W	08:08	08:44	105,88	107,43	00:35	01:24	2,553	R20	Burgau
19	17-10-2020	36º 55.1512 N	8º 56.6046 W	36º 52.2794 N	8º 56.7159 W	11:49	12:29	109,74	131,71	00:40	01:29	2,869	R21	Ponta de Sagres
20	18-10-2020	37º 01.4012 N	7º 17.2076 W	37º 03.4647 N	7º 17.1726 W	07:50	08:20	49,24	35,13	00:30	01:12	2,061	R11	Isla Cristina
21	18-10-2020	36º 55.9432 N	7º 07.1252 W	36º 53.1814 N	7º 07.0994 W	12:36	13:29	96,22	115,65	00:53	01:27	2,758	R10	El Rompido
22	18-10-2020	37º 00.0879 N	7º 07.1781 W	36º 58.1016 N	7º 07.1189 W	15:25	15:52	61,7	80,91	00:27	01:07	1,984	R10	El Rompido

Table 3. *ECOCADIZ-RECLUTAS 2020-10* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

Fishing haul	CATCH IN NUMBER												
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Blue Jack mack.*	*Horse-mack.*	*Medit. Horse-mack.*	*Bogue*	*Boarfish*	*Snipefish*	*Pearlside*	Other spp.	TOTAL
01	0	166	967	0	0	9375	688	375	0	0	0	1153	**12724**
02	0	0	3	0	79	0	41	1	0	0	0	3	**127**
03	4397	1100	0	0	0	0	33	0	0	0	0	42	**5572**
04	7138	6467	4	0	0	0	0	0	0	0	0	4	**13613**
05	61240	5019	133	24	0	0	0	0	0	0	0	9	**66425**
06	1297	1196	0	4	0	0	0	0	0	0	0	3	**2500**
07	7340	0	14697	62	0	0	0	0	0	0	0	0	**22099**
08	10576	9084	1	3	0	0	3	0	0	0	0	331	**19998**
09	403	2211	9550	2	0	0	0	0	0	0	0	0	**12166**
10	5184	5194	2359	23	66	0	0	2	0	168	0	7	**13003**
11	2935	1658	1050	414	560	3525	0	3	5	28	0	4	**10182**
12	166	52260	0	0	0	0	0	0	0	0	0	2	**52428**
13	3	57632	2315	0	0	0	0	0	0	0	0	98	**60048**
14	434	0	2411	4116	0	0	0	0	0	0	0	10	**6971**
15	0	0	5	184	1	0	0	0	0	0	43	12	**245**
16	16452	0	96	5695	0	44	0	3	0	0	0	10	**22300**
17	260	6181	5	0	0	4	0	3	0	0	0	39	**6492**
18	0	0	199	18076	0	2	0	0	0	0	0	3	**18280**
19	0	0	479	9296	0	5	0	4	0	0	0	3	**9787**
20	0	61097	2576	6	0	12	1	6	0	0	0	17	**63715**
21	35149	0	2760	124	0	0	0	0	0	0	0	2	**38035**
22	1509	3	22	12	0	0	0	0	0	0	0	4	**1550**
TOTAL	**154483**	**209268**	**39632**	**38041**	**706**	**12967**	**766**	**397**	**5**	**196**	**43**	**1756**	**458260**

Table 3. *ECOCADIZ-RECLUTAS 2020-10* survey. Cont'd.

Fishing haul	CATCH IN WEIGHT (kg)												
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Blue Jack mack.*	*Horse-mack.*	*Medit. Horse-mack.*	*Bogue*	*Boarfish*	*Snipefish*	*Pearlside*	Other spp.	TOTAL
01	0	9,685	100,467	0	0	467,612	135,209	34,399	0	0	0	155,857	**903,229**
02	0	0	0,685	0	11,215	0	18,820	0,095	0	0	0	0,295	**31,110**
03	28,055	17,840	0	0	0	0	8,285	0	0	0	0	17,960	**72,140**
04	48,979	126,418	0,208	0	0	0	0	0	0	0	0	0,740	**176,345**
05	779,129	104,033	6,485	3,725	0	0	0	0	0	0	0	6,401	**899,773**
06	6,360	22,590	0	0,690	0	0	0	0	0	0	0	0,655	**30,295**
07	120,232	0	1503,686	9,741	0	0	0	0	0	0	0	0	**1633,659**
08	55,701	141,060	0,120	0,490	0	0	0,560	0	0	0	0	21,335	**219,266**
09	6,447	103,388	661,298	0,552	0	0	0	0	0	0	0	0	**771,685**
10	96,591	281,462	180,902	1,380	5,580	0	0	0,285	0	2,875	0	3,590	**572,665**
11	53,423	83,807	87,201	23,468	39,649	291,841	0	0,450	0,030	0,374	0	2,495	**582,738**
12	2,759	2833,056	0	0	0	0	0	0	0	0	0	0,495	**2836,310**
13	0,052	3151,443	209,078	0	0	0	0	0	0	0	0	15,313	**3375,886**
14	11,415	0	163,252	214,402	0	0	0	0	0	0	0	1,370	**390,439**
15	0	0	0,378	10,820	0,102	0	0	0	0	0	0,044	20,530	**31,874**
16	448,198	0	8,110	334,519	0	4,735	0	0,395	0	0	0	9,685	**805,642**
17	5,370	346,770	0,390	0	0	0,335	0	0,220	0	0	0	38,100	**391,185**
18	0	0	17,790	999,115	0	0,245	0	0	0	0	0	0,595	**1017,745**
19	0	0	58,755	523,745	0	0,715	0	0,415	0	0	0	0,820	**584,4500**
20	0	3383,409	183,172	1,480	0	0,450	0,260	1,195	0	0	0	2,310	**3572,276**
21	659,000	0	253,690	22,220	0	0	0	0	0	0	0	2,825	**937,735**
22	14,925	0,090	1,500	2,590	0	0	0	0	0	0	0	10,440	**29,545**
TOTAL	**2336,636**	**10605,051**	**3437,167**	**2148,937**	**56,546**	**765,933**	**163,134**	**37,454**	**0,030**	**3,249**	**0,044**	**311,811**	**19865,992**

Table 4. *ECOCADIZ-RECLUTAS 2020-10* 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*.

Parameter	ANE	PIL	VAM	MAC	JAA	HOM	HMM	BOG	BOC	SNS	MAV
Size range (mm)	81-182	110-222	177-396	191-346	185-339	77-285	57-466	164-310	63-74	111-170	32-63
n	782	683	690	462	165	157	125	22	5	169	43
a	0.001748530	0.001951537	0.002745174	0.002565026	0.004480958	0.053022878	0.012904912	0.926958852	0.050078582	0.011618897	0.010776177
b	3.502940	3.526670	3.325389	3.305719	3.169282	2.381583	2.831593	1.563943	2.510806	2.722675	2.830778
r^2	0.9862151	0.9744992	0.9496379	0.9842858	0.9803037	0.7692541	0.9949514	0.4102040	0.9887192	0.8505975	0.9080930

Table 5. *ECOCADIZ-RECLUTAS 2020-10* 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 2020-10 . Engraulis encrasicolus* . ABUNDANCE (in numbers and million fish)**														
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	***n***			**Millions**		
									PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	4374875	0	0	0	4374875	4374875	0	4	4
8	0	0	0	0	0	30534570	0	2176528	0	32711098	32711098	0	33	33
8,5	0	0	0	0	0	87518833	0	6529583	0	94048416	94048416	0	94	94
9	0	0	0	0	711651	161435446	0	60781051	0	222928148	222928148	0	223	223
9,5	0	0	0	0	2134952	180011614	4203504	177595414	0	363945484	363945484	0	364	364
10	0	0	370198	2882530	4269904	101012283	0	201415294	370198	309580011	309950209	0	310	310
10,5	0	0	325621	2535431	9963109	37318628	4203504	179911204	325621	233931876	234257497	0	234	234
11	0	0	223097	1737133	37598875	8965084	4203504	107649723	223097	160154319	160377416	0	160	160
11,5	0	0	722978	5629435	41868779	13401802	33569647	77281979	722978	171751642	172474620	1	172	172
12	0	0	1226699	9551631	49696935	4436718	151063412	56670902	1226699	271419598	272646297	1	271	273
12,5	0	0	4128632	32147400	19214567	1458292	214013798	17748826	4128632	284582883	288711515	4	285	289
13	591522	620167	7699363	59950726	9251458	0	209810294	11811269	8911052	290823747	299734799	9	291	300
13,5	2535093	2112224	14364746	111850411	2846603	0	180444151	5937557	19012063	301078722	320090785	19	301	320
14	8619315	5380241	10124829	78836500	1423301	0	75531706	1979186	24124385	157770693	181895078	24	158	182
14,5	5999719	9601248	7992472	62233000	0	0	16784824	1979186	23593439	80997010	104590449	24	81	105
15	3126614	12588942	4423228	34441256	0	0	0	0	20138784	34441256	54580040	20	34	55
15,5	1014037	16175600	2645595	20599801	0	0	0	0	19835232	20599801	40435033	20	21	40
16	0	10583350	1119236	8714878	0	0	0	0	11702586	8714878	20417464	12	9	20
16,5	84503	7623372	527796	4109662	0	0	0	1979186	8235671	6088848	14324519	8	6	14
17	0	2129338	133236	1037437	0	0	0	0	2262574	1037437	3300011	2	1	3
17,5	0	473682	44136	343660	0	0	0	0	517818	343660	861478	1	0,3	1
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19,5	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
TOTAL *n*	21970803	67288164	56071862	436600891	178980134	630468145	893828344	911446888	145330829	3051324402	3196655231	**145**	**3051**	**3197**
Millions	**22**	**67**	**56**	**437**	**179**	**630**	**894**	**911**						

Table 5. *ECOCADIZ-RECLUTAS 2020-10* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ-RECLUTAS 2020-10 . Engraulis encrasicolus* . BIOMASS (t)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**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	9,973	0	0	**0**	**9,973**	**9,973**
8	0	0	0	0	0	86,646	0	6,176	**0**	**92,822**	**92,822**
8,5	0	0	0	0	0	305,191	0	22,77	**0**	**327,961**	**327,961**
9	0	0	0	0	3,015	683,925	0	257,5	**0**	**944,440**	**944,440**
9,5	0	0	0	0	10,876	917,059	21,415	904,75	**0**	**1854,100**	**1854,100**
10	0	0	2,247	17,497	25,918	613,129	0	1222,561	**2,247**	**1879,105**	**1881,352**
10,5	0	0	2,335	18,184	71,455	267,646	30,147	1290,307	**2,335**	**1677,739**	**1680,074**
11	0	0	1,876	14,609	316,207	75,397	35,352	905,337	**1,876**	**1346,902**	**1348,778**
11,5	0	0	7,081	55,134	410,055	131,255	328,775	756,885	**7,081**	**1682,104**	**1689,185**
12	0	0	13,902	108,25	563,220	50,282	1712,015	642,256	**13,902**	**3076,023**	**3089,925**
12,5	0	0	53,829	419,136	250,518	19,013	2790,298	231,408	**53,829**	**3710,373**	**3764,202**
13	8,825	9,252	114,864	894,38	138,019	0	3130,074	176,207	**132,941**	**4338,680**	**4471,621**
13,5	43,060	35,877	243,993	1899,838	48,351	0	3064,939	100,853	**322,930**	**5113,981**	**5436,911**
14	165,917	103,566	194,897	1517,555	27,398	0	1453,940	38,098	**464,380**	**3036,991**	**3501,371**
14,5	130,320	208,549	173,605	1351,767	0	0	364,584	42,99	**512,474**	**1759,341**	**2271,815**
15	76,326	307,316	107,978	840,766	0	0	0	0	**491,620**	**840,766**	**1332,386**
15,5	27,716	442,115	72,310	563,038	0	0	0	0	**542,141**	**563,038**	**1105,179**
16	0	322,733	34,130	265,755	0	0	0	0	**356,863**	**265,755**	**622,618**
16,5	2,865	258,506	17,897	139,357	0	0	0	67,114	**279,268**	**206,471**	**485,739**
17	0	80,042	5,008	38,997	0	0	0	0	**85,050**	**38,997**	**124,047**
17,5	0	19,68	1,834	14,278	0	0	0	0	**21,514**	**14,278**	**35,792**
18	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
19	0	0	0	0	0	0	0	0	**0**	**0**	**0**
19,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
20	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**455,029**	**1787,636**	**1047,786**	**8158,541**	**1865,032**	**3159,516**	**12931,539**	**6665,212**	**3290,451**	**32779,840**	**36070,291**

Table 6. *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). 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**	**2020**
Biomass (t)	13680 (13354)	8113 (5131)	30827 (29219)	19861 (15969)	7642 (7290)	10493 (3834)	48357 (36405)	36070 (21060)
Abundance (millions)	2469 (2619)	986 (814)	5227 (5117)	3667 (3445)	1492 (1433)	953 (543)	5505 (4845)	3197 (2385)

Table 7. *ECOCADIZ-RECLUTAS 2020-10* 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 2020-10. 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	0	0	0	0	0	0	0	0	0	0
10	0	0	33871508	0	0	0	0	33871508	33871508	0	34	34
10,5	0	0	140398695	0	0	0	0	140398695	140398695	0	140	140
11	0	0	290493433	2511166	0	0	0	293004599	293004599	0	293	293
11,5	0	0	237229840	9534189	10606052	0	0	257370081	257370081	0	257	257
12	0	0	155007399	29139447	88111819	0	0	272258665	272258665	0	272	272
12,5	0	0	40464817	40468827	182342515	0	0	263276159	263276159	0	263	263
13	0	0	38137767	107216466	111771475	0	0	257125708	257125708	0	257	257
13,5	0	0	57142010	147478635	25699281	0	0	230319926	230319926	0	230	230
14	2381260	1493391	42404026	125878851	13053603	0	2381260	182829871	185211131	2	183	185
14,5	10017664	6282509	38654889	50183022	8566427	0	10017664	103686847	113704511	10	104	114
15	20216017	12678336	37879206	27478638	4487176	0	20216017	82523356	102739373	20	83	103
15,5	64182566	40251655	30510214	16787574	2039625	0	64182566	89589068	153771634	64	90	154
16	103212346	64728915	16030790	2670371	0	0	103212346	83430076	186642422	103	83	187
16,5	180265783	113052449	8403237	899799	2039625	4157	180265783	124399267	304665050	180	124	305
17	224806398	140985790	2585611	1797394	0	9699	224806398	145378494	370184892	225	145	370
17,5	397749424	249445822	1680647	897595	0	12471	397749424	252036535	649785959	398	252	650
18	433556757	271902145	1680647	74800	0	33255	433556757	273690847	707247604	434	274	707
18,5	277567598	174074614	904964	37400	0	34641	277567598	175051619	452619217	278	175	453
19	114653751	71904313	0	0	0	52654	114653751	71956967	186610718	115	72	187
19,5	85676860	53731654	0	37400	0	24941	85676860	53793995	139470855	86	54	139
20	51112618	32054928	0	37400	0	38798	51112618	32131126	83243744	51	32	83
20,5	29712232	18633822	0	0	0	9699	29712232	18643521	48355753	30	19	48
21	8284820	5195768	904964	0	0	5543	8284820	6106275	14391095	8	6	14
21,5	2040256	1279533	0	0	0	4157	2040256	1283690	3323946	2	1	3
22	834652	523446	0	0	0	0	834652	523446	1358098	1	1	1
22,5	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	2006271002	1258219090	1174384664	563128974	448717598	230015	2006271002	3444680341	5450951343	**2006**	**3445**	**5451**
Millions	**2006**	**1258**	**1174**	**563**	**449**	**0,2**	**2006**	**3445**	**5451**			

Table 7. *ECOCADIZ-RECLUTAS 2020-10* survey. Sardine (*Sardina pilchardus*). Cont'd.

***ECOCADIZ-RECLUTAS 2020-10 . 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	0	0	0	0	0	0
10	0	0	242,494	0	0	0	0	242,494	242,494
10,5	0	0	1188,987	0	0	0	0	1188,987	1188,987
11	0	0	2887,893	24,964	0	0	0	2912,857	2912,857
11,5	0	0	2749,264	110,492	122,914	0	0	2982,67	2982,670
12	0	0	2080,779	391,16	1182,79	0	0	3654,729	3654,729
12,5	0	0	625,495	625,557	2818,605	0	0	4069,657	4069,657
13	0	0	675,176	1898,118	1978,758	0	0	4552,052	4552,052
13,5	0	0	1152,79	2975,252	518,460	0	0	4646,502	4646,502
14	54,489	34,172	970,304	2880,406	298,697	0	54,489	4183,579	4238,068
14,5	258,873	162,350	998,906	1296,813	221,371	0	258,873	2679,440	2938,313
15	587,590	368,503	1100,981	798,682	130,422	0	587,590	2398,588	2986,178
15,5	2090,293	1310,913	993,654	546,736	66,426	0	2090,293	2917,729	5008,022
16	3753,086	2353,722	582,924	97,102	0	0	3753,086	3033,748	6786,834
16,5	7294,344	4574,598	340,032	36,410	82,532	0,168	7294,344	5033,740	12328,084
17	10090,956	6328,474	116,061	80,680	0	0,435	10090,956	6525,650	16616,606
17,5	19746,792	12384,065	83,438	44,562	0	0,619	19746,792	12512,684	32259,476
18	23739,988	14888,371	92,026	4,096	0	1,821	23739,988	14986,314	38726,302
18,5	16718,633	10484,976	54,508	2,253	0	2,087	16718,633	10543,824	27262,457
19	7577,540	4752,202	0	0	0	3,480	7577,540	4755,682	12333,222
19,5	6198,374	3887,268	0	2,706	0	1,804	6198,374	3891,778	10090,152
20	4038,636	2532,803	0	2,955	0	3,066	4038,636	2538,824	6577,460
20,5	2558,587	1604,600	0	0	0	0,835	2558,587	1605,435	4164,022
21	775,919	486,613	84,755	0	0	0,519	775,919	571,887	1347,806
21,5	207,414	130,079	0	0	0	0,423	207,414	130,502	337,916
22	91,933	57,655	0	0	0	0	91,933	57,655	149,588
22,5	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
TOTAL	**105783,447**	**66341,364**	**17020,467**	**11818,944**	**7420,975**	**15,257**	**105783,447**	**102617,007**	**208400,454**

Table 8. *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**	**2020**
Biomass (t)	22119 (9182)	36571 (705)	30992 (8645)	35173 (21899)	12119 (8778)	20679 (15224)	36465 (7858)	208400 (49259)
Abundance (millions)	603 (359)	507 (26)	861 (509)	2379 (1940)	591 (483)	1134 (1036)	937 (384)	5451 (2454)

Table 9. *ECOCADIZ-RECLUTAS 2020-10* 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 2020-10 . Scomber scombrus* . ABUNDANCE (in numbers and million fish)**								
Size class	**POL01**	**POL02**	***n***			**Millions**		
			PORTUGAL	**SPAIN**	**TOTAL**	**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	0	0	0	0	0	0
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	5750117	0	5750117	0	5750117	6	0	6
19	102553533	0	102553533	0	102553533	103	0	103
19,5	611636280	0	611636280	0	611636280	612	0	612
20	989619379	0	989619379	0	989619379	990	0	990
20,5	1169782886	0	1169782886	0	1169782886	1170	0	1170
21	498827213	0	498827213	0	498827213	499	0	499
21,5	80465316	21016	80465316	21016	80486332	80	0,02	80
22	2842208	0	2842208	0	2842208	3	0	3
22,5	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
23,5	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0
26	0	105082	0	105082	105082	0	0,1	0,1
26,5	0	252198	0	252198	252198	0	0,3	0,3
27	0	651511	0	651511	651511	0	1	1
27,5	101362	1134890	101362	1134890	1236252	0,1	1	1
28	0	945742	0	945742	945742	0	1	1
28,5	280493	693544	280493	693544	974037	0,3	1	1
29	0	420330	0	420330	420330	0	0,4	0,4
29,5	0	378297	0	378297	378297	0	0,4	0,4
30	0	252198	0	252198	252198	0	0,3	0,3
30,5	0	189148	0	189148	189148	0	0,2	0,2
31	0	126099	0	126099	126099	0	0,1	0,1
31,5	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0
32,5	140247	0	140247	0	140247	0,1	0	0,1
33	1534584	21016	1534584	21016	1555600	2	0,02	2
33,5	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0
34,5	0	21016	0	21016	21016	0	0,02	0,02
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
37	0	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0
TOTAL *n*	3463533618	5212087	3463533618	5212087	3468745705	**3464**	**5**	**3469**
Millions	**3464**	**5**						

Table 9. *ECOCADIZ-RECLUTAS 2020-10* survey. Atlantic mackerel (*Scomber scombrus*). Cont'd.

ECOCADIZ-RECLUTAS 2020-10 . Scomber scombrus . BIOMASS (t)					
Size class	**POL01**	**POL02**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0
14,5	0	0	0	0	0
15	0	0	0	0	0
15,5	0	0	0	0	0
16	0	0	0	0	0
16,5	0	0	0	0	0
17	0	0	0	0	0
17,5	0	0	0	0	0
18	0	0	0	0	0
18,5	238,206	0	238,206	0	238,206
19	4634,572	0	4634,572	0	4634,572
19,5	30086,106	0	30086,106	0	30086,106
20	52873,030	0	52873,030	0	52873,030
20,5	67746,832	0	67746,832	0	67746,832
21	31254,875	0	31254,875	0	31254,875
21,5	5444,590	1,422	5444,59	1,422	5446,012
22	207,321	0	207,321	0	207,321
22,5	0	0	0	0	0
23	0	0	0	0	0
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	13,239	0	13,239	13,239
26,5	0	33,819	0	33,819	33,819
27	0	92,882	0	92,882	92,882
27,5	15,346	171,818	15,346	171,818	187,164
28	0	151,888	0	151,888	151,888
28,5	47,738	118,036	47,738	118,036	165,774
29	0	75,733	0	75,733	75,733
29,5	0	72,087	0	72,087	72,087
30	0	50,780	0	50,780	50,780
30,5	0	40,206	0	40,206	40,206
31	0	28,272	0	28,272	28,272
31,5	0	0	0	0	0
32	0	0	0	0	0
32,5	36,715	0	36,715	0	36,715
33	422,375	5,784	422,375	5,784	428,159
33,5	0	0	0	0	0
34	0	0	0	0	0
34,5	0	6,693	0	6,693	6,693
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
37	0	0	0	0	0
37,5	0	0	0	0	0
38	0	0	0	0	0
TOTAL	**193007,706**	**862,659**	**193007,706**	**862,659**	**193870,365**

Table 10. *ECOCADIZ-RECLUTAS 2020-10* 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 2020-10 **.** ***Scomber colias*** **. ABUNDANCE (in numbers and million fish)**													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	***n***			**Millions**		
								PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0
17,5	0	0	431902	0	110977	191270	0	431902	302247	734149	0,4	0,3	1
18	0	0	1678804	0	431370	908532	0	1678804	1339902	3018706	2	1	3
18,5	0	0	6912766	154801	1776240	1577976	7656	6912766	3516673	10429439	7	4	10
19	0	0	13162928	158976	3382224	1625794	7862	13162928	5174856	18337784	13	5	18
19,5	0	426413	20557902	216141	5282368	1291071	10689	20984315	6800269	27784584	21	7	28
20	0	1722539	23991438	480181	6164618	334722	23748	25713977	7003269	32717246	26	7	33
20,5	0	1727449	17680313	803559	4542970	143452	39741	19407762	5529722	24937484	19	6	25
21	0	3948213	12947122	1599676	3326772	143452	79113	16895335	5149013	22044348	17	5	22
21,5	0	9487583	10636239	2565111	2732989	95635	126859	20123822	5520594	25644416	20	6	26
22	0	13153135	10697070	4782212	2748620	0	236508	23850205	7767340	31617545	24	8	32
22,5	222916	15218695	7989236	5566213	2052840	47817	275281	23430847	7942151	31372998	23	8	31
23	140789	9310226	7830670	6225946	2012096	0	307909	17281685	8545951	25827636	17	9	26
23,5	527958	2934030	6916904	3757105	1777304	0	185810	10378892	5720219	16099111	10	6	16
24	668747	2450464	2859236	3022665	734683	0	149488	5978447	3906836	9885283	6	4	10
24,5	1138044	544503	1152104	1591742	296034	0	78721	2834651	1966497	4801148	3	2	5
25	774339	106015	1578630	1269963	405630	0	62807	2458984	1738400	4197384	2	2	4
25,5	750874	220864	1004172	154801	258023	0	7656	1975910	420480	2396390	2	0,4	2
26	727409	106015	431320	211966	110828	0	10483	1264744	333277	1598021	1	0,3	2
26,5	445832	0	0	217226	0	0	10743	445832	227969	673801	0,4	0,2	1
27	164254	0	0	160061	0	0	7916	164254	167977	332231	0,2	0,2	0,3
27,5	58662	0	0	0	0	0	0	58662	0	58662	0,1	0	0,1
28	0	0	151193	0	38849	0	0	151193	38849	190042	0,2	0,04	0,2
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0
29,5	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
30,5	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	57165	0	0	2827	0	59992	59992	0	0,1	0,1
35,5	0	0	0	57165	0	0	2827	0	59992	59992	0	0,1	0,1
36	0	0	0	57165	0	0	2827	0	59992	59992	0	0,1	0,1
36,5	0	0	0	57165	0	0	2827	0	59992	59992	0	0,1	0,1
37	0	0	0	0	0	0	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	5619824	61356144	148609949	33167005	38185435	6359721	1640298	215585917	79352459	294938376	**216**	**79**	**295**
Millions	**6**	**61**	**149**	**33**	**38**	**6**	**2**						

Table 10. *ECOCADIZ-RECLUTAS 2020-10* survey. Chub mackerel (*Scomber colias*). Cont'd.

ECOCADIZ-RECLUTAS 2020-10 . Scomber colias . BIOMASS (t)										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**PORTUGAL**	**SPAIN**	**TOTAL**
14	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
17,5	0	0	16,905	0	4,344	7,487	0	16,905	11,831	28,736
18	0	0	72,071	0	18,519	39,003	0	72,071	57,522	129,593
18,5	0	0	324,673	7,271	83,425	74,113	0,360	324,673	165,169	489,842
19	0	0	674,768	8,150	173,382	83,343	0,403	674,768	265,278	940,046
19,5	0	23,805	1147,66	12,066	294,892	72,075	0,597	1171,465	379,630	1551,095
20	0	104,499	1455,451	29,130	373,979	20,306	1,441	1559,95	424,856	1984,806
20,5	0	113,651	1163,208	52,867	298,887	9,438	2,615	1276,859	363,807	1640,666
21	0	281,161	921,994	113,917	236,907	10,216	5,634	1203,155	366,674	1569,829
21,5	0	729,958	818,333	197,355	210,271	7,358	9,760	1548,291	424,744	1973,035
22	0	1091,429	887,628	396,821	228,077	0	19,625	1979,057	644,523	2623,580
22,5	19,916	1359,685	713,783	497,303	183,407	4,272	24,594	2093,384	709,576	2802,96
23	13,522	894,166	752,067	597,948	193,244	0	29,572	1659,755	820,764	2480,519
23,5	54,423	302,448	713,014	387,293	183,21	0	19,154	1069,885	589,657	1659,542
24	73,882	270,722	315,882	333,937	81,166	0	16,515	660,486	431,618	1092,104
24,5	134,558	64,380	136,220	188,201	35,002	0	9,308	335,158	232,511	567,669
25	97,851	13,397	199,487	160,482	51,258	0	7,937	310,735	219,677	530,412
25,5	101,279	29,791	135,444	20,880	34,803	0	1,033	266,514	56,716	323,230
26	104,594	15,244	62,019	30,478	15,936	0	1,507	181,857	47,921	229,778
26,5	68,257	0	0	33,257	0	0	1,645	68,257	34,902	103,159
27	26,745	0	0	26,062	0	0	1,289	26,745	27,351	54,096
27,5	10,147	0	0	0	0	0	0	10,147	0	10,147
28	0	0	27,753	0	7,131	0	0	27,753	7,131	34,884
28,5	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0
30,5	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0	0	0	0
35	0	0	0	21,908	0	0	1,083	0	22,991	22,991
35,5	0	0	0	22,959	0	0	1,135	0	24,094	24,094
36	0	0	0	24,044	0	0	1,189	0	25,233	25,233
36,5	0	0	0	25,165	0	0	1,244	0	26,409	26,409
37	0	0	0	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0
TOTAL	**705,174**	**5294,336**	**10538,360**	**3187,494**	**2707,840**	**327,611**	**157,640**	**16537,870**	**6380,585**	**22918,455**

Table 11. *ECOCADIZ-RECLUTAS* surveys series. Chub mackerel (*Scomber colias*). 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**	**2020**
Biomass (t)	11155 (n.a.)	17471 (n.a.)	5683 (n.a.)	13689 (n.a.)	11726 (n.a.)	6950 (n.a.)	26212 (5265)	22918 (2759)
Abundance (millions)	157 (n.a.)	148 (n.a.)	65 (n.a.)	297 (n.a.)	86 (n.a.)	108 (n.a.)	367 (88)	295 (51)

Table 12. *ECOCADIZ-RECLUTAS 2020-10* 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 2020-10 . Trachurus trachurus* . ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**Millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**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	0	0	565	64125	0	64690	64690	0	0,1	0,1
15	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0
16	0	0	2811	319200	0	322011	322011	0	0,3	0,3
16,5	0	0	5069	575700	0	580769	580769	0	1	1
17	0	0	7316	830775	0	838091	838091	0	1	1
17,5	0	136768	18007	2044876	136768	2062883	2199651	0,1	2	2
18	0	68384	19136	2173126	68384	2192262	2260646	0,1	2	2
18,5	0	269513	29262	3323101	269513	3352363	3621876	0,3	3	4
19	0	543048	20265	2301376	543048	2321641	2864689	1	2	3
19,5	0	406280	6186	702525	406280	708711	1114991	0,4	1	1
20	0	611431	4505	511575	611431	516080	1127511	1	1	1
20,5	0	611431	1129	128250	611431	129379	740810	1	0,1	1
21	0	1560759	1694	192375	1560759	194069	1754828	2	0,2	2
21,5	24331	2103807	1129	128250	2128138	129379	2257517	2	0,1	2
22	97322	1898655	565	64125	1995977	64690	2060667	2	0,1	2
22,5	97322	1967039	0	0	2064361	0	2064361	2	0	2
23	218975	2441703	0	0	2660678	0	2660678	3	0	3
23,5	194645	880944	0	0	1075589	0	1075589	1	0	1
24	170314	406280	0	0	576594	0	576594	1	0	1
24,5	97322	136768	0	0	234090	0	234090	0,2	0	0,2
25	48661	136768	0	0	185429	0	185429	0,2	0	0,2
25,5	97322	0	0	0	97322	0	97322	0,1	0	0,1
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
28	0	0	0	0	0	0	0	0	0	0
28,5	24331	0	0	0	24331	0	24331	0,02	0	0,02
29	0	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	1070545	14179578	117639	13359379	15250123	13477018	28727141	**15**	**13**	**29**
Millions	**1**	**14**	**0,1**	**13**						

Table 12. *ECOCADIZ-RECLUTAS 2020-10* survey. Horse mackerel (*Trachurus trachurus*). Cont'd.

ECOCADIZ-RECLUTAS 2020-10 . Trachurus trachurus . BIOMASS (t)							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
12	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
14,5	0	0	0,018	2,066	0	2,084	2,084
15	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0
16	0	0	0,114	12,950	0	13,064	13,064
16,5	0	0	0,221	25,105	0	25,326	25,326
17	0	0	0,342	38,856	0	39,198	39,198
17,5	0	6,847	0,902	102,376	6,847	103,278	110,125
18	0	3,658	1,024	116,238	3,658	117,262	120,92
18,5	0	15,374	1,669	189,568	15,374	191,237	206,611
19	0	32,982	1,231	139,775	32,982	141,006	173,988
19,5	0	26,229	0,399	45,355	26,229	45,754	71,983
20	0	41,896	0,309	35,054	41,896	35,363	77,259
20,5	0	44,402	0,082	9,313	44,402	9,395	53,797
21	0	119,954	0,130	14,785	119,954	14,915	134,869
21,5	1,976	170,899	0,092	10,418	172,875	10,510	183,385
22	8,345	162,812	0,048	5,499	171,157	5,547	176,704
22,5	8,799	177,844	0	0	186,643	0	186,643
23	20,850	232,490	0	0	253,340	0	253,340
23,5	19,497	88,241	0	0	107,738	0	107,738
24	17,927	42,766	0	0	60,693	0	60,693
24,5	10,754	15,113	0	0	25,867	0	25,867
25	5,640	15,851	0	0	21,491	0	21,491
25,5	11,818	0	0	0	11,818	0	11,818
26	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0
28,5	3,841	0	0	0	3,841	0	3,841
29	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
TOTAL	**109,447**	**1197,358**	**6,581**	**747,358**	**1306,805**	**753,939**	**2060,744**

Table 13. *ECOCADIZ-RECLUTAS 2020-10* 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 2020-10 . Trachurus mediterraneus . ABUNDANCE (in numbers and million fish)										
Size class	POL01	POL02	POL03	POL04	*n*			Millions		
					PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
4	0	0	0	0	0	0	0	0	0	0
4,5	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
5,5	0	0	0	11970	0	11970	11970	0	0,01	0,01
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	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	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0	0	0	0
19	0	0	0	5985	0	5985	5985	0	0,01	0,01
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	5985	0	5985	5985	0	0,01	0,01
21	0	0	0	0	0	0	0	0	0	0
21,5	0	0	0	5985	0	5985	5985	0	0,01	0,01
22	0	0	0	5985	0	5985	5985	0	0,01	0,01
22,5	0	0	0	0	0	0	0	0	0	0
23	0	0	0	53865	0	53865	53865	0	0,1	0,1
23,5	0	0	0	17955	0	17955	17955	0	0,02	0,02
24	0	0	0	41895	0	41895	41895	0	0,04	0,04
24,5	0	0	0	5985	0	5985	5985	0	0,01	0,01
25	0	0	0	17955	0	17955	17955	0	0,02	0,02
25,5	0	0	0	23940	0	23940	23940	0	0,02	0,02
26	0	0	0	53865	0	53865	53865	0	0,1	0,1
26,5	0	0	0	17955	0	17955	17955	0	0,02	0,02
27	0	0	0	83790	0	83790	83790	0	0,1	0,1
27,5	0	0	0	35910	0	35910	35910	0	0,04	0,04
28	0	0	0	35910	0	35910	35910	0	0,04	0,04
28,5	0	0	0	65835	0	65835	65835	0	0,1	0,1
29	0	0	0	137655	0	137655	137655	0	0,1	0,1
29,5	3411	187604	0	107730	0	298745	298745	0	0,3	0,3
30	3411	187604	0	89775	0	280790	280790	0	0,3	0,3
30,5	13645	750417	0	83790	0	847852	847852	0	1	1
31	13645	750417	0	59850	0	823912	823912	0	1	1
31,5	13645	750417	0	47880	0	811942	811942	0	1	1
32	17056	938022	0	5985	0	961063	961063	0	1	1
32,5	17056	938022	0	5985	0	961063	961063	0	1	1
33	17056	938022	0	0	0	955078	955078	0	1	1
33,5	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0
34,5	6823	375209	0	0	0	382032	382032	0	0,4	0,4
35	0	0	0	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0
36,5	0	0	0	0	0	0	0	0	0	0
37	0	0	6972	0	0	6972	6972	0	0,01	0,01
37,5	0	0	10458	0	0	10458	10458	0	0,01	0,01
38	0	0	17430	0	0	17430	17430	0	0,02	0,02
38,5	0	0	10458	0	0	10458	10458	0	0,01	0,01
39	0	0	13944	0	0	13944	13944	0	0,01	0,01
39,5	0	0	10458	0	0	10458	10458	0	0,01	0,01
40	3411	187604	17430	0	0	208445	208445	0	0,2	0,2
40,5	0	0	10458	0	0	10458	10458	0	0,01	0,01
41	0	0	3486	0	0	3486	3486	0	0,003	0,003
41,5	0	0	10458	0	0	10458	10458	0	0,01	0,01
42	0	0	6972	0	0	6972	6972	0	0,01	0,01
42,5	0	0	0	0	0	0	0	0	0	0
43	0	0	6972	0	0	6972	6972	0	0,01	0,01
43,5	0	0	0	0	0	0	0	0	0	0
44	0	0	3486	0	0	3486	3486	0	0,003	0,003
44,5	3411	187604	6972	0	0	197987	197987	0	0,2	0,2
45	0	0	0	0	0	0	0	0	0	0
45,5	0	0	3486	0	0	3486	3486	0	0,003	0,003
46	0	0	0	0	0	0	0	0	0	0
46,5	0	0	3486	0	0	3486	3486	0	0,003	0,003
47	0	0	0	0	0	0	0	0	0	0
47,5	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0
48,5	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0
49,5	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	112570	6190942	142926	1029420	0	7475858	7475858	**0**	**7**	**7**
Millions	**0,1**	**6**	**0,1**	**1**						

Table 132. *ECOCADIZ-RECLUTAS 2020-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Cont'd.

ECOCADIZ-RECLUTAS 2020-10 . Trachurus mediterraneus. BIOMASS (t)							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
4	0	0	0	0	0	0	0
4,5	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
5,5	0	0	0	0,022	0	0,022	0,022
6	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0
11	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	0	0	0	0	0	0	0
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
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
16,5	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0
19	0	0	0	0,335	0	0,335	0,335
19,5	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
20,5	0	0	0	0,414	0	0,414	0,414
21	0	0	0	0	0	0	0
21,5	0	0	0	0,473	0	0,473	0,473
22	0	0	0	0,505	0	0,505	0,505
22,5	0	0	0	0	0	0	0
23	0	0	0	5,143	0	5,143	5,143
23,5	0	0	0	1,821	0	1,821	1,821
24	0	0	0	4,507	0	4,507	4,507
24,5	0	0	0	0,682	0	0,682	0,682
25	0	0	0	2,166	0	2,166	2,166
25,5	0	0	0	3,052	0	3,052	3,052
26	0	0	0	7,252	0	7,252	7,252
26,5	0	0	0	2,550	0	2,550	2,550
27	0	0	0	12,541	0	12,541	12,541
27,5	0	0	0	5,659	0	5,659	5,659
28	0	0	0	5,952	0	5,952	5,952
28,5	0	0	0	11,468	0	11,468	11,468
29	0	0	0	25,178	0	25,178	25,178
29,5	0,655	36,001	0	20,673	0	57,329	57,329
30	0,686	37,741	0	18,060	0	56,487	56,487
30,5	2,875	158,136	0	17,657	0	178,668	178,668
31	3,010	165,525	0	13,202	0	181,737	181,737
31,5	3,148	173,135	0	11,047	0	187,330	187,330
32	4,113	226,209	0	1,443	0	231,765	231,765
32,5	4,296	236,281	0	1,508	0	242,085	242,085
33	4,485	246,639	0	0	0	251,124	251,124
33,5	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0
34,5	2,033	111,785	0	0	0	113,818	113,818
35	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0
36,5	0	0	0	0	0	0	0
37	0	0	2,529	0	0	2,529	2,529
37,5	0	0	3,939	0	0	3,939	3,939
38	0	0	6,814	0	0	6,814	6,814
38,5	0	0	4,242	0	0	4,242	4,242
39	0	0	5,865	0	0	5,865	5,865
39,5	0	0	4,559	0	0	4,559	4,559
40	1,541	84,731	7,872	0	0	94,144	94,144
40,5	0	0	4,891	0	0	4,891	4,891
41	0	0	1,688	0	0	1,688	1,688
41,5	0	0	5,239	0	0	5,239	5,239
42	0	0	3,612	0	0	3,612	3,612
42,5	0	0	0	0	0	0	0
43	0	0	3,860	0	0	3,860	3,860
43,5	0	0	0	0	0	0	0
44	0	0	2,059	0	0	2,059	2,059
44,5	2,080	114,386	4,251	0	0	120,717	120,717
45	0	0	0	0	0	0	0
45,5	0	0	2,263	0	0	2,263	2,263
46	0	0	0	0	0	0	0
46,5	0	0	2,406	0	0	2,406	2,406
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
TOTAL	**28,922**	**1590,569**	**66,089**	**173,310**	**0**	**1858,890**	**1858,890**

Table 14. *ECOCADIZ-RECLUTAS 2020-10* 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 2020-10 . *Trachurus picturatus* . 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	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
18,5	11256	0	0	11256	0	11256	0,01	0	0,01
19	93800	0	0	93800	0	93800	0,1	0	0,1
19,5	262640	0	0	262640	0	262640	0,3	0	0,3
20	453992	0	0	453992	0	453992	0,5	0	0,5
20,5	412720	44133	0	456853	0	456853	0,5	0	0,5
21	180096	80911	0	261007	0	261007	0,3	0	0,3
21,5	146328	139756	7361	286084	7361	293445	0,3	0,01	0,3
22	285152	80911	0	366063	0	366063	0,4	0	0,4
22,5	116312	29422	0	145734	0	145734	0,1	0	0,1
23	75040	22067	7361	97107	7361	104468	0,1	0,01	0,1
23,5	52528	29422	22083	81950	22083	104033	0,1	0,02	0,1
24	11256	22067	22083	33323	22083	55406	0,03	0,02	0,1
24,5	0	7356	33125	7356	33125	40481	0,01	0,03	0,04
25	0	22067	40486	22067	40486	62553	0,02	0,04	0,1
25,5	0	7356	29444	7356	29444	36800	0,01	0,03	0,04
26	0	0	18403	0	18403	18403	0	0,02	0,02
26,5	0	0	18403	0	18403	18403	0	0,02	0,02
27	0	0	11042	0	11042	11042	0	0,01	0,01
27,5	0	0	33125	0	33125	33125	0	0,03	0,03
28	0	0	0	0	0	0	0	0	0
28,5	0	0	0	0	0	0	0	0	0
29	0	0	7361	0	7361	7361	0	0,01	0,01
29,5	0	0	7361	0	7361	7361	0	0,01	0,01
30	0	0	7361	0	7361	7361	0	0,01	0,01
30,5	0	0	0	0	0	0	0	0	0
31	0	0	18403	0	18403	18403	0	0,02	0,02
31,5	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0
33,5	0	0	7361	0	7361	7361	0	0,01	0,01
34	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0
35,5	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0
36,5	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0
37,5	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0
TOTAL *n*	2101120	485468	290763	2586588	290763	2877351	**3**	**0,3**	**3**
Millions	**2**	**0,5**	**0,3**						

Table 14. *ECOCADIZ-RECLUTAS 2020-10* survey. Blue Jack mackerel (*Trachurus picturatus*). Cont'd.

***ECOCADIZ-RECLUTAS 2020-10 . Trachurus picturatus .* 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	0	0	0	0	0
16	0	0	0	0	0	0
16,5	0	0	0	0	0	0
17	0	0	0	0	0	0
17,5	0	0	0	0	0	0
18	0	0	0	0	0	0
18,5	0,546	0	0	0,546	0	0,546
19	4,946	0	0	4,946	0	4,946
19,5	15,023	0	0	15,023	0	15,023
20	28,109	0	0	28,109	0	28,109
20,5	27,608	2,952	0	30,560	0	30,560
21	12,991	5,837	0	18,828	0	18,828
21,5	11,363	10,852	0,572	22,215	0,572	22,787
22	23,797	6,752	0	30,549	0	30,549
22,5	10,415	2,635	0	13,050	0	13,050
23	7,199	2,117	0,706	9,316	0,706	10,022
23,5	5,390	3,019	2,266	8,409	2,266	10,675
24	1,234	2,419	2,421	3,653	2,421	6,074
24,5	0	0,860	3,874	0,860	3,874	4,734
25	0	2,750	5,045	2,750	5,045	7,795
25,5	0	0,975	3,904	0,975	3,904	4,879
26	0	0	2,593	0	2,593	2,593
26,5	0	0	2,753	0	2,753	2,753
27	0	0	1,752	0	1,752	1,752
27,5	0	0	5,567	0	5,567	5,567
28	0	0	0	0	0	0
28,5	0	0	0	0	0	0
29	0	0	1,462	0	1,462	1,462
29,5	0	0	1,542	0	1,542	1,542
30	0	0	1,626	0	1,626	1,626
30,5	0	0	0	0	0	0
31	0	0	4,507	0	4,507	4,507
31,5	0	0	0	0	0	0
32	0	0	0	0	0	0
32,5	0	0	0	0	0	0
33	0	0	0	0	0	0
33,5	0	0	2,301	0	2,301	2,301
34	0	0	0	0	0	0
34,5	0	0	0	0	0	0
35	0	0	0	0	0	0
35,5	0	0	0	0	0	0
36	0	0	0	0	0	0
36,5	0	0	0	0	0	0
37	0	0	0	0	0	0
37,5	0	0	0	0	0	0
38	0	0	0	0	0	0
TOTAL	**148,621**	**41,168**	**42,891**	**189,789**	**42,891**	**232,680**

Table 15. *ECOCADIZ-RECLUTAS 2020-10* 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 2020-10 . *Boops boops* . 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	285	977	198	576	2810	1460	3386	4846	0,001	0,003	0,005
16	0	0	0	0	0	0	0	0	0	0	0
16,5	1138	3908	791	2304	11238	5837	13542	19379	0,01	0,01	0,02
17	285	977	198	576	2810	1460	3386	4846	0,001	0,003	0,005
17,5	1423	4884	989	2879	14048	7296	16927	24223	0,01	0,02	0,02
18	1707	5861	1187	3455	16857	8755	20312	29067	0,01	0,02	0,03
18,5	1138	3908	791	2304	11238	5837	13542	19379	0,01	0,01	0,02
19	4126	14165	2868	8350	40738	21159	49088	70247	0,02	0,05	0,1
19,5	5264	18072	3659	10654	51976	26995	62630	89625	0,03	0,1	0,1
20	5264	18072	3659	10654	51976	26995	62630	89625	0,03	0,1	0,1
20,5	6402	21980	4450	12957	63214	32832	76171	109003	0,03	0,1	0,1
21	6402	21980	4450	12957	63214	32832	76171	109003	0,03	0,1	0,1
21,5	6971	23933	4846	14109	68833	35750	82942	118692	0,04	0,1	0,1
22	4410	15142	3066	8926	43547	22618	52473	75091	0,02	0,1	0,1
22,5	1423	4884	989	2879	14048	7296	16927	24223	0,01	0,02	0,02
23	2845	9769	1978	5759	28095	14592	33854	48446	0,01	0,03	0,05
23,5	1707	5861	1187	3455	16857	8755	20312	29067	0,01	0,02	0,03
24	854	2931	593	1728	8429	4378	10157	14535	0,004	0,01	0,01
24,5	569	1954	396	1152	5619	2919	6771	9690	0,003	0,01	0,01
25	0	0	0	0	0	0	0	0	0	0	0
25,5	285	977	198	576	2810	1460	3386	4846	0,001	0,003	0,005
26	285	977	198	576	2810	1460	3386	4846	0,001	0,003	0,005
26,5	285	977	198	576	2810	1460	3386	4846	0,001	0,003	0,005
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	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
30,5	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0
31,5	285	977	198	576	2810	1460	3386	4846	0,001	0,003	0,005
32	0	0	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	53353	183166	37087	107978	526787	273606	634765	908371	**0,3**	**1**	**1**
Millions	**0,1**	**0,2**	**0,04**	**0,1**	**1**						

Table 15. *ECOCADIZ-RECLUTAS 2020-10* survey. Bogue (*Boops boops*). Cont'd.

***ECOCADIZ-RECLUTAS 2020-10 . Boops boops* . 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	0,020	0,068	0,014	0,040	0,194	0,102	0,234	0,336
16	0	0	0	0	0	0	0	0
16,5	0,087	0,297	0,060	0,175	0,855	0,444	1,030	1,474
17	0,023	0,078	0,016	0,046	0,224	0,117	0,270	0,387
17,5	0,119	0,407	0,082	0,240	1,170	0,608	1,410	2,018
18	0,149	0,510	0,103	0,301	1,467	0,762	1,768	2,530
18,5	0,103	0,355	0,072	0,209	1,020	0,530	1,229	1,759
19	0,390	1,340	0,271	0,790	3,853	2,001	4,643	6,644
19,5	0,518	1,779	0,360	1,049	5,117	2,657	6,166	8,823
20	0,539	1,850	0,375	1,091	5,322	2,764	6,413	9,177
20,5	0,681	2,338	0,473	1,378	6,724	3,492	8,102	11,594
21	0,707	2,427	0,491	1,430	6,979	3,625	8,409	12,034
21,5	0,798	2,740	0,555	1,615	7,881	4,093	9,496	13,589
22	0,523	1,796	0,364	1,059	5,166	2,683	6,225	8,908
22,5	0,175	0,600	0,121	0,354	1,726	0,896	2,080	2,976
23	0,362	1,241	0,251	0,732	3,570	1,854	4,302	6,156
23,5	0,224	0,770	0,156	0,454	2,215	1,150	2,669	3,819
24	0,116	0,398	0,080	0,235	1,144	0,594	1,379	1,973
24,5	0,080	0,274	0,055	0,161	0,787	0,409	0,948	1,357
25	0	0	0	0	0	0	0	0
25,5	0,042	0,146	0,030	0,086	0,419	0,218	0,505	0,723
26	0,044	0,150	0,030	0,088	0,432	0,224	0,520	0,744
26,5	0,045	0,155	0,031	0,091	0,445	0,231	0,536	0,767
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	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	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
31,5	0,059	0,202	0,041	0,119	0,581	0,302	0,70	1,002
32	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0
34,5	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0
TOTAL	**5,804**	**19,921**	**4,031**	**11,743**	**57,291**	**29,756**	**69,034**	**98,790**

Table 16. *ECOCADIZ-RECLUTAS 2020-10* 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 34**.

***ECOCADIZ-RECLUTAS 2020-10 . Capros aper .* ABUNDANCE (in numbers and million fish)**							
Size class	**POL01**	***n***			**Millions**		
		PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
4	0	0	0	0	0	0	0
4,5	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
5,5	0	0	0	0	0	0	0
6	6042	6042	0	6042	0,006042	0	0,006042
6,5	6042	6042	0	6042	0,006042	0	0,006042
7	3021	3021	0	3021	0,003021	0	0,003021
7,5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
TOTAL *n*	15105	15105	0	15105	**0,02**	**0**	**0,02**
Millions	**0,02**						

***ECOCADIZ-RECLUTAS 2020-10 . Capros aper .* BIOMASS (t)**				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
4	0	0	0	0
4,5	0	0	0	0
5	0	0	0	0
5,5	0	0	0	0
6	0,030	0,030	0	0,030
6,5	0,037	0,037	0	0,037
7	0,022	0,022	0	0,022
7,5	0	0	0	0
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
TOTAL	**0,089**	**0,089**	**0**	**0,089**

Table 17. *ECOCADIZ-RECLUTAS 2020-10* 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 37**.

ECOCADIZ-RECLUTAS 2020-10 . *Macroramphosus scolopax* . ABUNDANCE (in numbers and million fish)							
Size class	POL01	*n*			Millions		
		PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
5	0	0	0	0	0	0	0
5,5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
11,5	24959	24959	0	24959	0,02	0	0,02
12	24959	24959	0	24959	0,02	0	0,02
12,5	8320	8320	0	8320	0,01	0	0,01
13	66557	66557	0	66557	0,1	0	0,1
13,5	232949	232949	0	232949	0,2	0	0,2
14	407661	407661	0	407661	0,4	0	0,4
14,5	266227	266227	0	266227	0,3	0	0,3
15	166392	166392	0	166392	0,2	0	0,2
15,5	83196	83196	0	83196	0,1	0	0,1
16	66557	66557	0	66557	0,1	0	0,1
16,5	41598	41598	0	41598	0,04	0	0,04
17	8320	8320	0	8320	0,01	0	0,01
17,5	0	0	0	0	0	0	0
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
TOTAL *n*	1397695	1397695	0	1397695	1	0	1
Millions	1						

Table 17. *ECOCADIZ-RECLUTAS 2020-10* survey. Longspine snipefish (*Macroramphosus scolopax*). Cont'd.

ECOCADIZ-RECLUTAS 2020-10 . M. scolopax . BIOMASS (t)				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
5	0	0	0	0
5,5	0	0	0	0
6	0	0	0	0
6,5	0	0	0	0
7	0	0	0	0
7,5	0	0	0	0
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	0	0	0	0
11	0	0	0	0
11,5	0,238	0,238	0	0,238
12	0,266	0,266	0	0,266
12,5	0,099	0,099	0	0,099
13	0,879	0,879	0	0,879
13,5	3,401	3,401	0	3,401
14	6,560	6,560	0	6,560
14,5	4,706	4,706	0	4,706
15	3,221	3,221	0	3,221
15,5	1,758	1,758	0	1,758
16	1,532	1,532	0	1,532
16,5	1,040	1,040	0	1,040
17	0,225	0,225	0	0,225
17,5	0	0	0	0
18	0	0	0	0
18,5	0	0	0	0
19	0	0	0	0
19,5	0	0	0	0
20	0	0	0	0
TOTAL	**23,925**	**23,925**	**0**	**23,925**

Table 17. *ECOCADIZ-RECLUTAS 2020-10* 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 40**.

***ECOCADIZ-RECLUTAS 2020-10*. *Maurolicus muelleri*. ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**Millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
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	131174033	1874742	1511496	5312044	131174033	8698282	139872315	131	9	140
3,5	0	0	0	0	0	0	0	0	0	0
4	524696130	7498966	6045983	21248175	524696130	34793124	559489254	525	35	559
4,5	1049392260	14997933	12091967	42496350	1049392260	69586250	1118978510	1049	70	1119
5	327935081	4686854	3778740	13280109	327935081	21745703	349680784	328	22	350
5,5	524696130	7498966	6045983	21248175	524696130	34793124	559489254	525	35	559
6	262348065	3749483	3022992	10624087	262348065	17396562	279744627	262	17	280
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
TOTAL *n*	2820241699	40306944	32497161	114208940	2820241699	187013045	3007254744	**2820**	**187**	**3007**
Millions	**2820**	**40**	**32**	**114**						

***ECOCADIZ-RECLUTAS 2020-10*. *Maurolicus muelleri*. BIOMASS (t)**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
1	0	0	0	0	0	0	0
1,5	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
2,5	0	0	0	0	0	0	0
3	39,750	0,568	0,458	1,610	39,750	2,636	42,386
3,5	0	0	0	0	0	0	0
4	339,783	4,856	3,915	13,760	339,783	22,531	362,314
4,5	931,047	13,307	10,728	37,704	931,047	61,739	992,786
5	386,246	5,520	4,451	15,641	386,246	25,612	411,858
5,5	799,509	11,427	9,213	32,377	799,509	53,017	852,526
6	506,177	7,234	5,833	20,498	506,177	33,565	539,742
6,5	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
TOTAL	**3002,512**	**42,912**	**34,598**	**121,590**	**3002,512**	**199,100**	**3201,612**

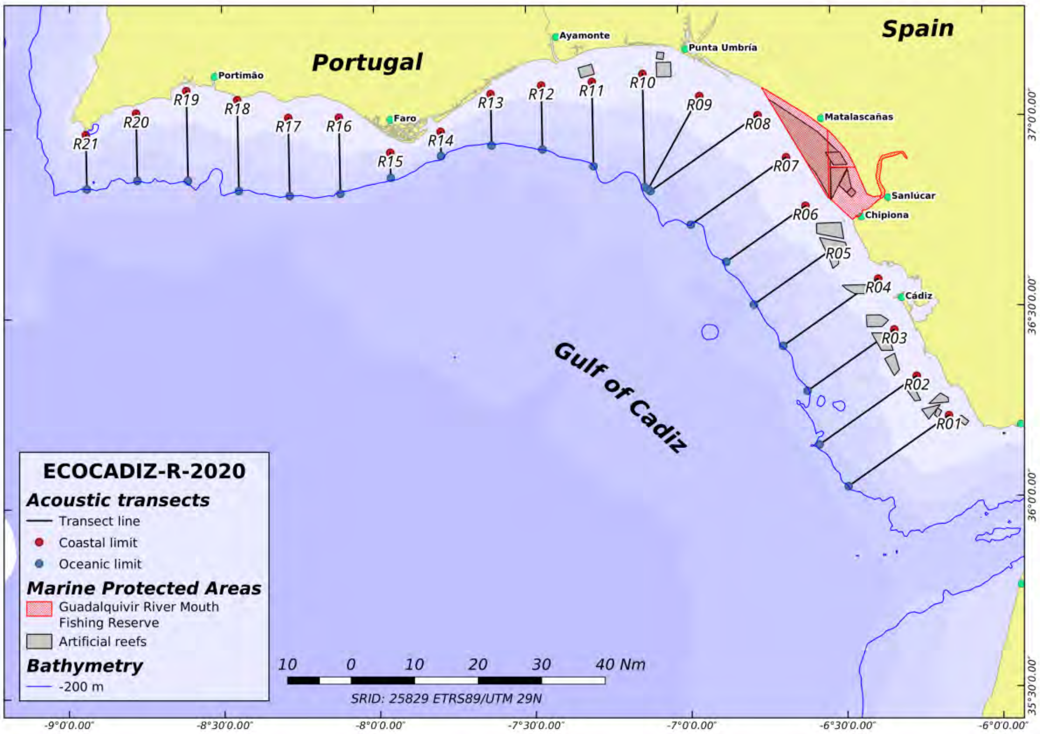


Figure 1. *ECOCADIZ-RECLUTAS 2020-10* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

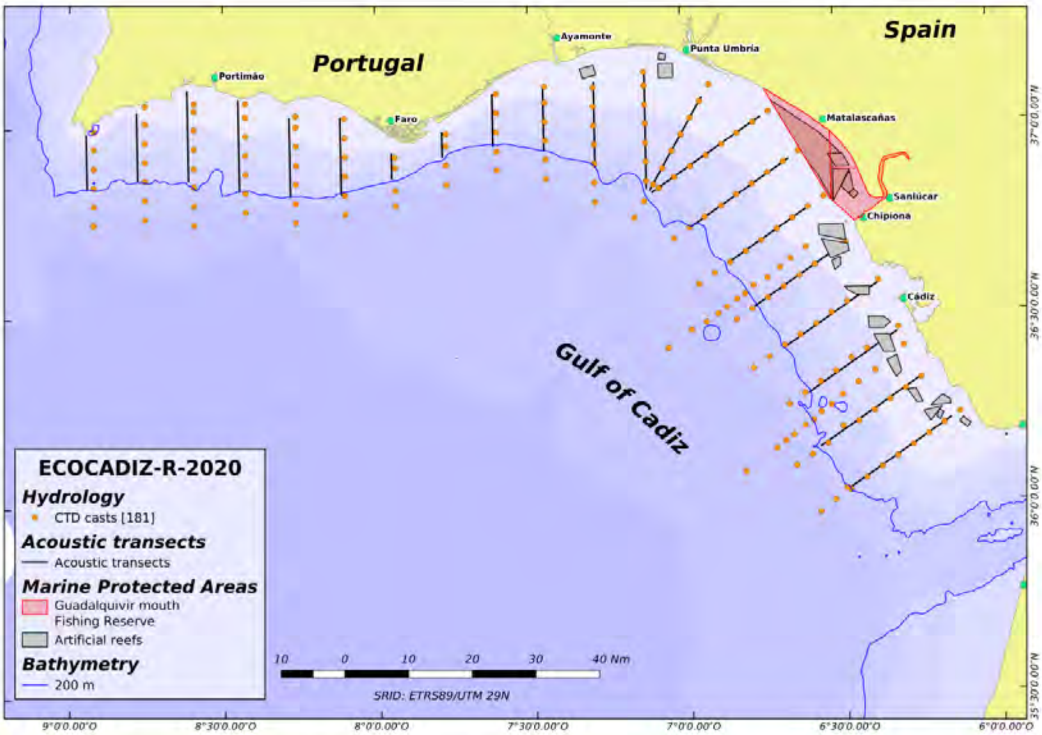


Figure 2. *ECOCADIZ-RECLUTAS 2020-10* survey. Location of CTD stations.

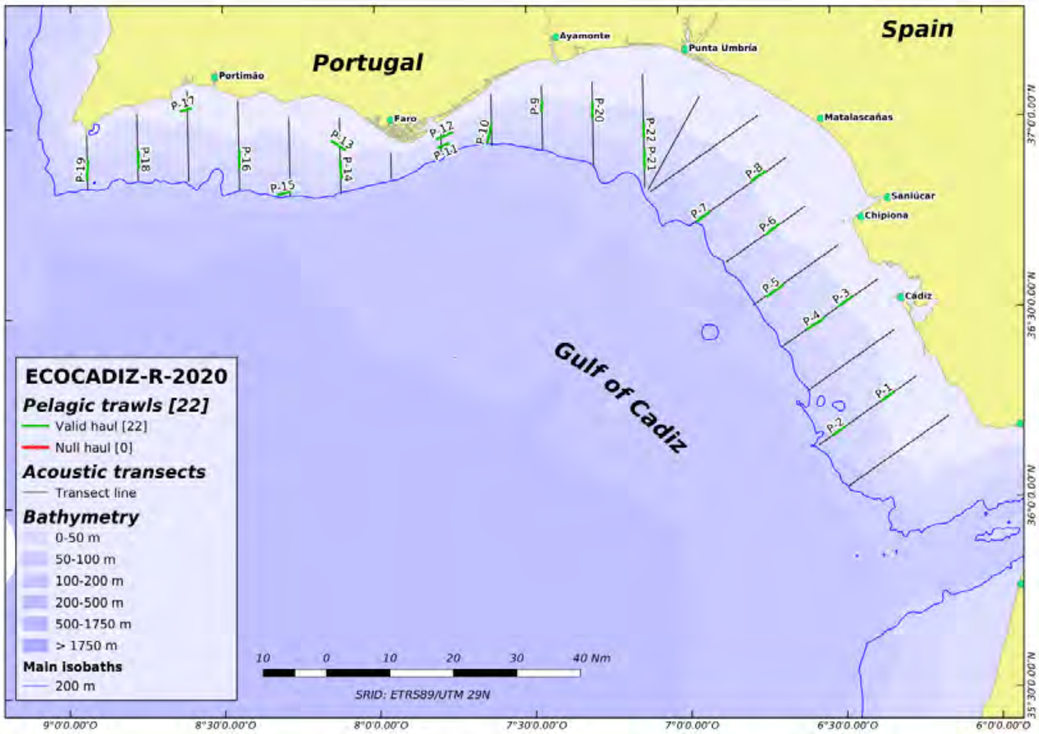


Figure 3. *ECOCADIZ-RECLUTAS 2020-10* survey. Location of ground-truthing fishing hauls.

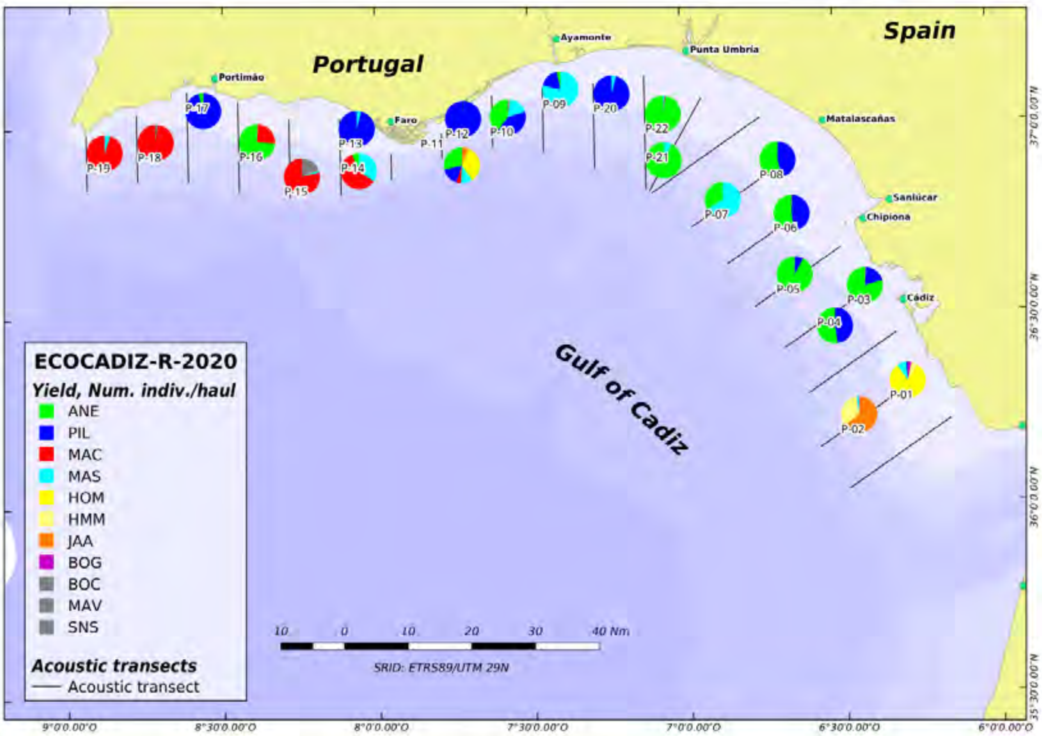


Figure 4. *ECOCADIZ-RECLUTAS 2020-10* survey. Species composition (percentages in number) in valid fishing hauls.

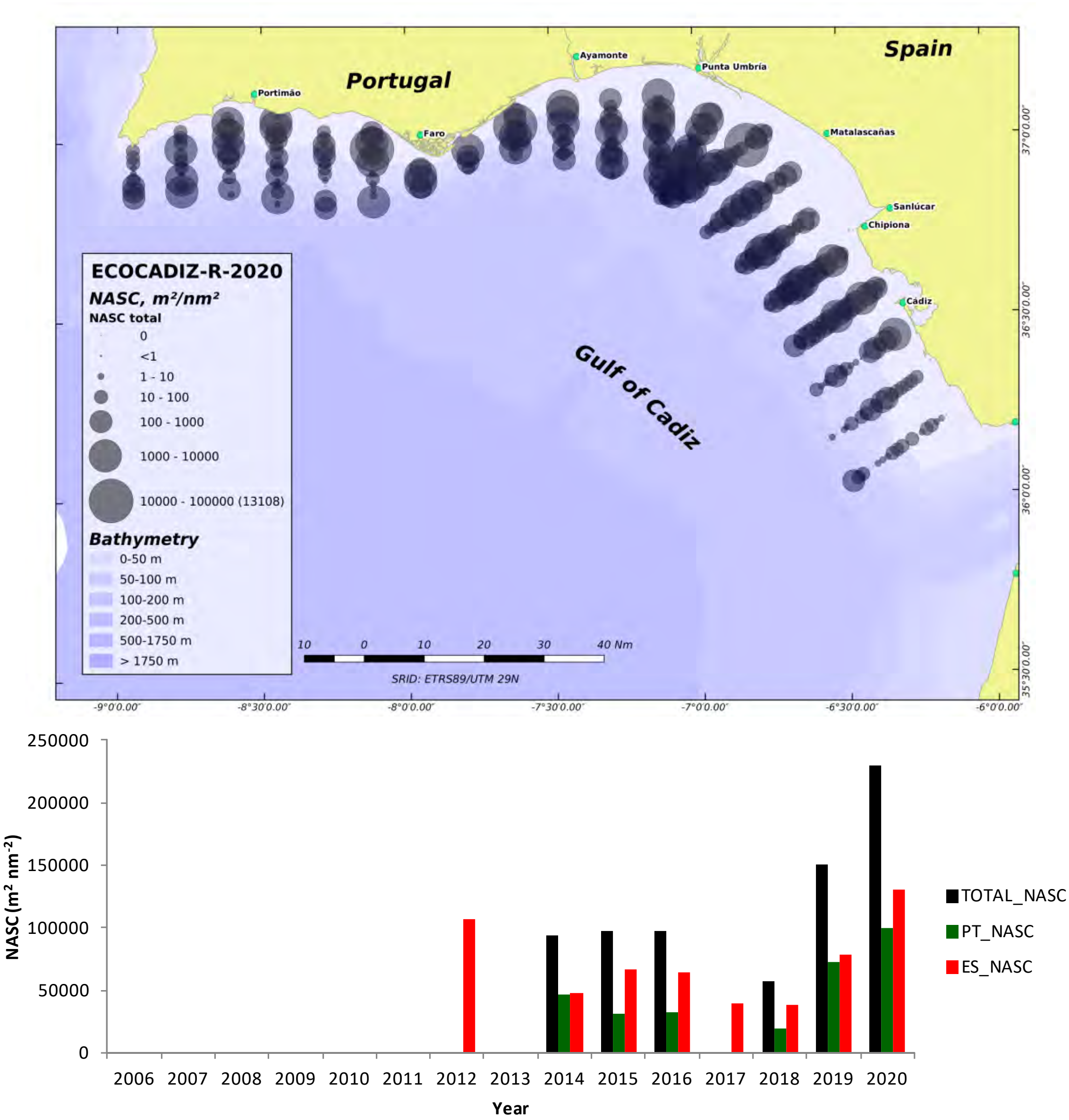


Figure 5. *ECOCADIZ-RECLUTAS 2020-10* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.

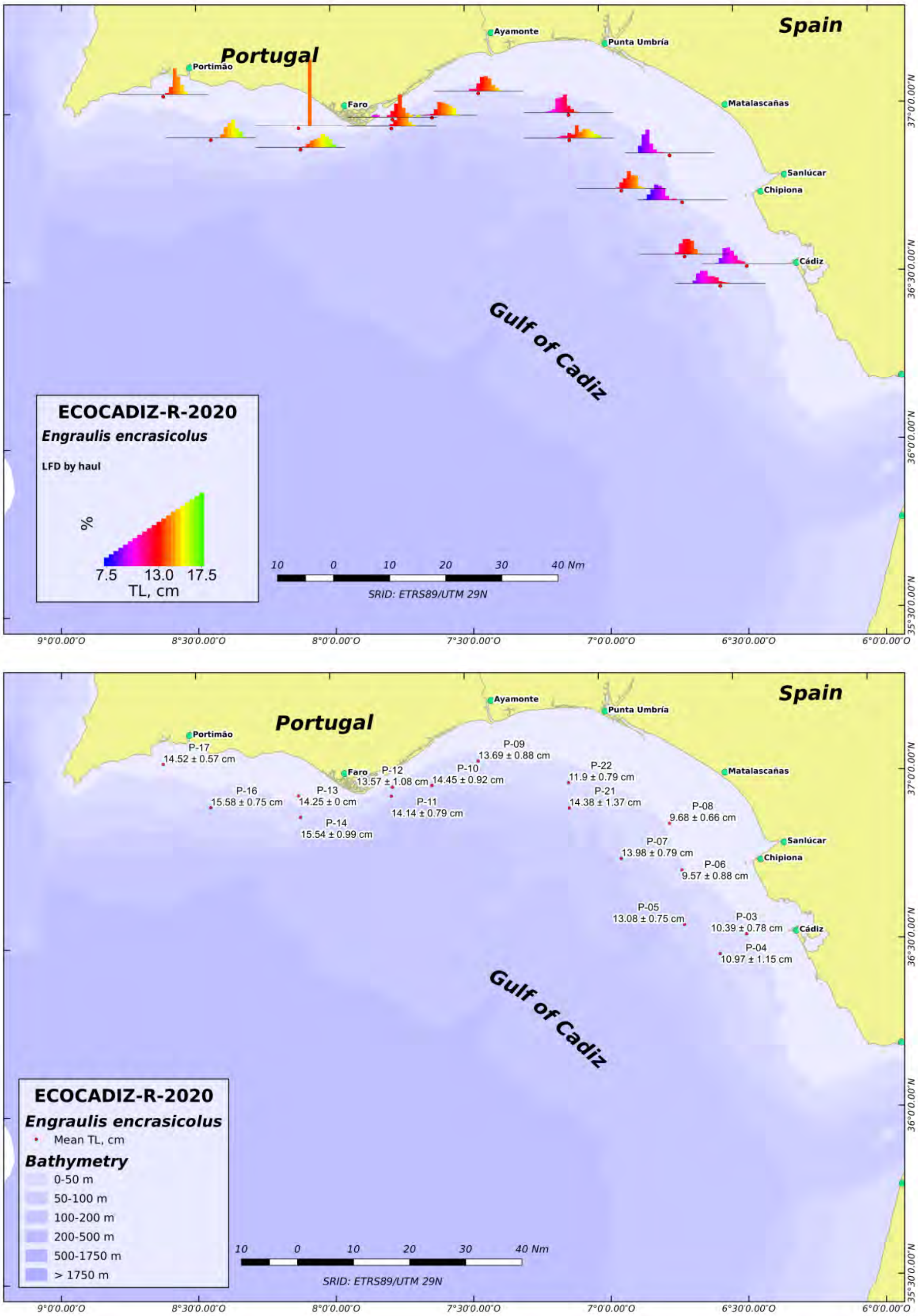
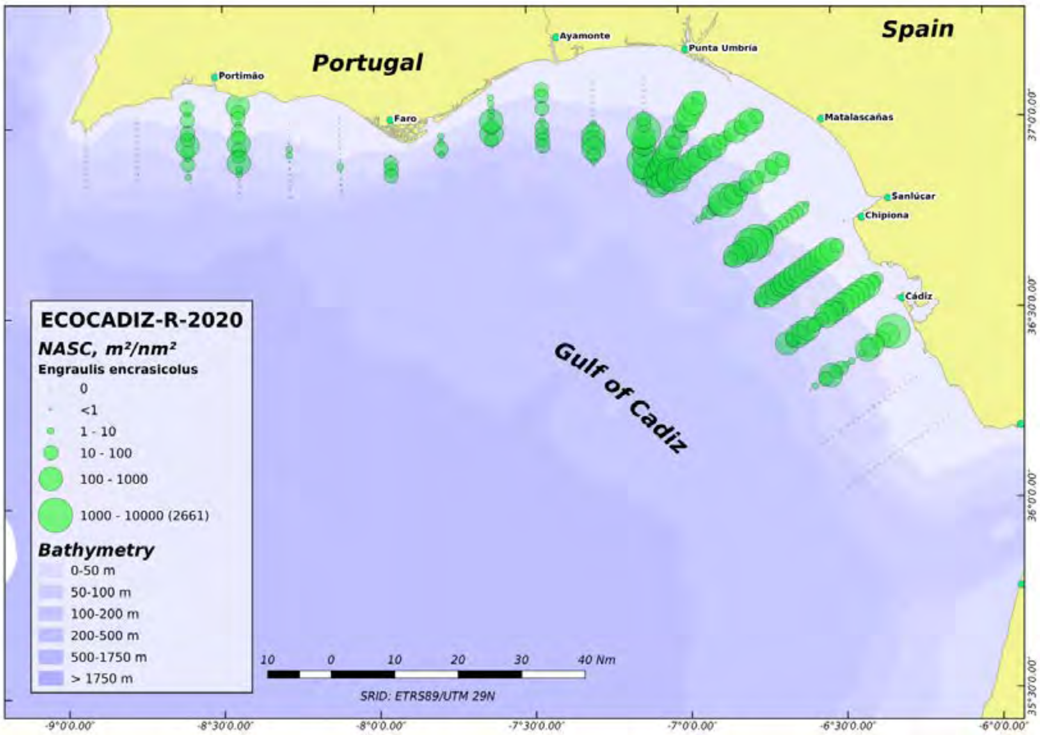


Figure 6. *ECOCADIZ-RECLUTAS 2020-10* survey. Anchovy (*Engraulis encrasicolus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.



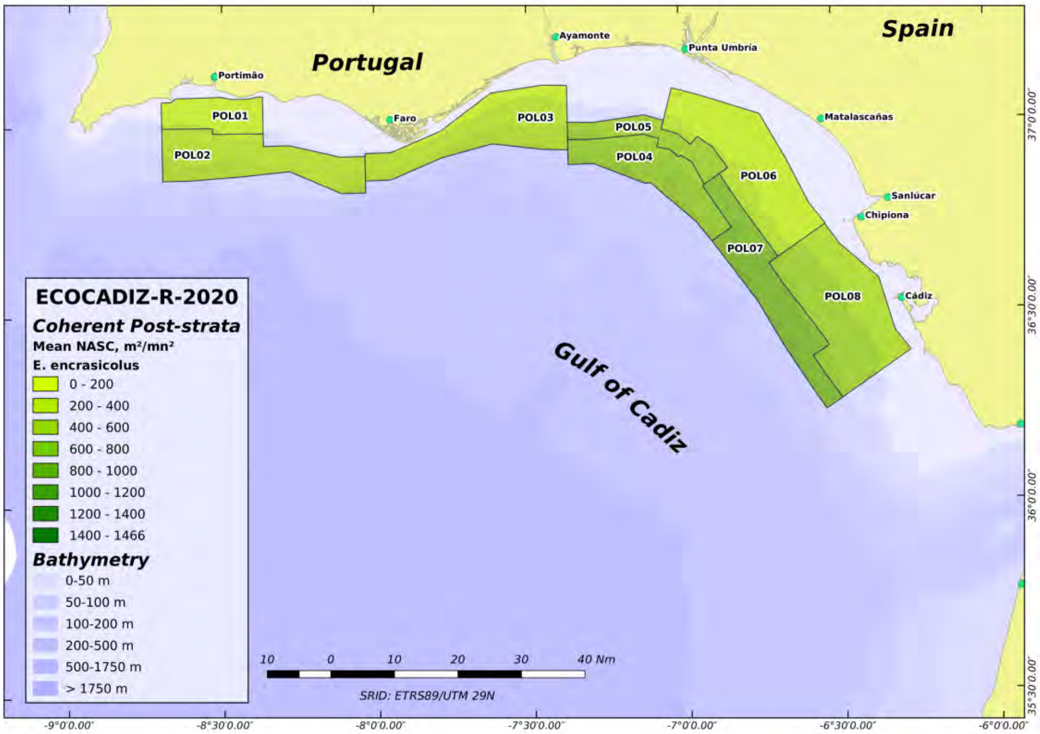


Figure 7. *ECOCADIZ-RECLUTAS 2020-10* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

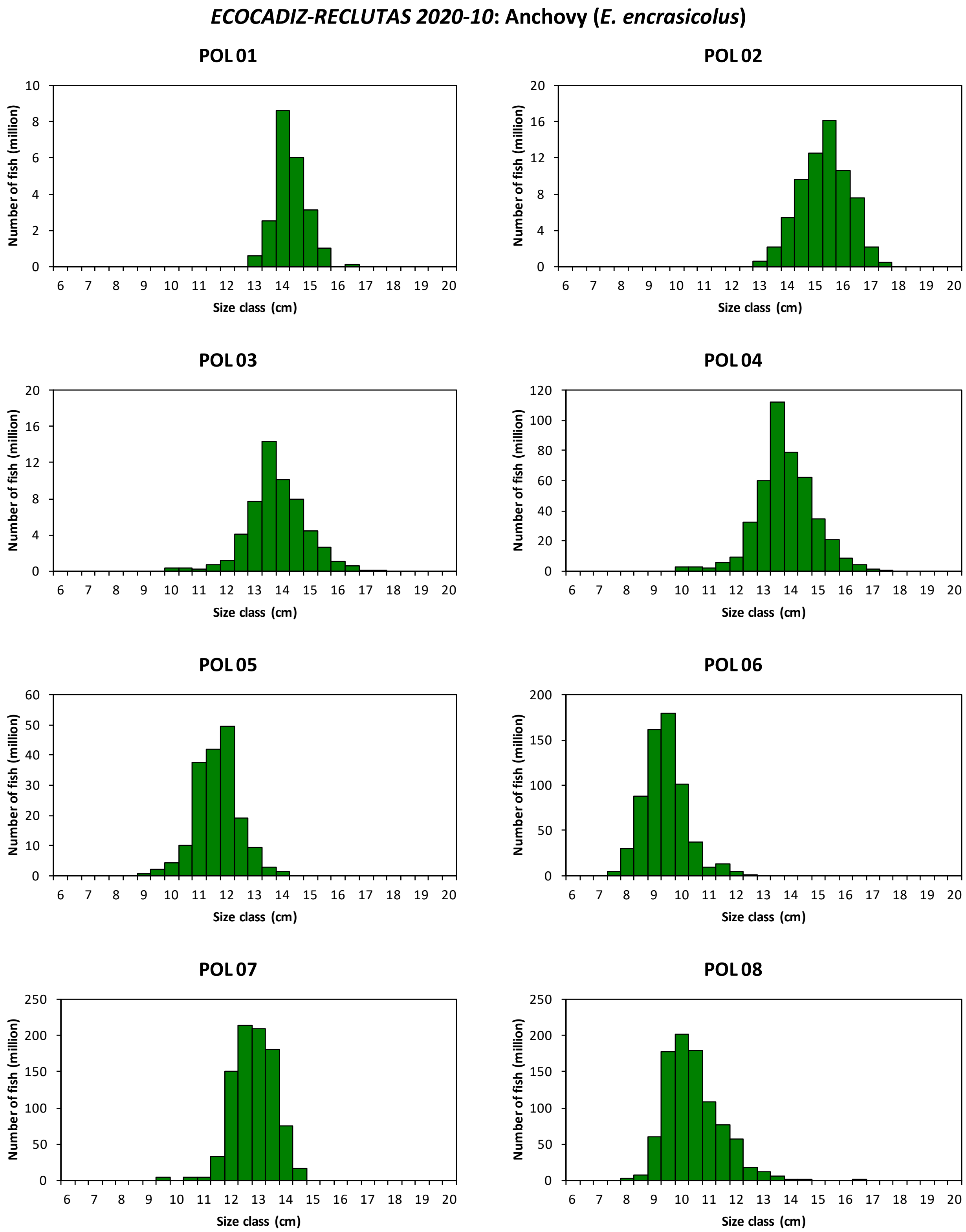


Figure 8. *ECOCADIZ-RECLUTAS 2020-10* survey. Anchovy (*Engraulis encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 7**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

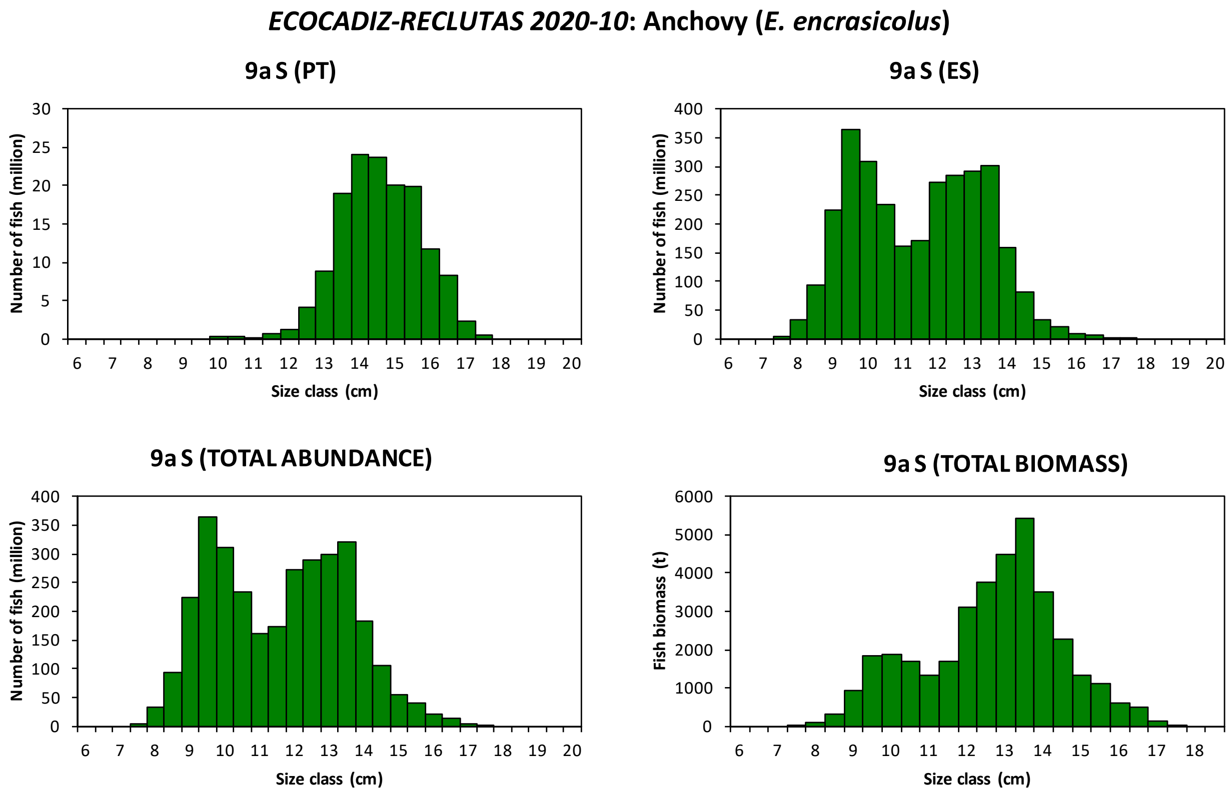


Figure 8. *ECOCADIZ-RECLUTAS 2020-10* survey. Anchovy (*Engraulis encrasicolus*). Cont'd.

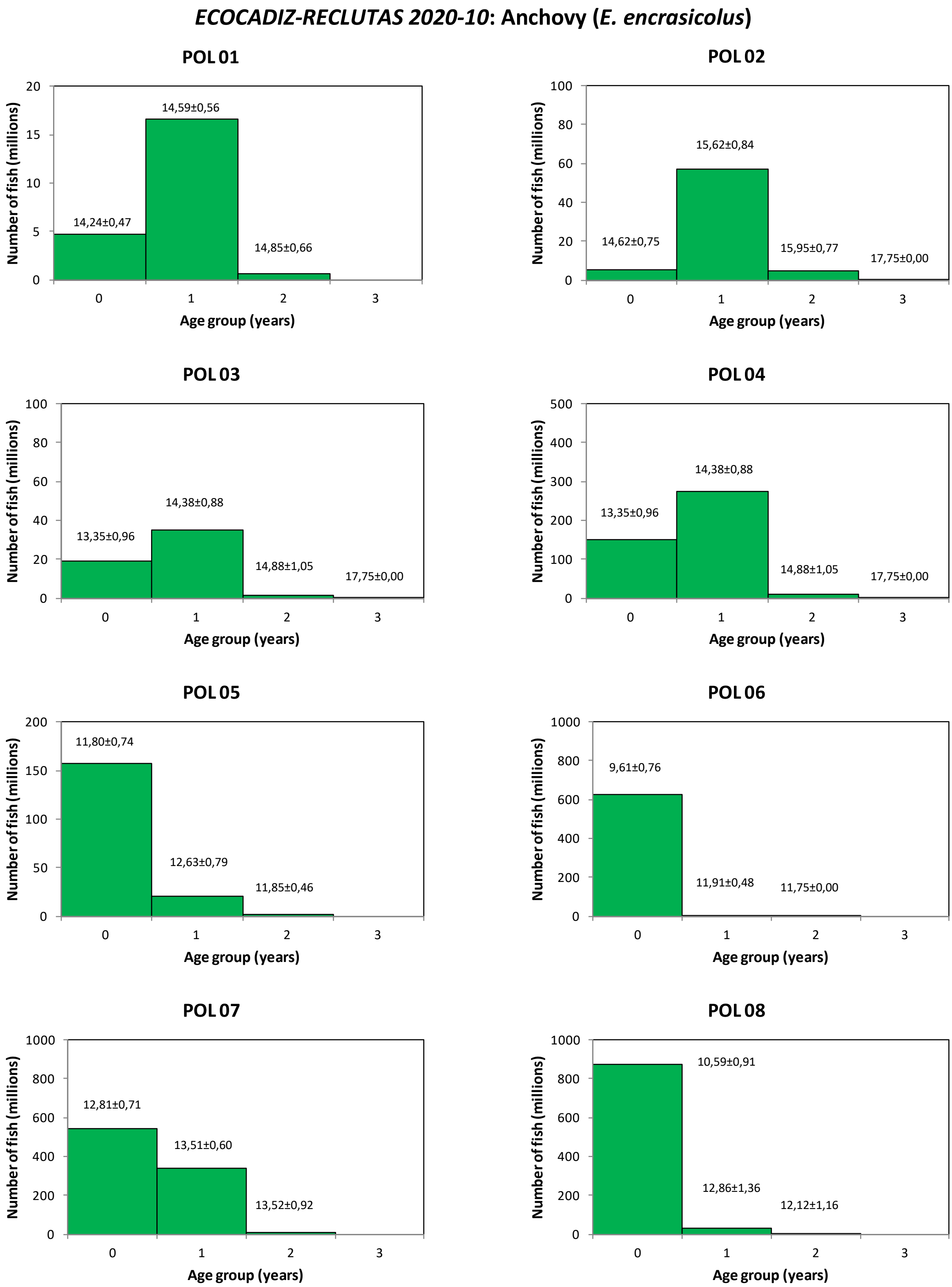


Figure 9. *ECOCADIZ-RECLUTAS 2020-10* survey. Anchovy (*Engraulis encrasicolus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 7**) and total sampled area. Post-strata ordered in the W-E direction. Mean (±SD) sizes of age groups are also shown. 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.

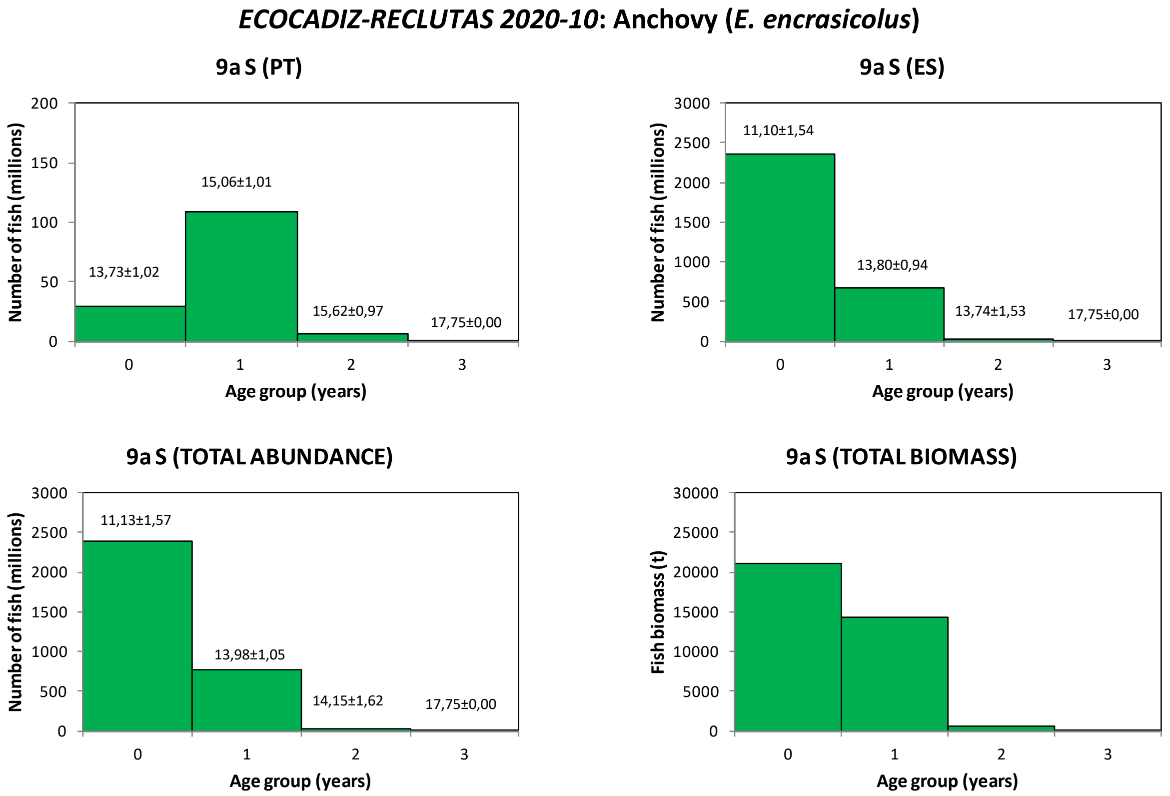


Figure 9. *ECOCADIZ-RECLUTAS 2020-10* survey. Anchovy (*Engraulis encrasicolus*). Cont'd.

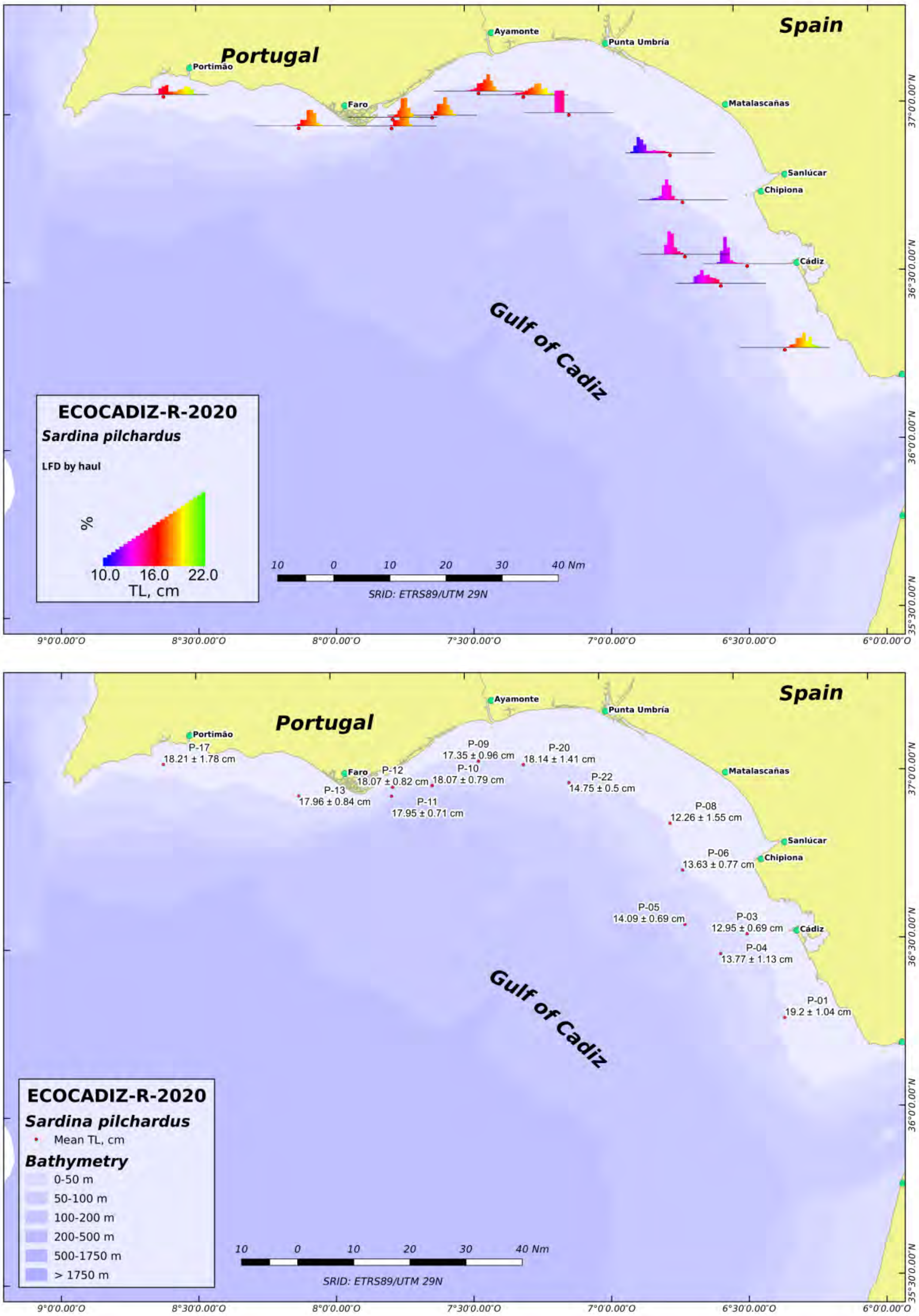


Figure 10. *ECOCADIZ-RECLUTAS 2020-10* survey. Sardine (*Sardina pilchardus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

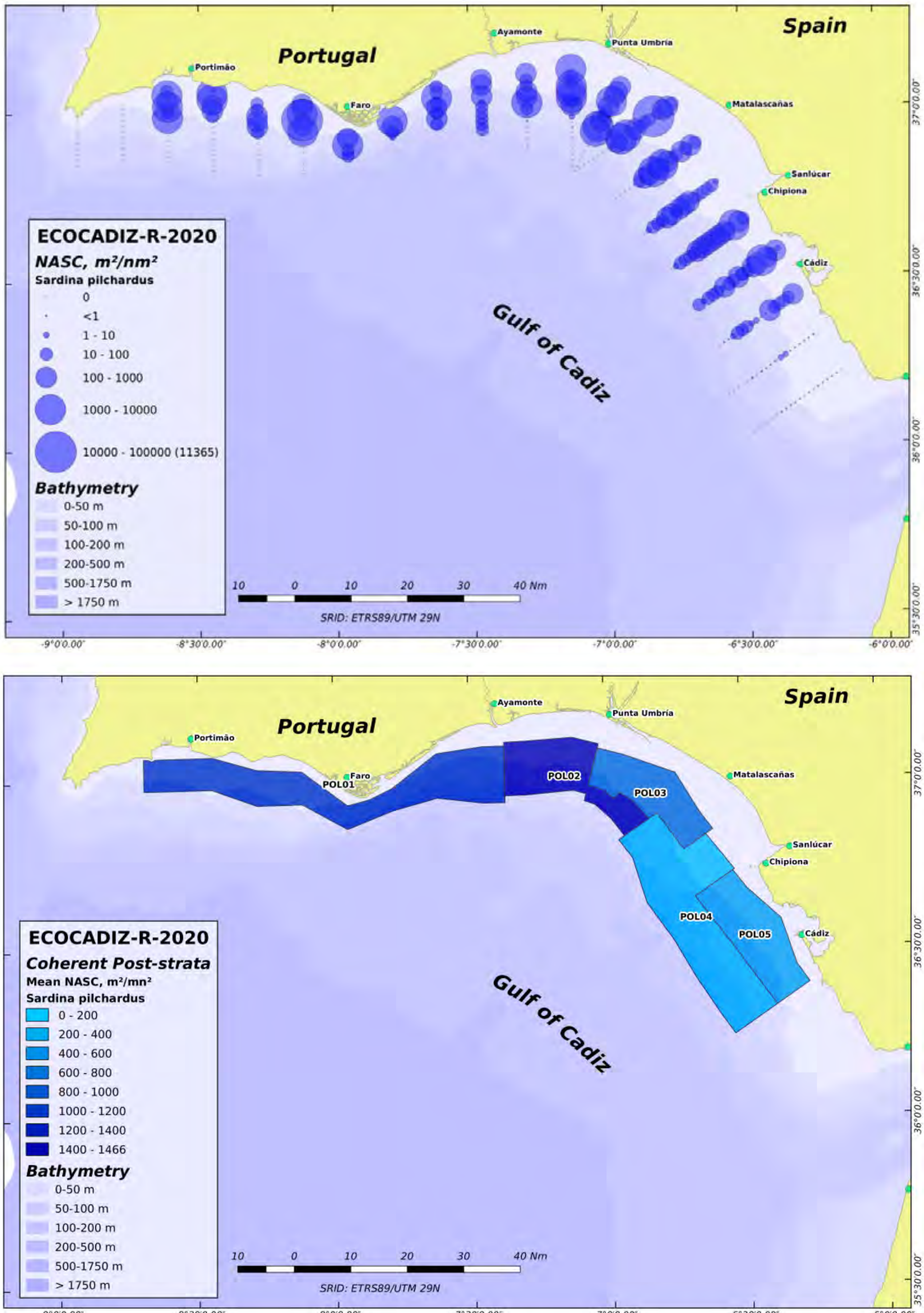


Figure 11. *ECOCADIZ-RECLUTAS 2020-10* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

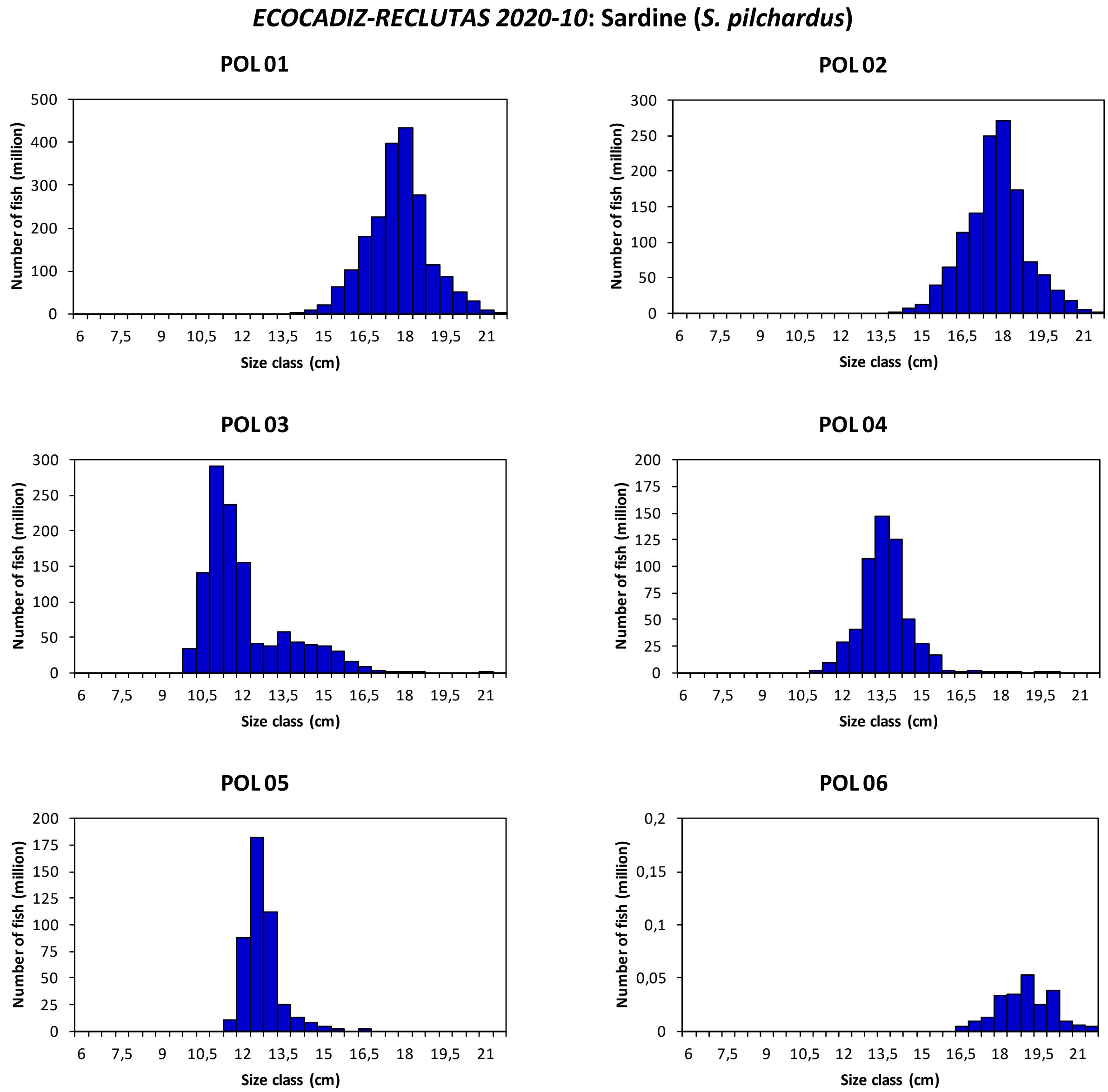


Figure 12. *ECOCADIZ-RECLUTAS 2020-10* survey. Sardine (*Sardina pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 11**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

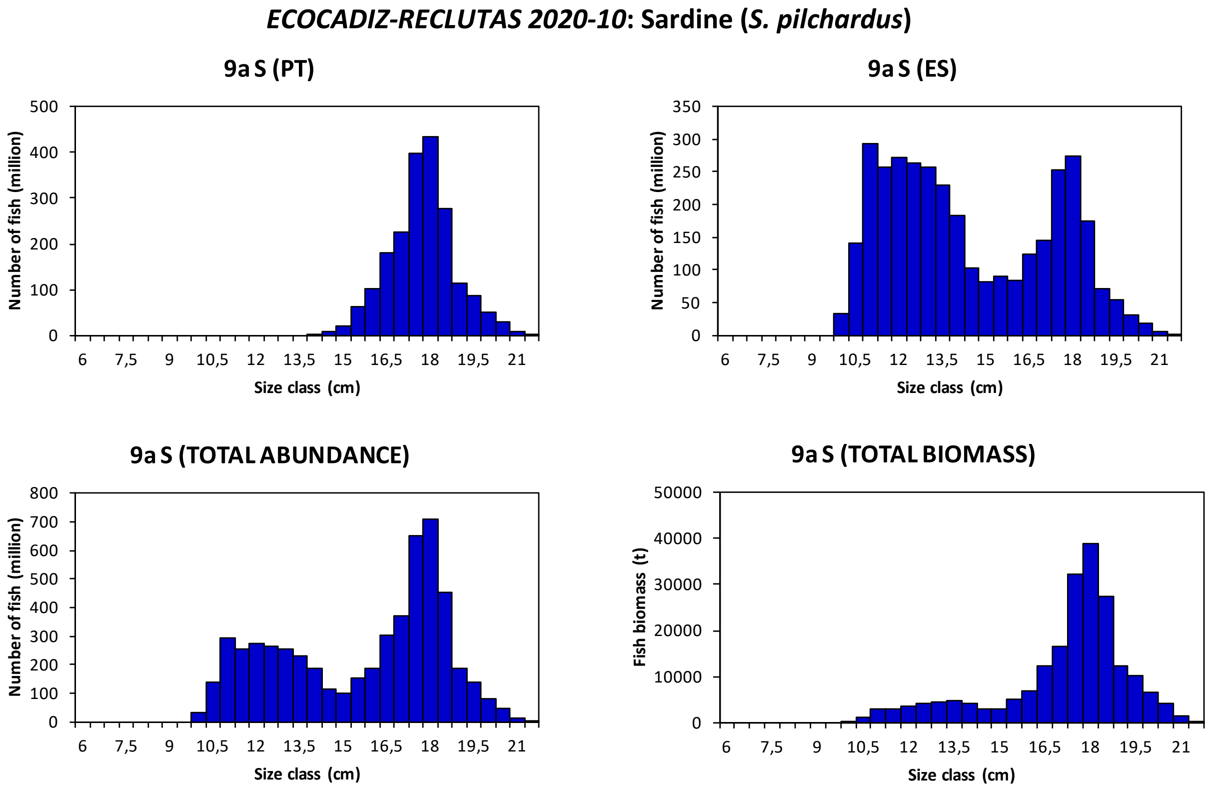


Figure 12. *ECOCADIZ-RECLUTAS 2020-10* survey. Sardine (*Sardina pilchardus*). Cont'd.

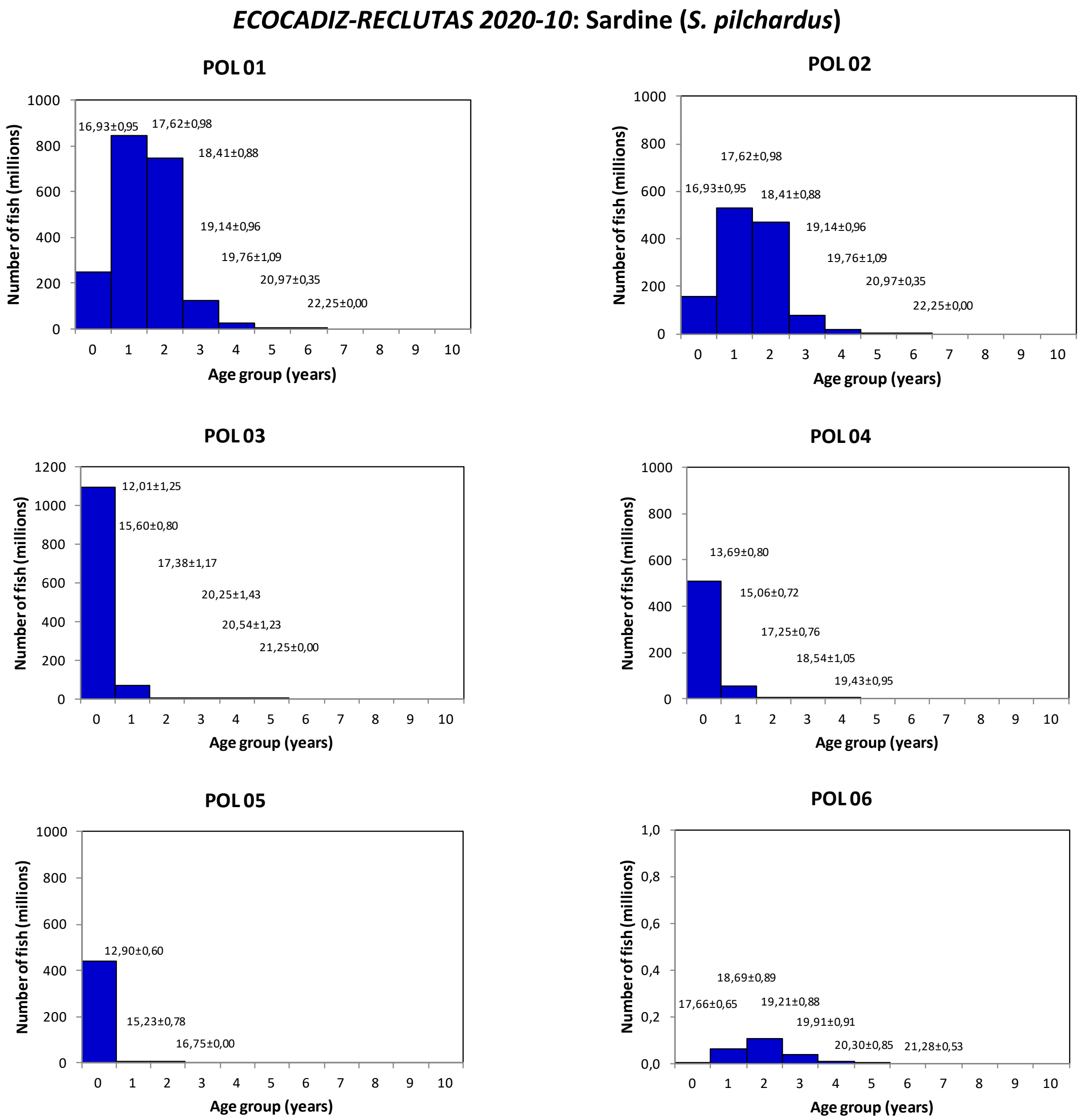


Figure 13. *ECOCADIZ-RECLUTAS 2020-10* survey. Sardine (*Sardina pilchardus*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 11**) and total sampled area. Post-strata ordered in the W-E direction. Mean (±SD) sizes of age groups are also shown. 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.

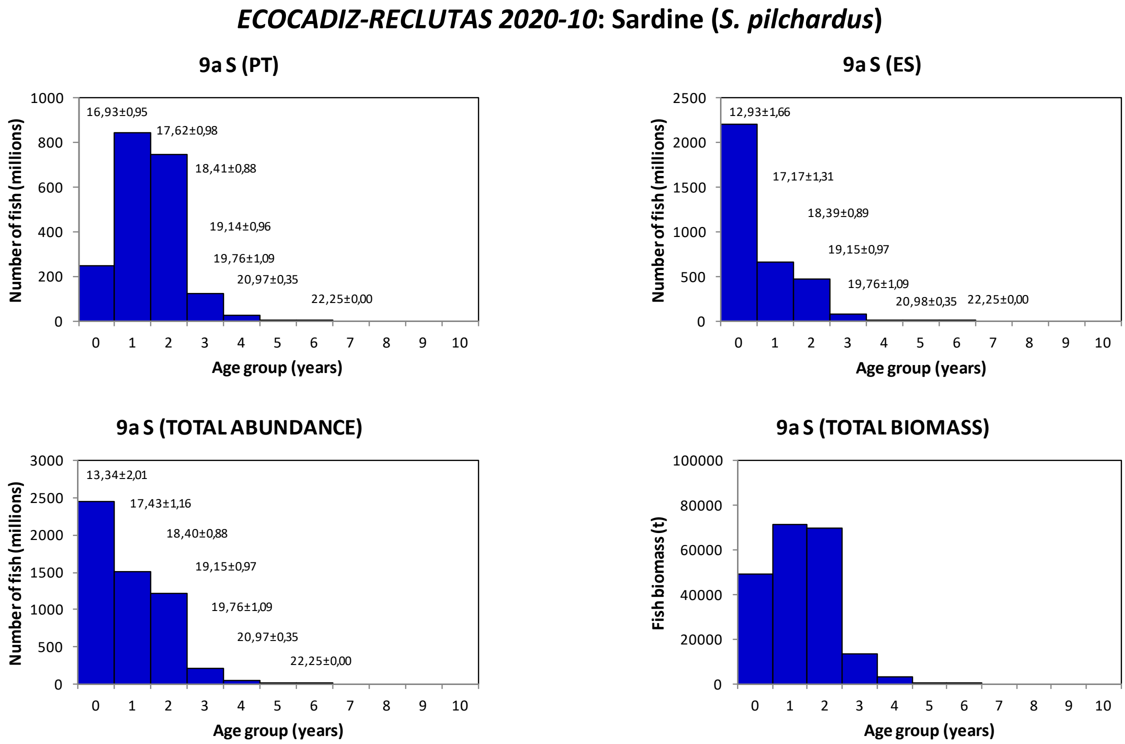


Figure 13. *ECOCADIZ-RECLUTAS 2020-10* survey. Sardine (*Sardina pilchardus*). Cont'd.

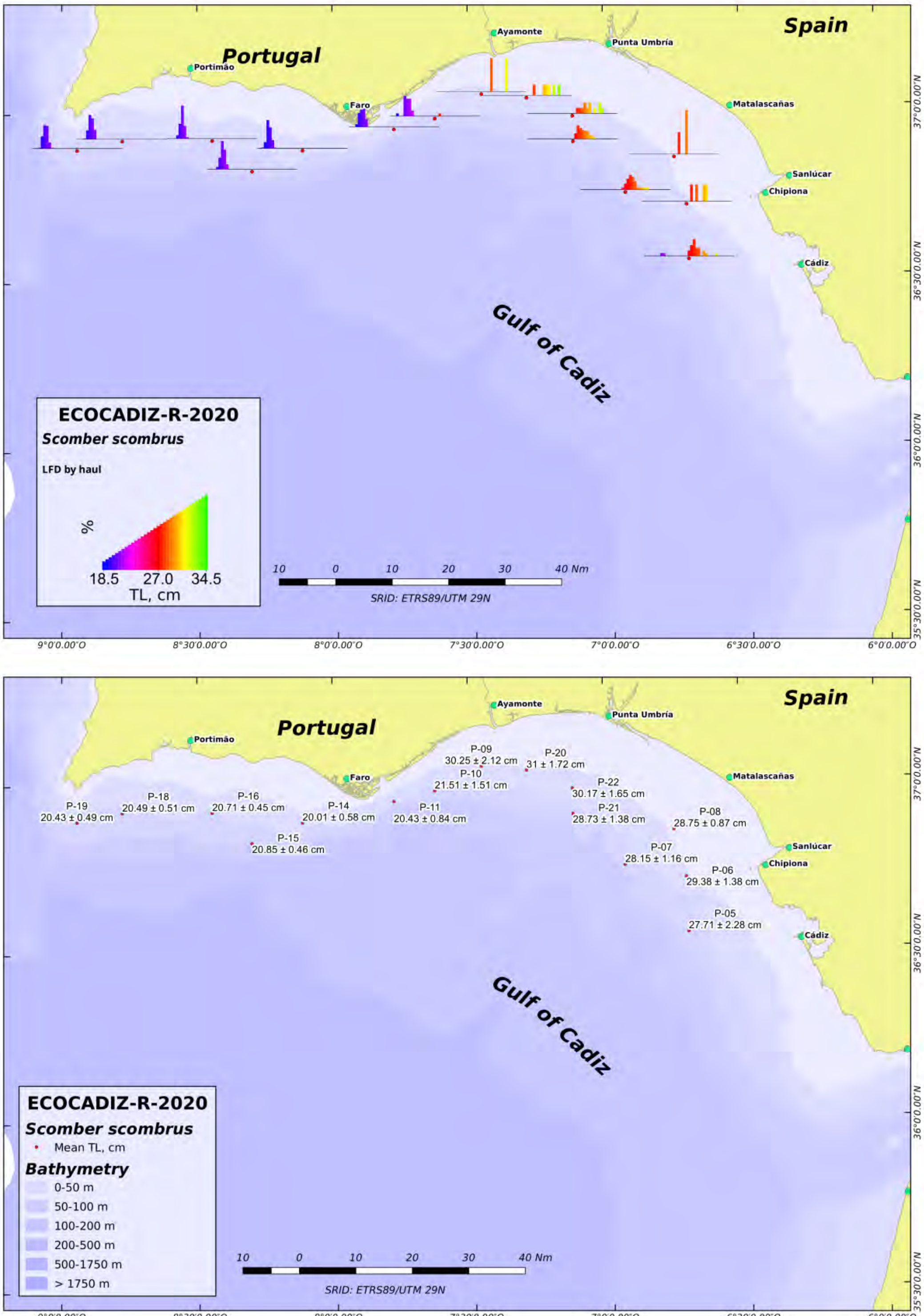


Figure 14. *ECOCADIZ-RECLUTAS 2020-10* survey. Atlantic mackerel (*Scomber scombrus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

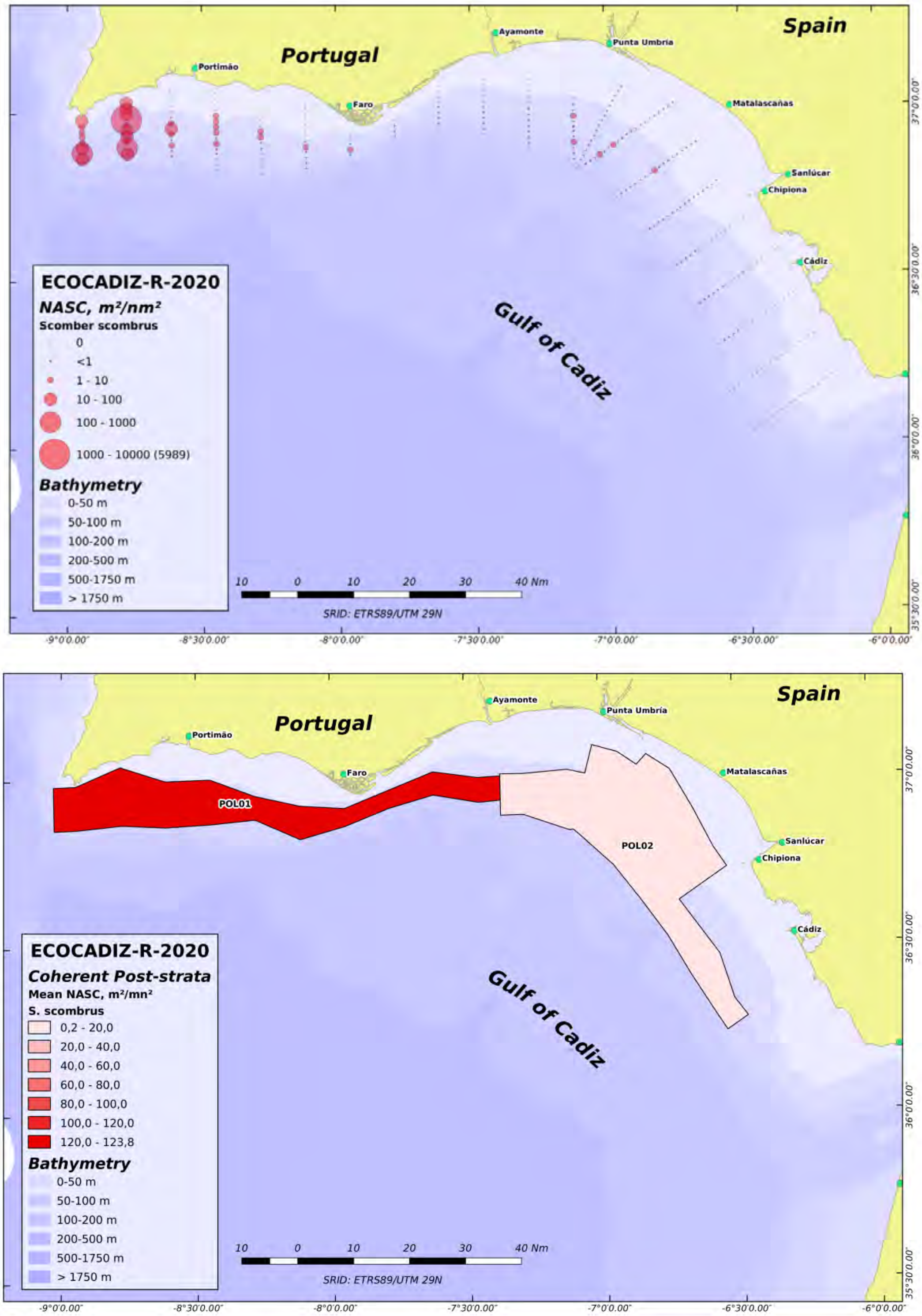


Figure 15. *ECOCADIZ-RECLUTAS 2020-10* survey. Atlantic mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

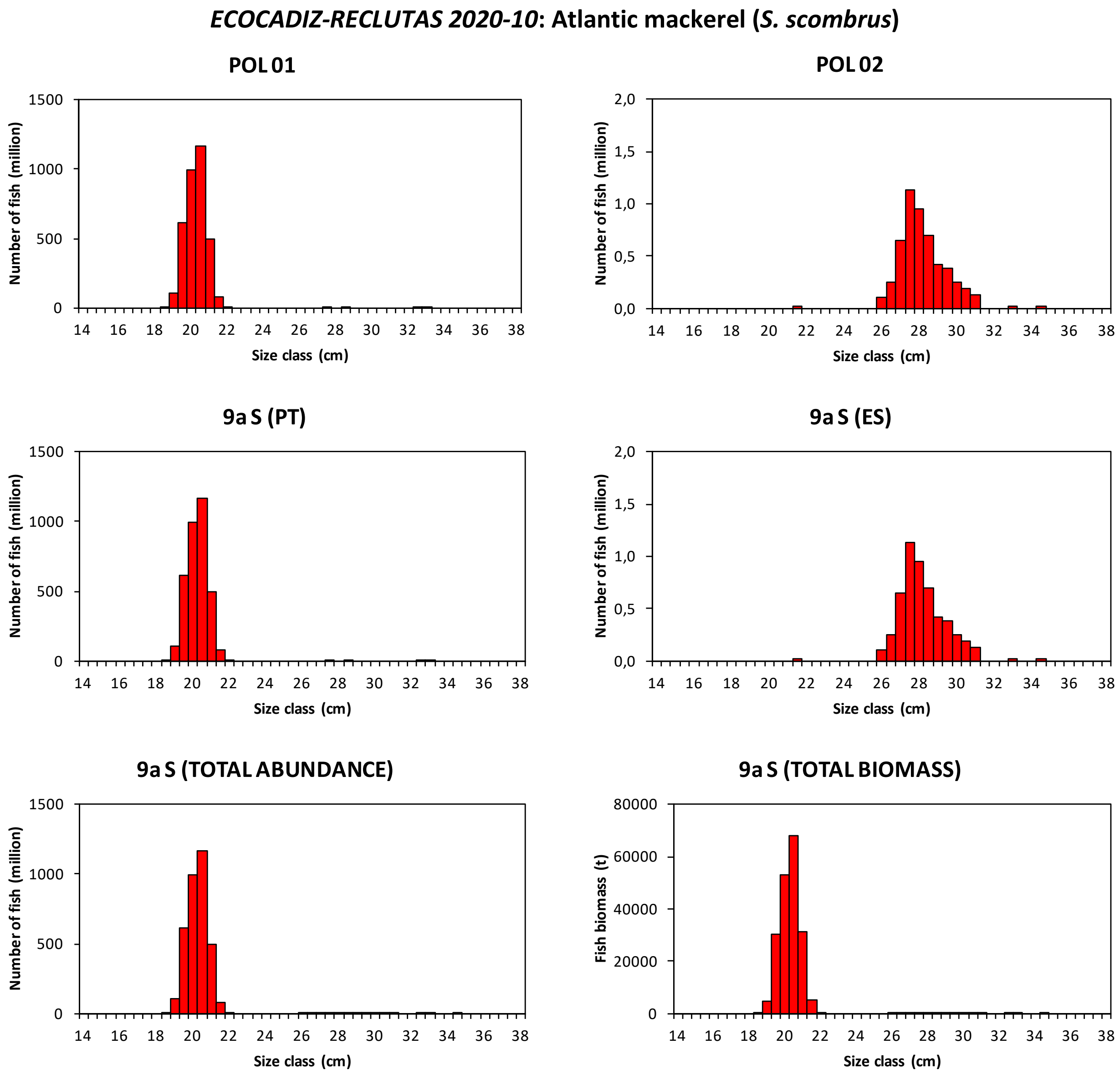


Figure 16. *ECOCADIZ-RECLUTAS 2020-10* survey. Atlantic mackerel (*Scomber scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 15**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

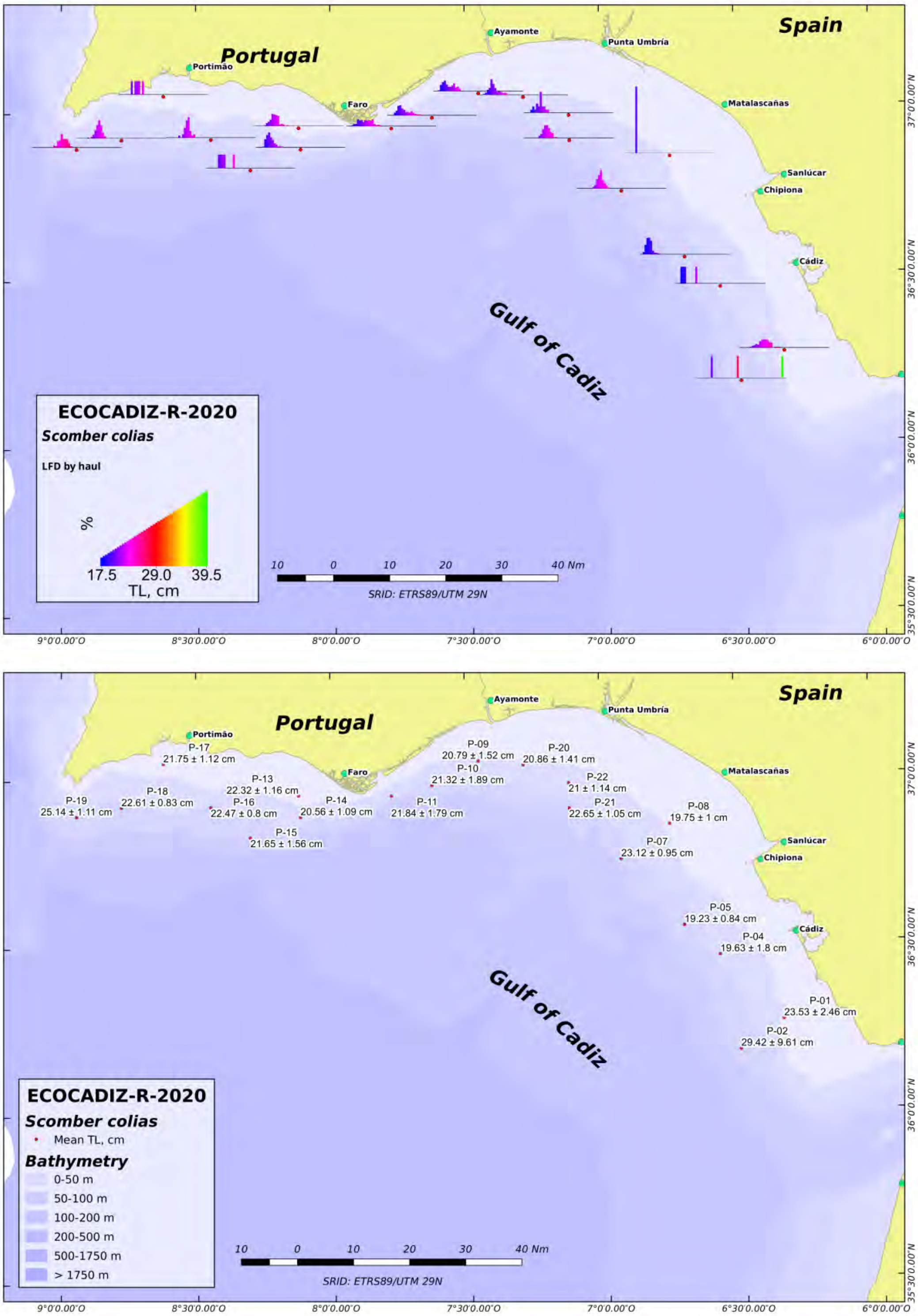


Figure 17. *ECOCADIZ-RECLUTAS 2020-10* survey. Chub mackerel (*Scomber colias*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

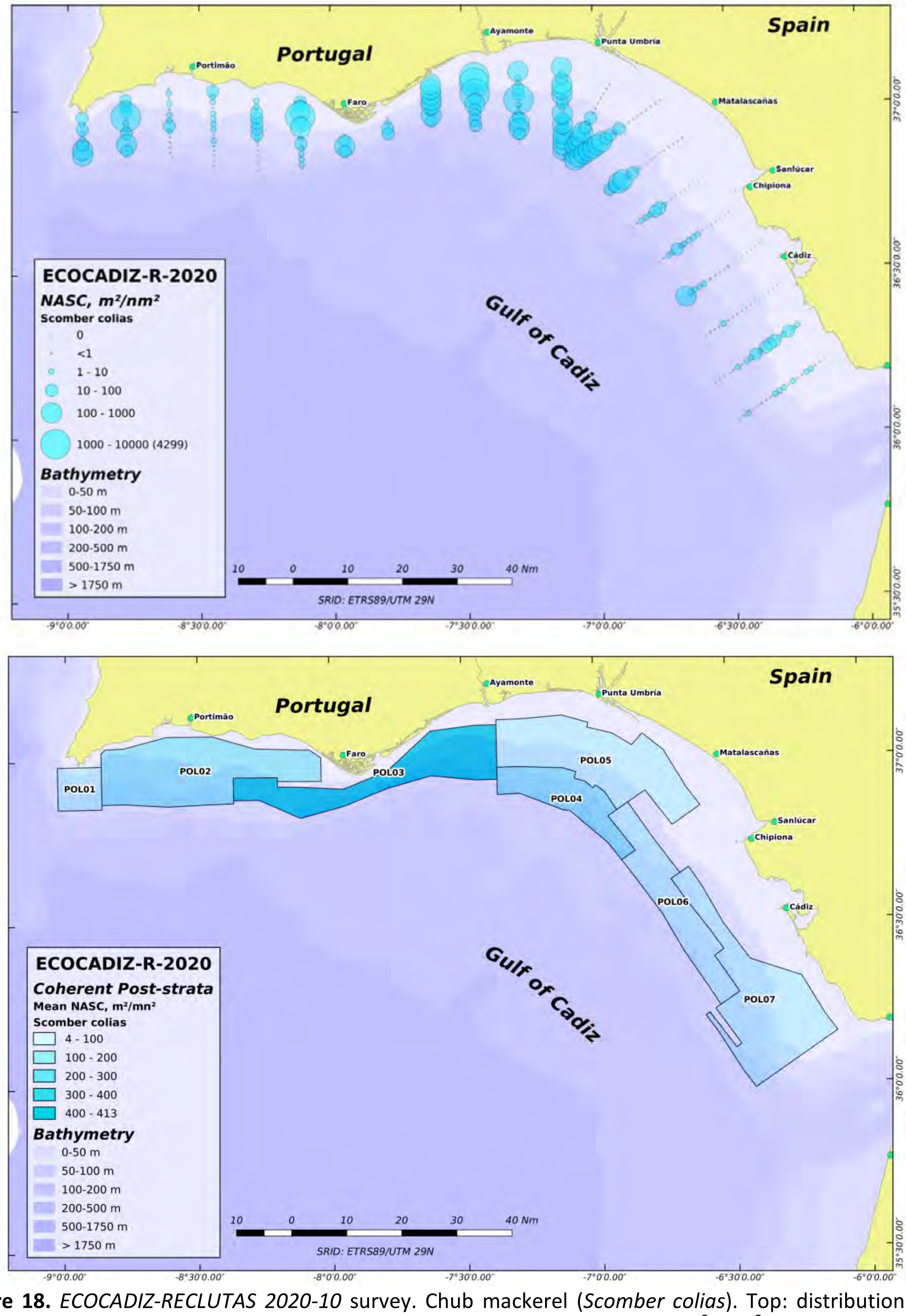


Figure 18. *ECOCADIZ-RECLUTAS 2020-10* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

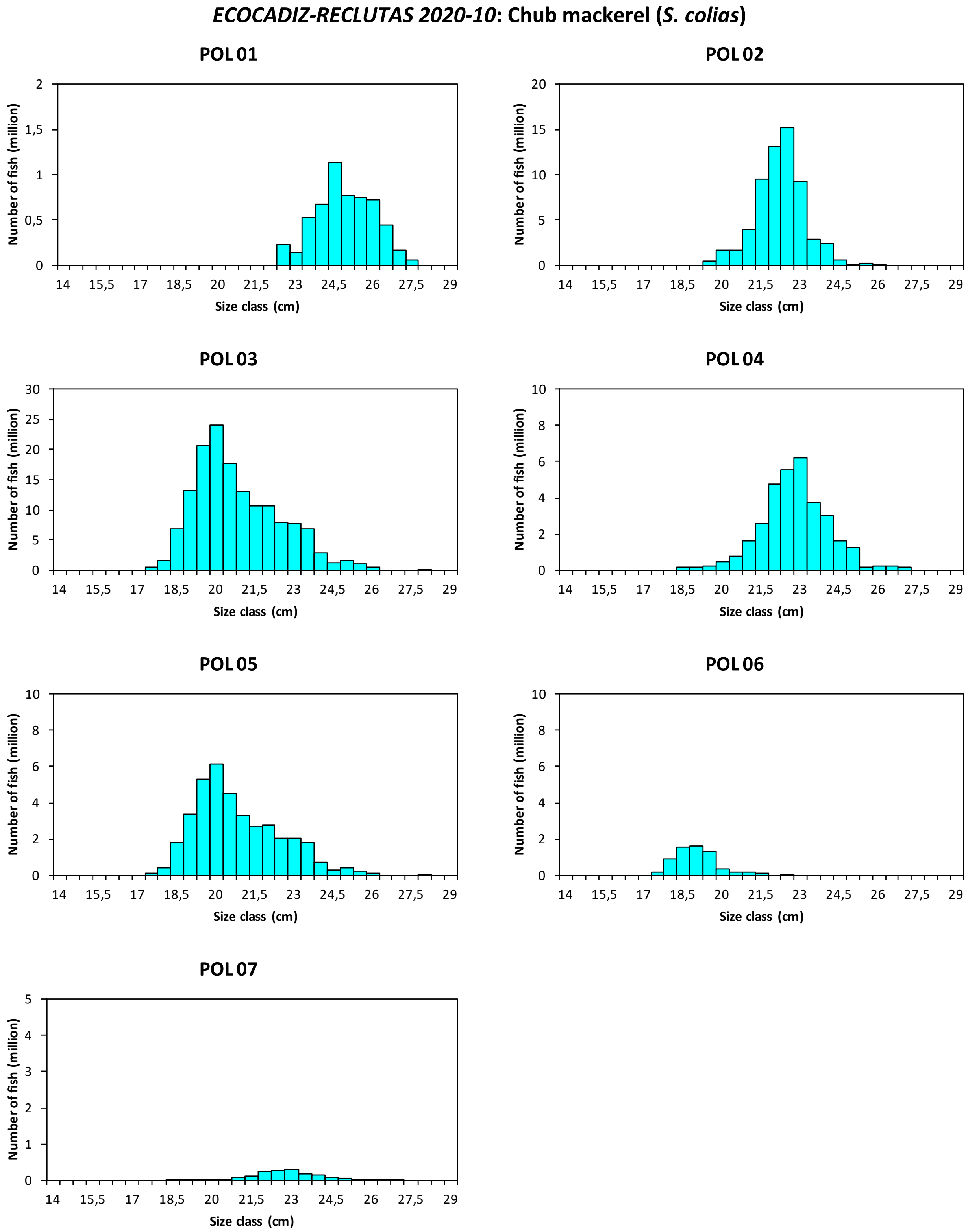


Figure 19. *ECOCADIZ-RECLUTAS 2020-10* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 18**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

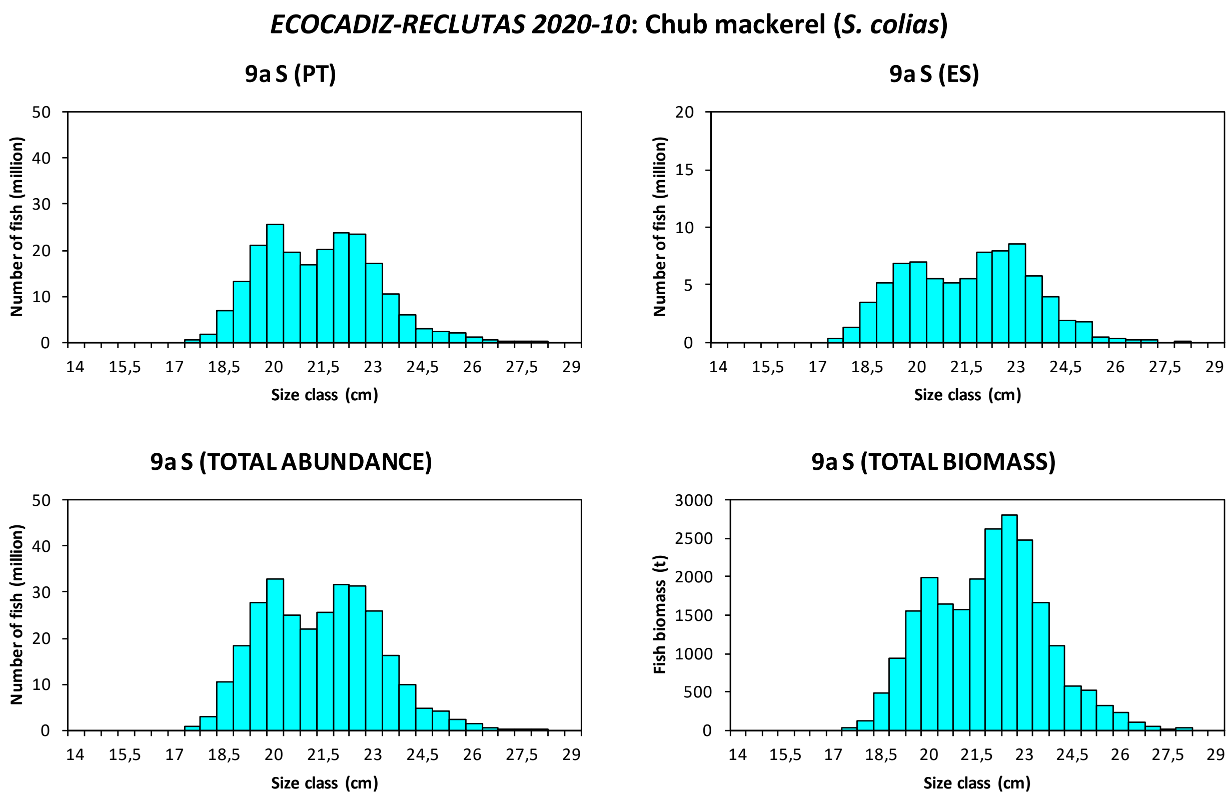


Figure 19. *ECOCADIZ-RECLUTAS 2020-10* survey. Chub mackerel (*Scomber colias*). Cont'd.

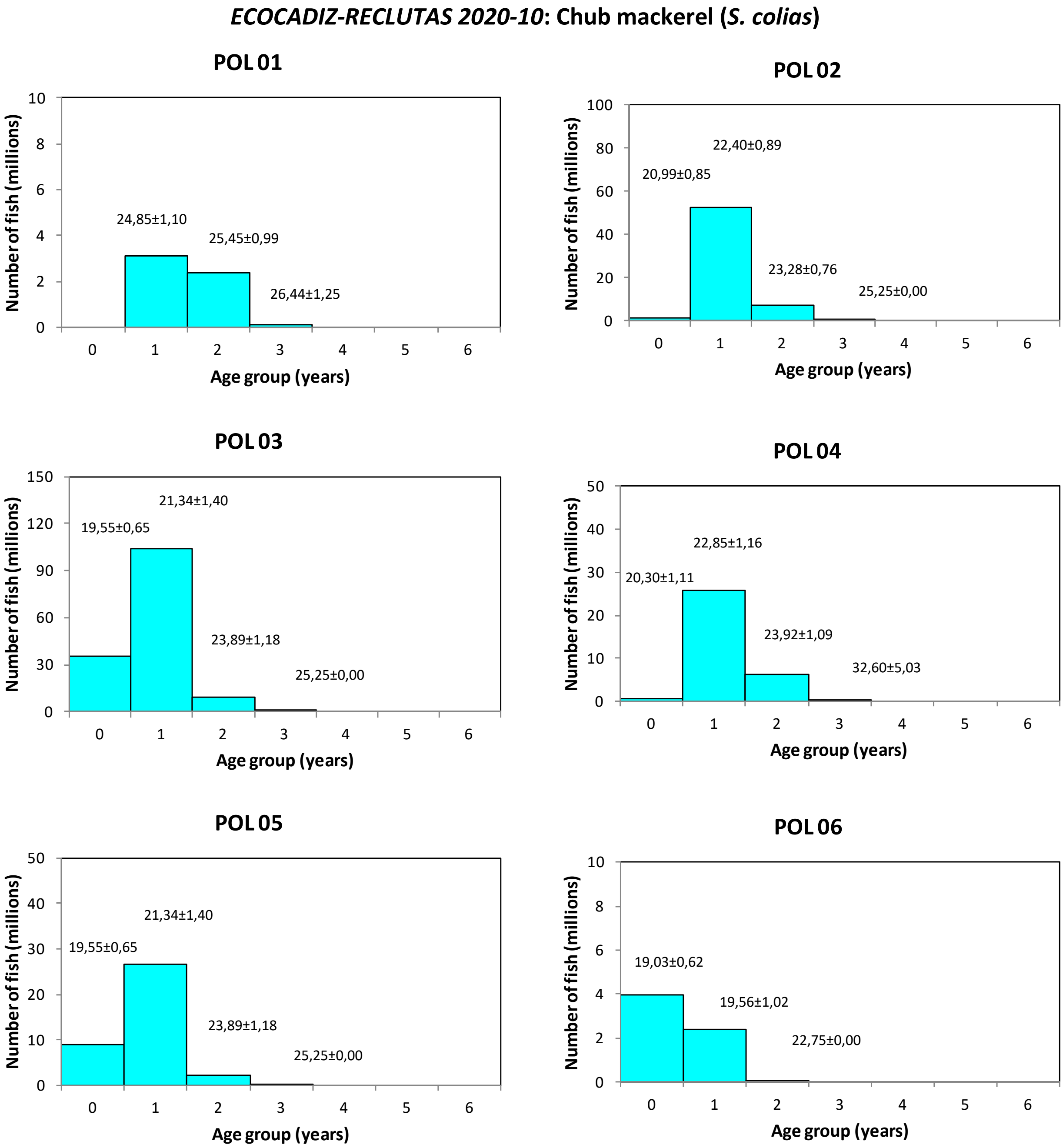


Figure 20. *ECOCADIZ-RECLUTAS 2020-10* survey. Chub mackerel (*Scomber colias*). Estimated abundances (number of fish in millions) by age group (years) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 18**) and total sampled area. Post-strata ordered in the W-E direction. Mean (±SD) sizes of age groups are also shown. 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.

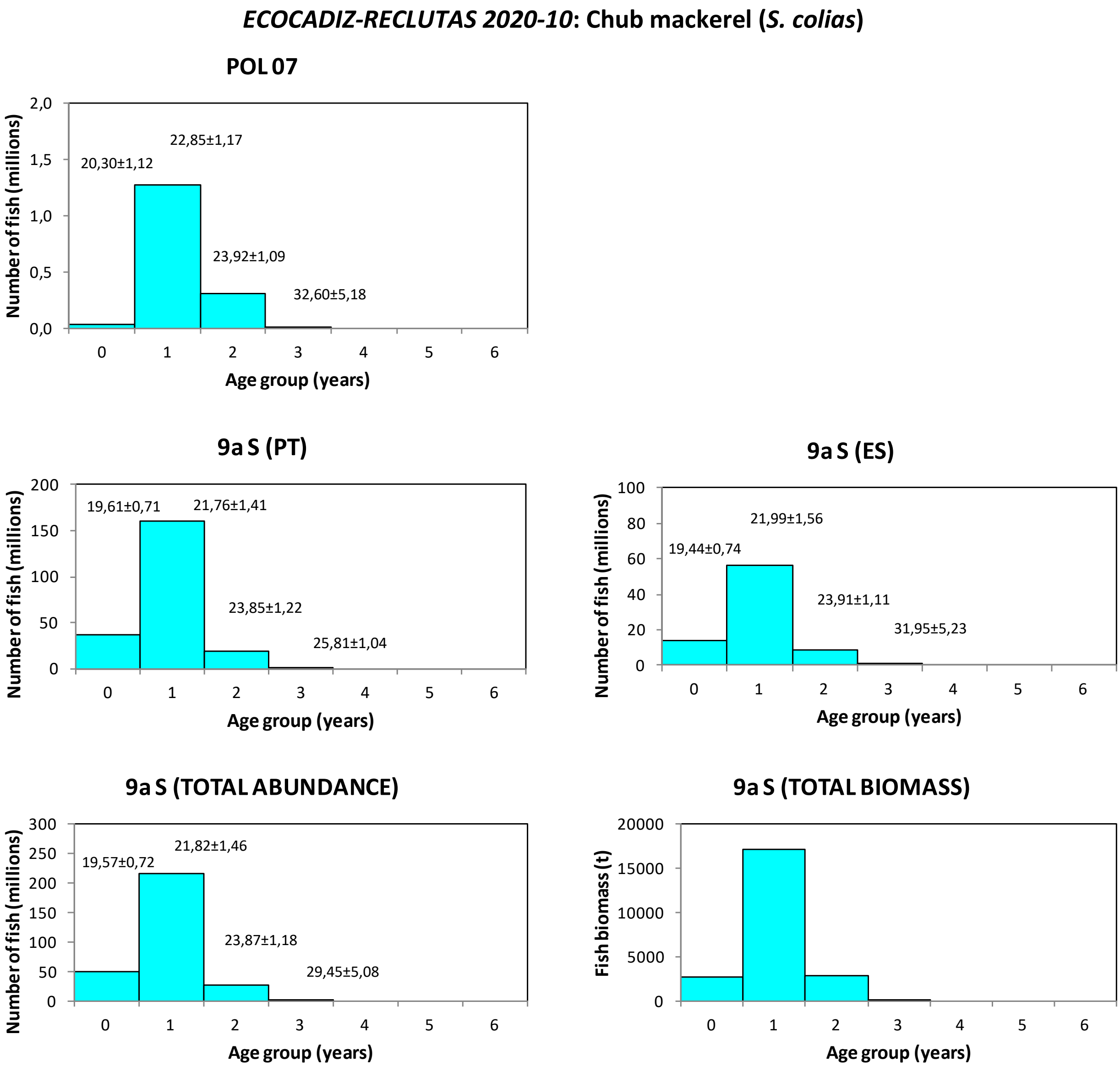


Figure 20. *ECOCADIZ-RECLUTAS 2020-10* survey. Chub mackerel (*Scomber colias*). Cont'd.

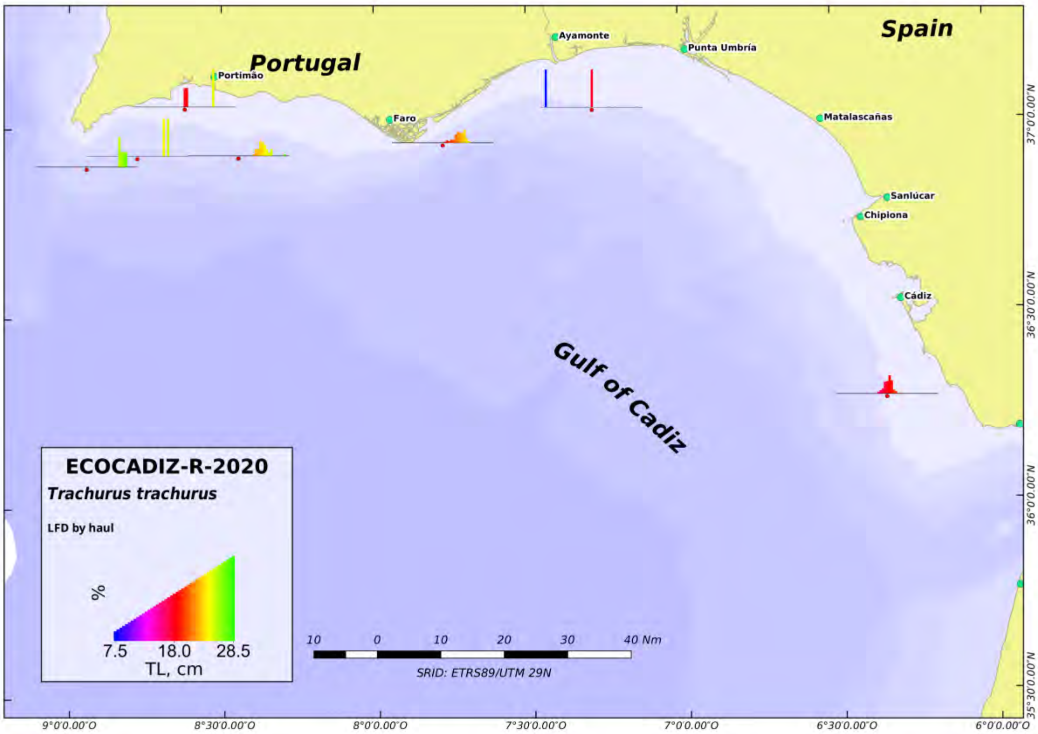


Figure 21. *ECOCADIZ-RECLUTAS 2020-10* survey. Horse mackerel (*Trachurus trachurus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

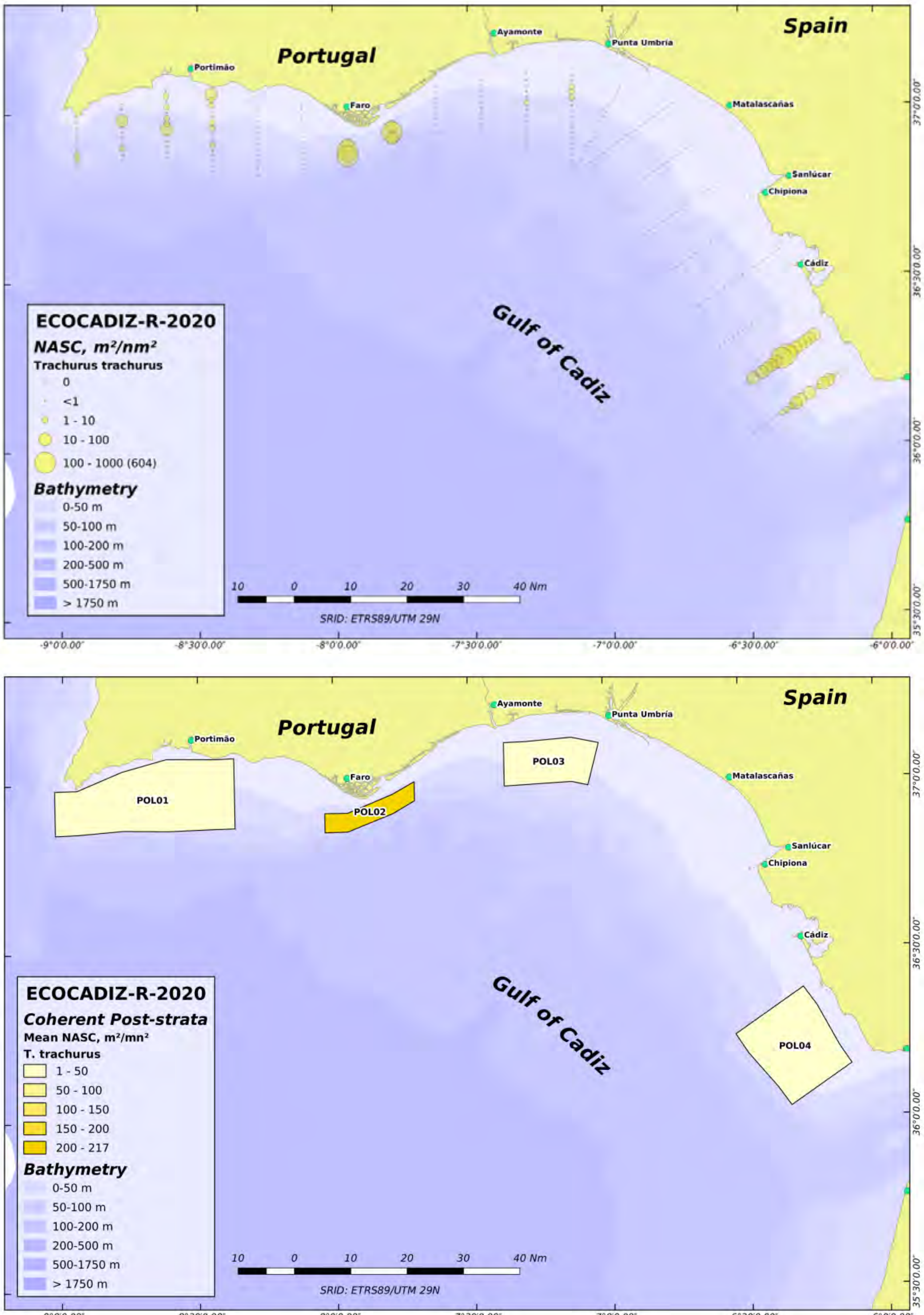


Figure 22. *ECOCADIZ-RECLUTAS 2020-10* survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

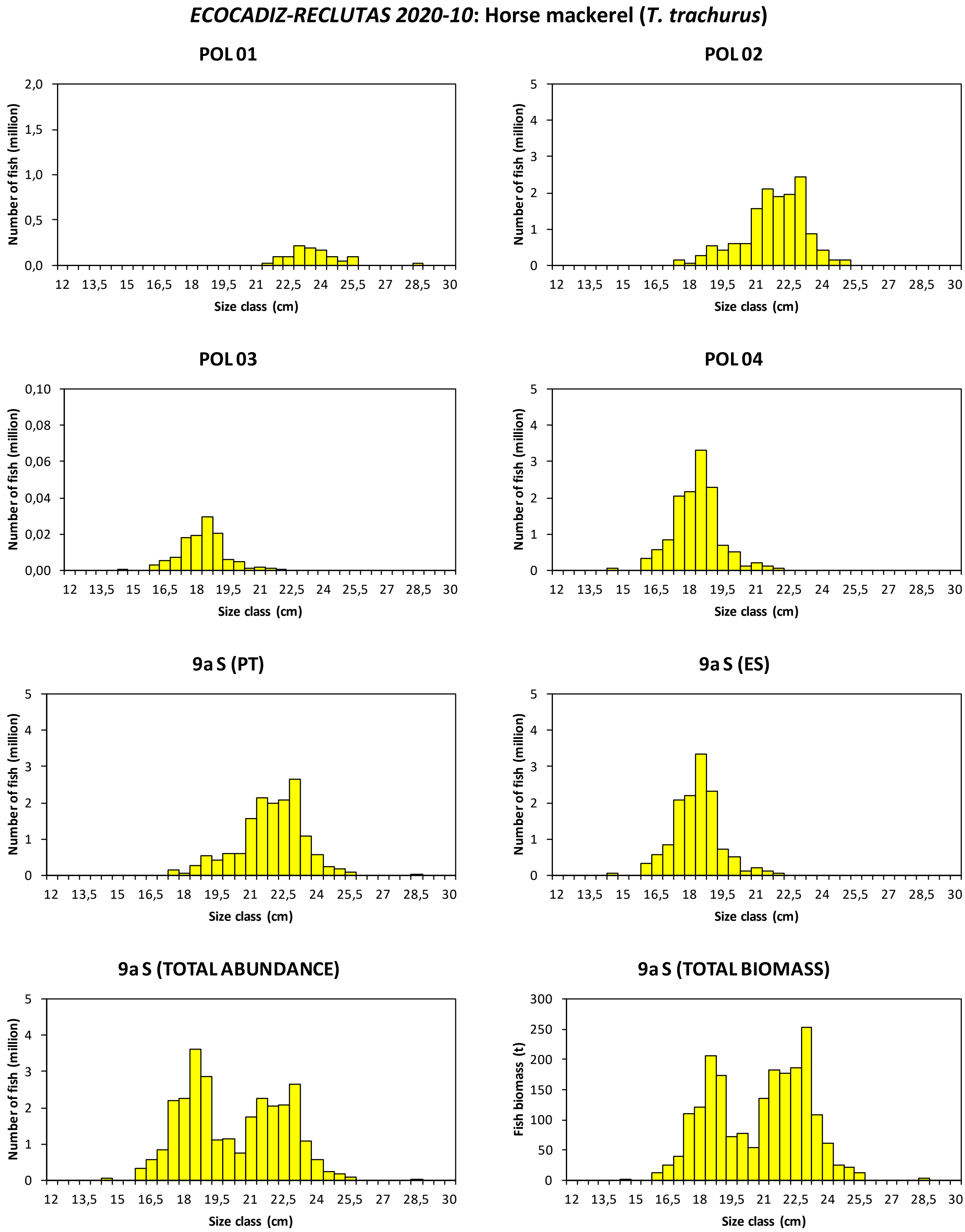


Figure 23. *ECOCADIZ-RECLUTAS 2020-10* survey. Horse mackerel (*Trachurus trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 22**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

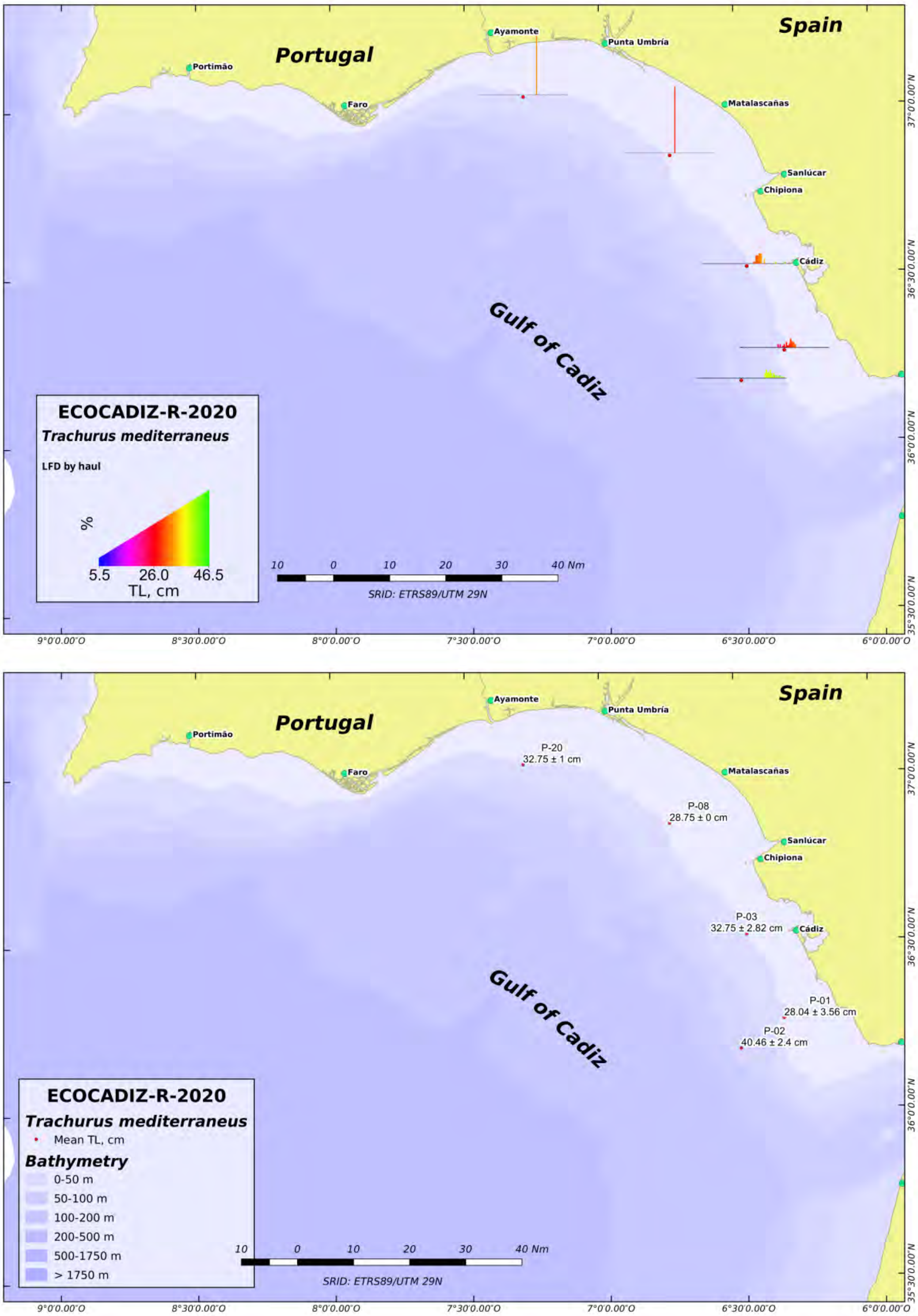


Figure 24. *ECOCADIZ-RECLUTAS 2020-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

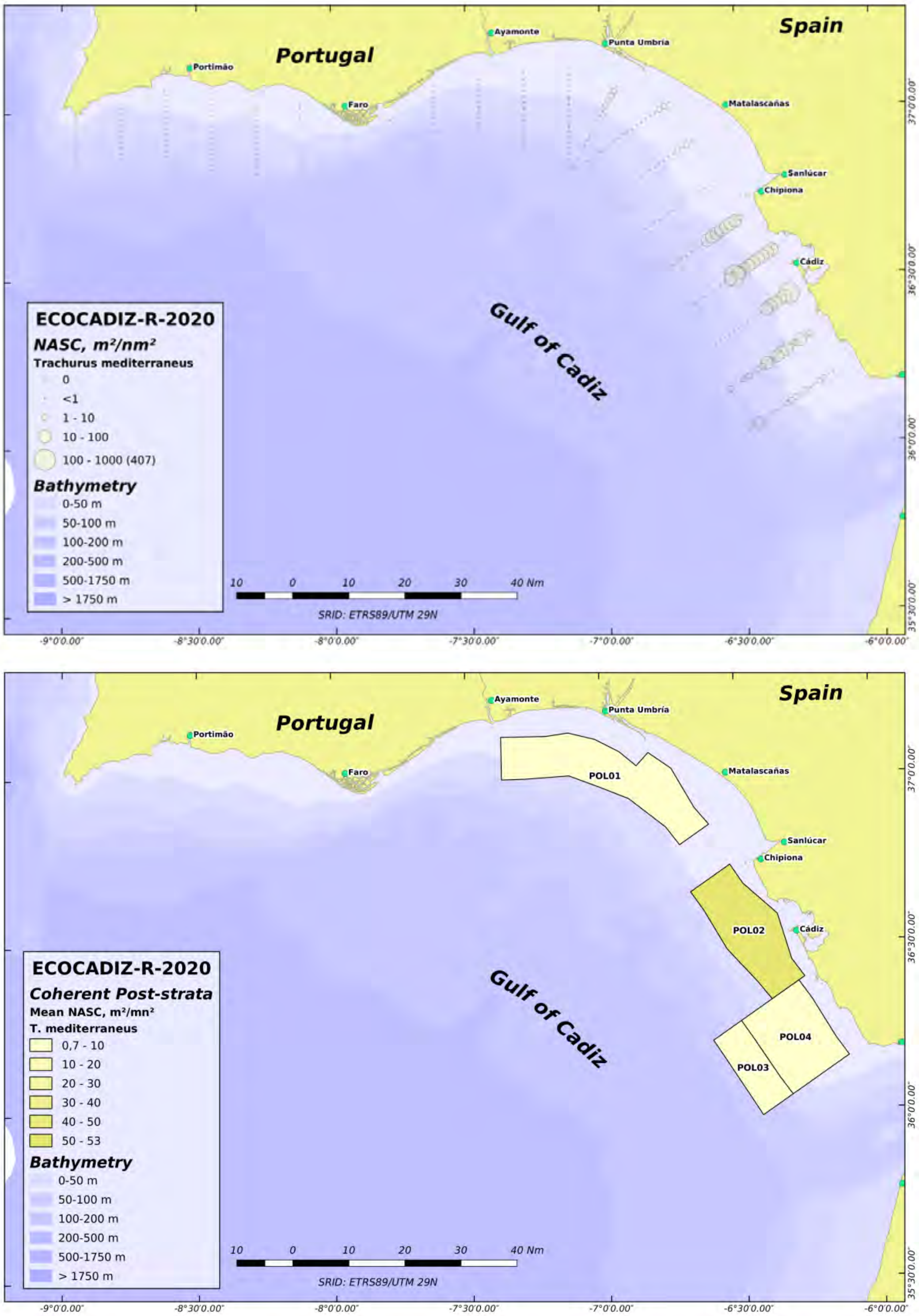


Figure 25. *ECOCADIZ-RECLUTAS 2020-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

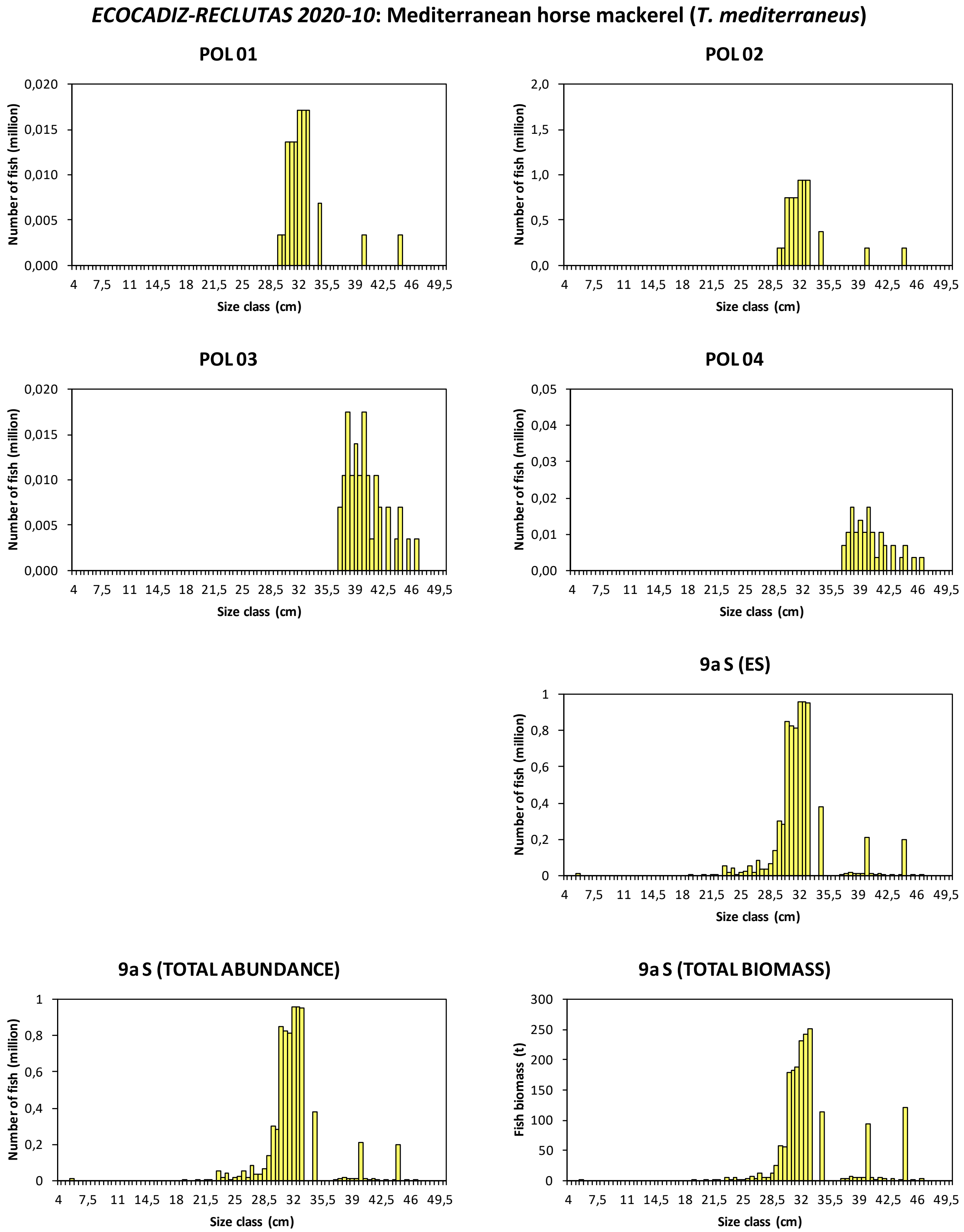
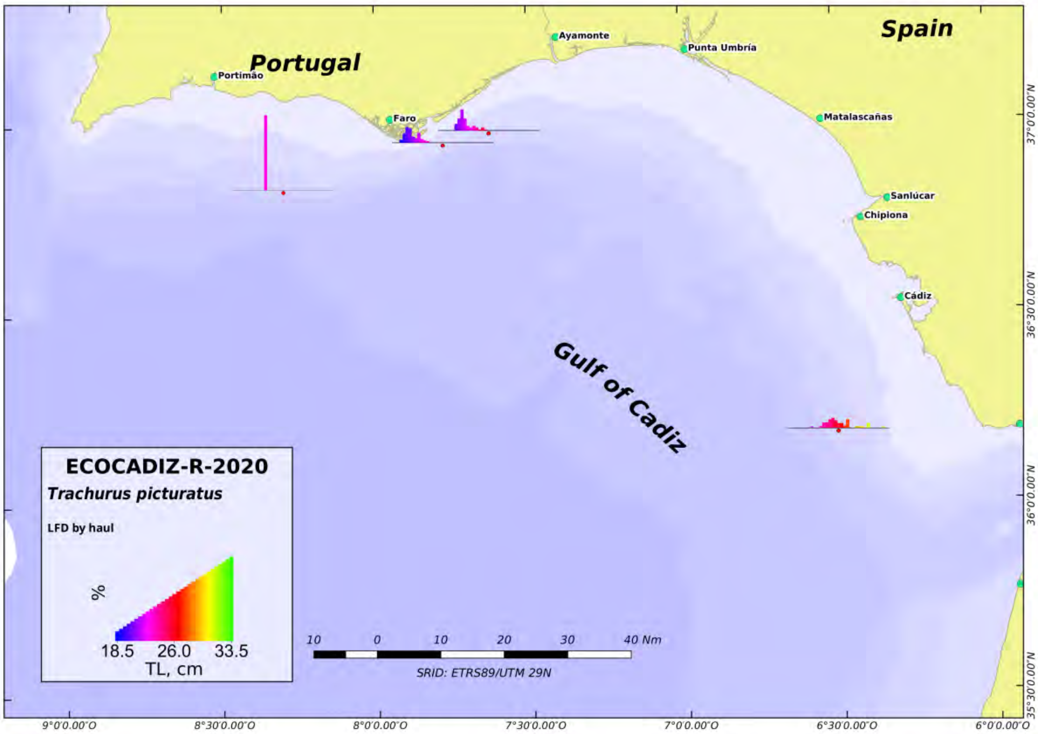


Figure 26. *ECOCADIZ-RECLUTAS 2020-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 25**) and total sampled area. Post-strata ordered in the W-E 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.



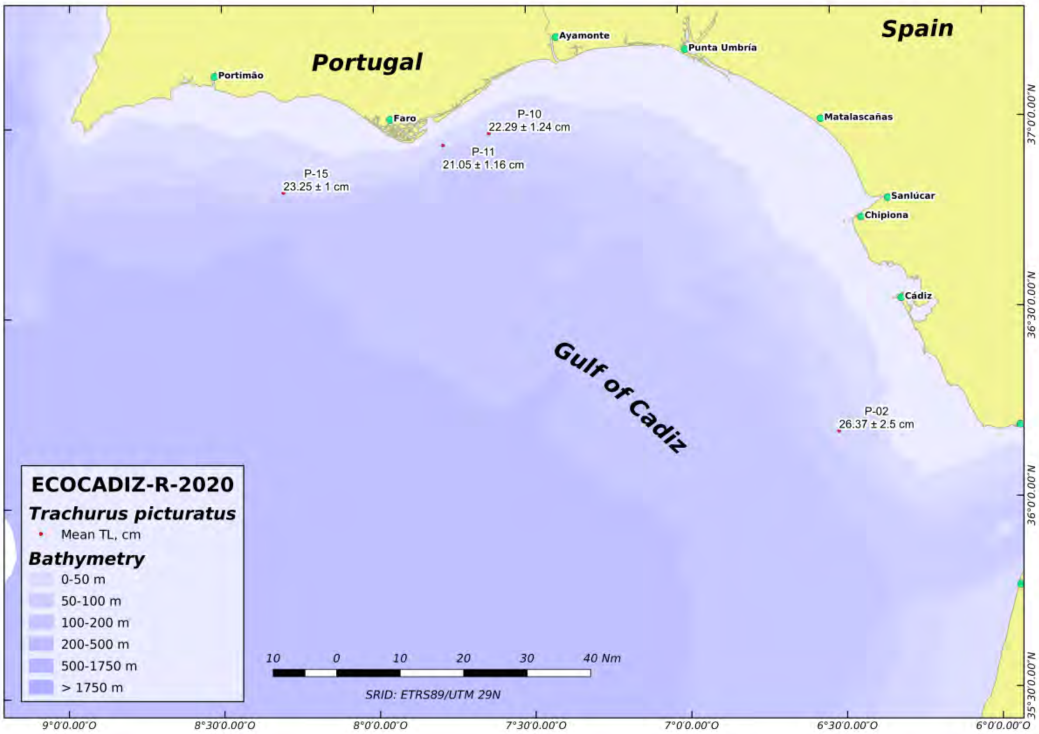


Figure 27. *ECOCADIZ-RECLUTAS 2020-10* survey. Blue jack mackerel (*Trachurus picturatus*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

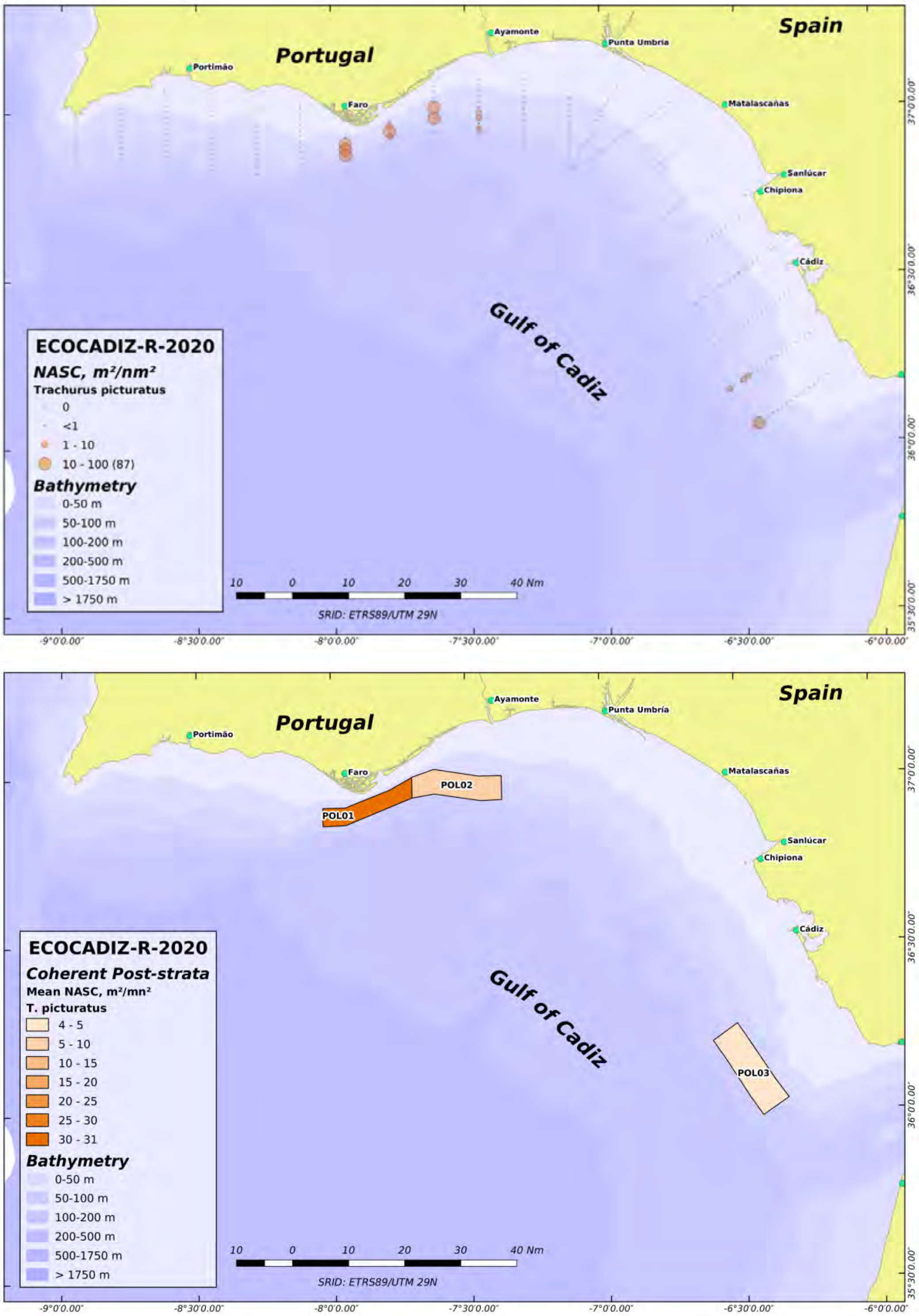


Figure 28. *ECOCADIZ-RECLUTAS 2020-10* survey. Blue jack mackerel (*Trachurus picturatus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

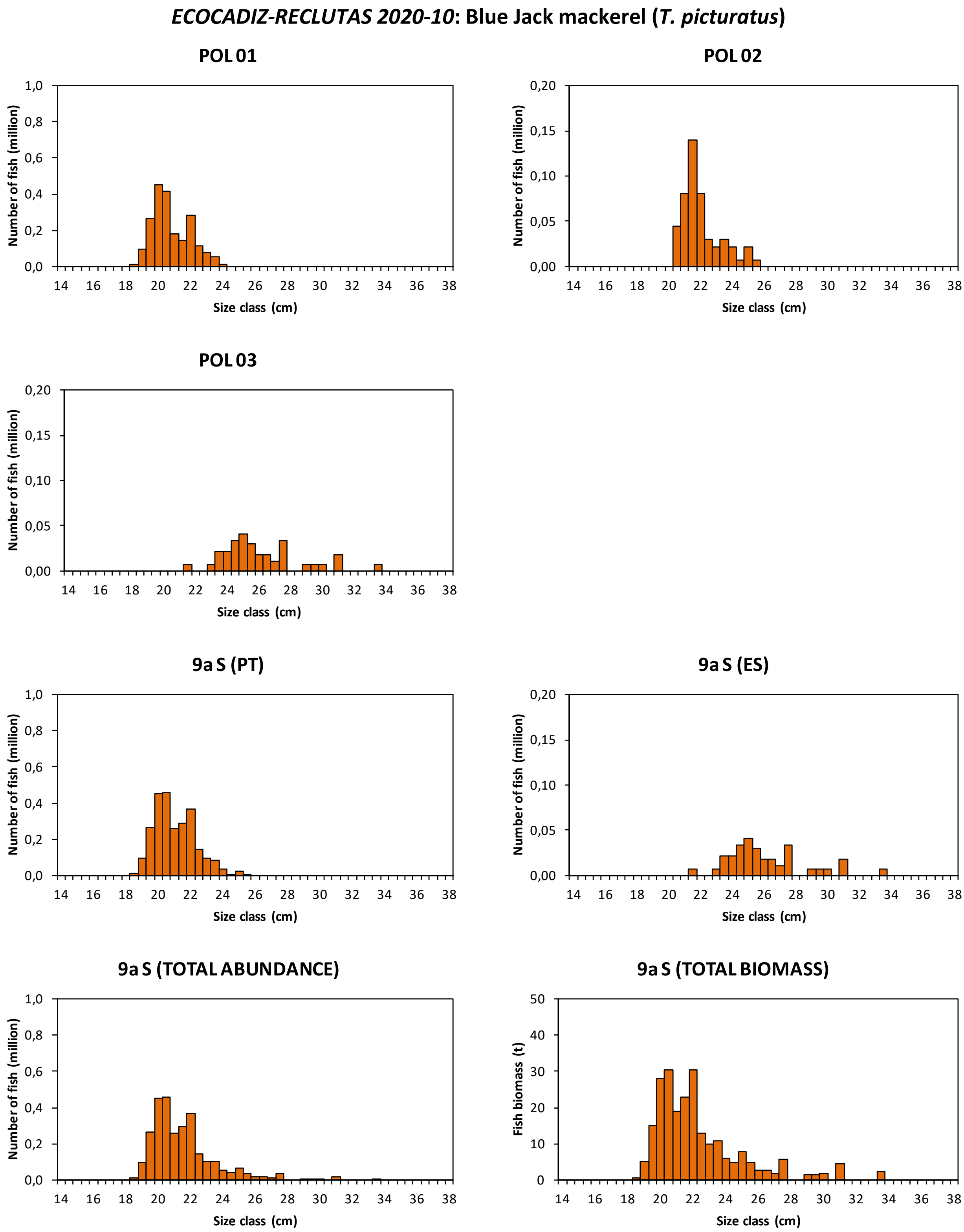


Figure 29. *ECOCADIZ-RECLUTAS 2020-10* survey. Blue jack mackerel (*Trachurus picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 28**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

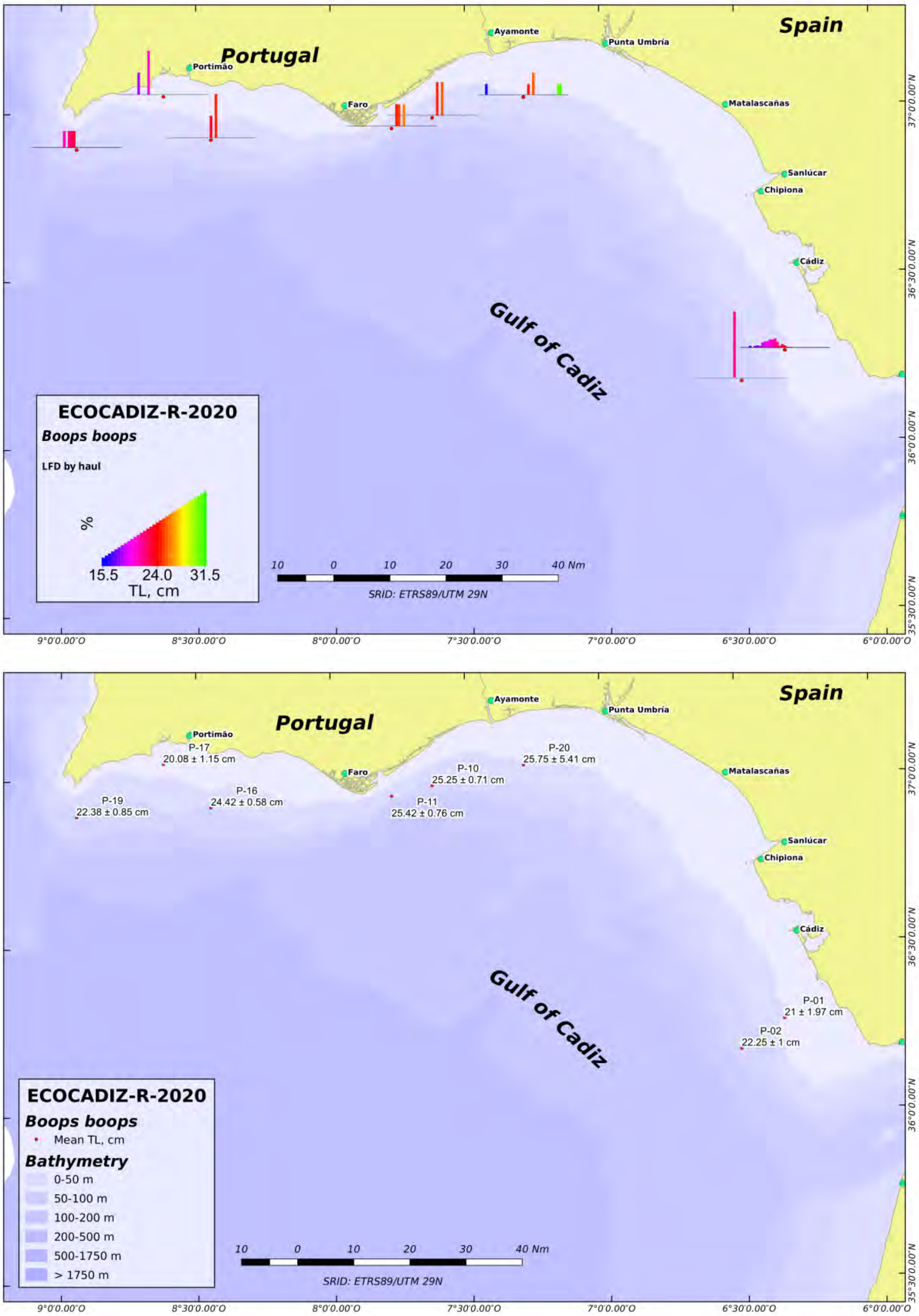


Figure 30. *ECOCADIZ-RECLUTAS 2020-10* survey. Bogue (*Boops boops*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

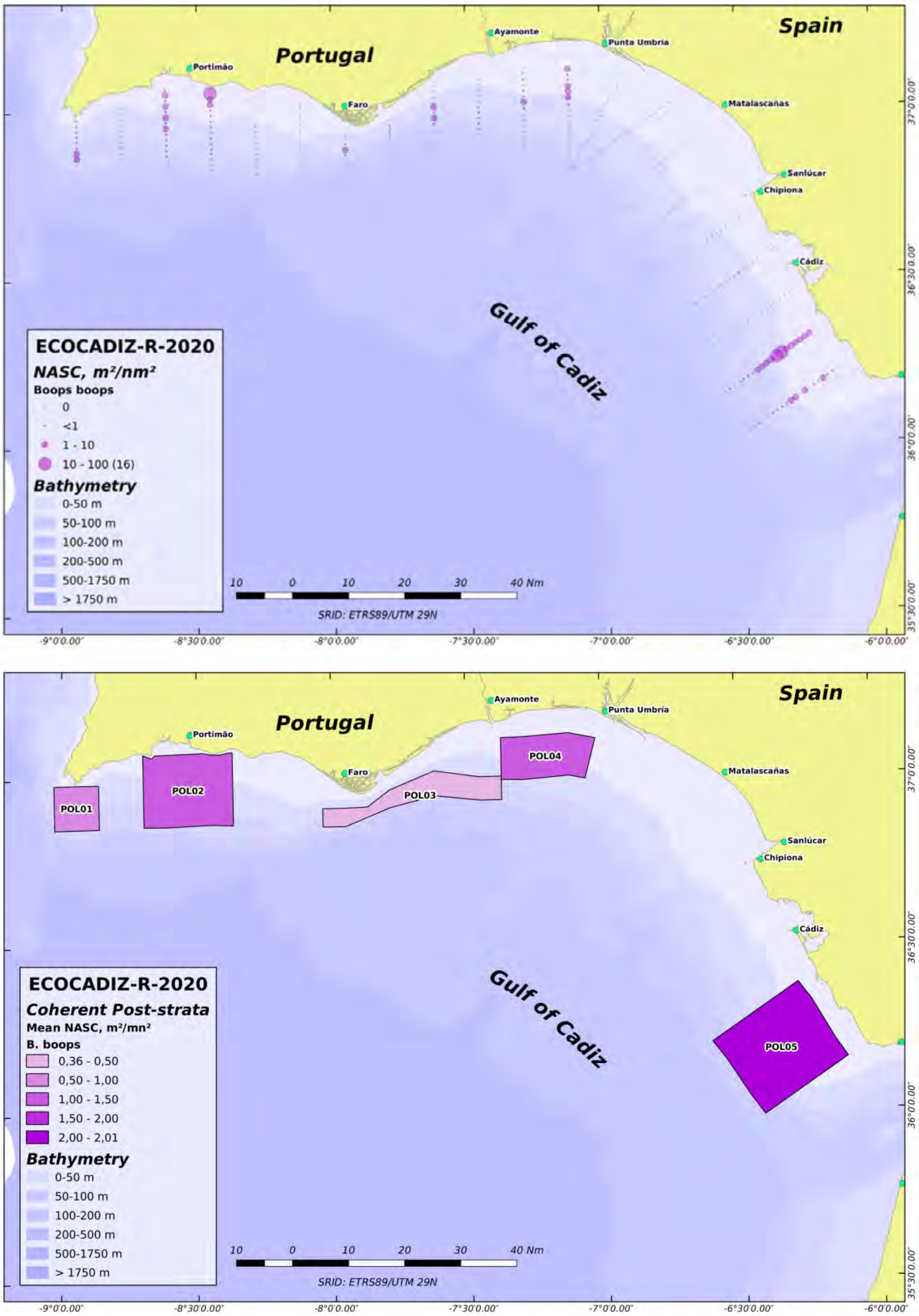


Figure 31. *ECOCADIZ-RECLUTAS 2020-10* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

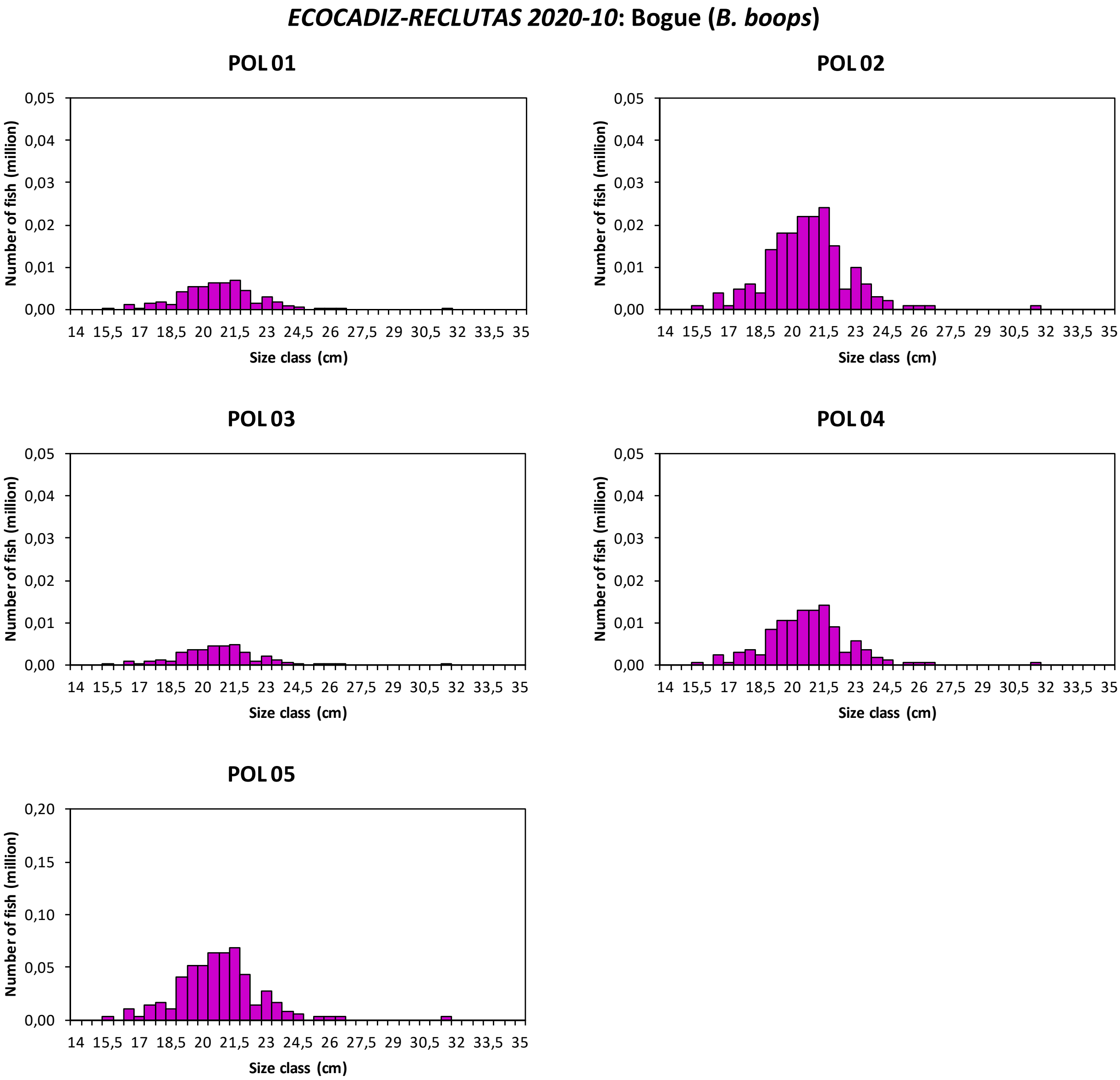


Figure 32. *ECOCADIZ-RECLUTAS 2020-10* survey. Bogue (*Boops boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 31**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

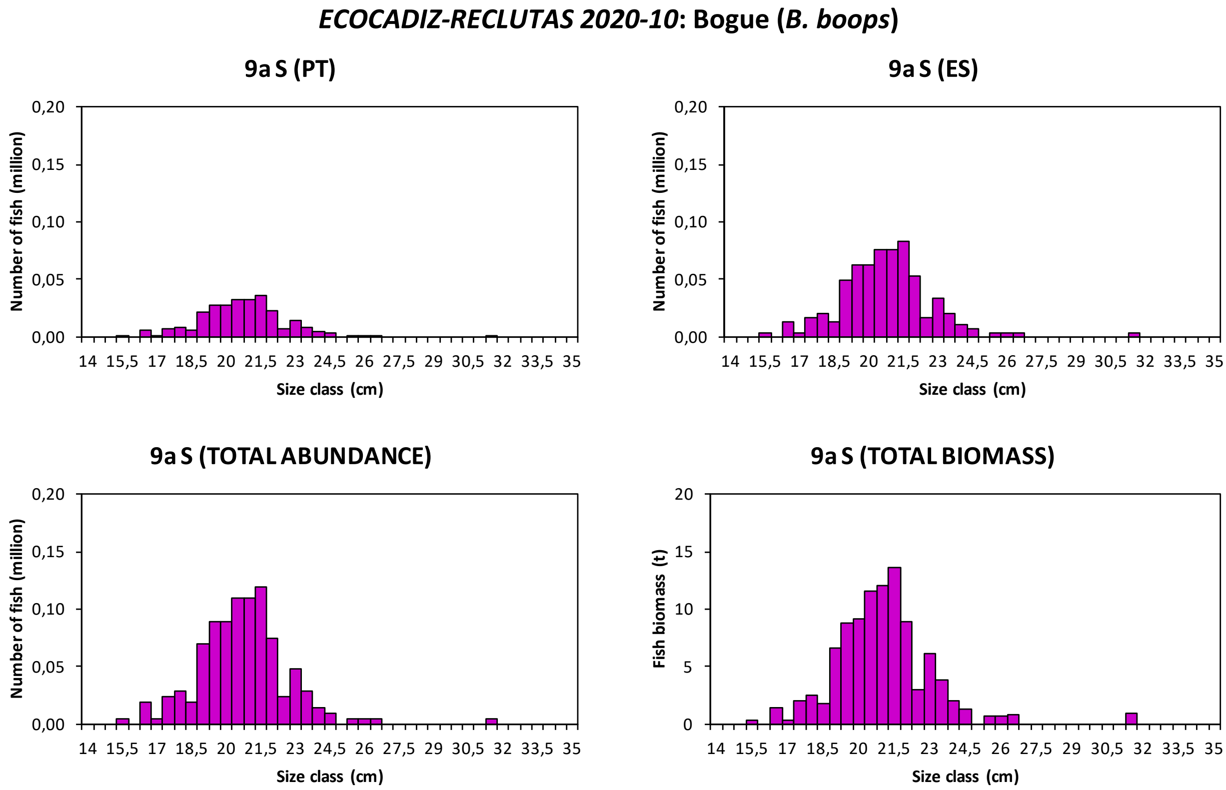


Figure 32. *ECOCADIZ-RECLUTAS 2020-10* survey. Bogue (*Boops boops*). Cont'd.

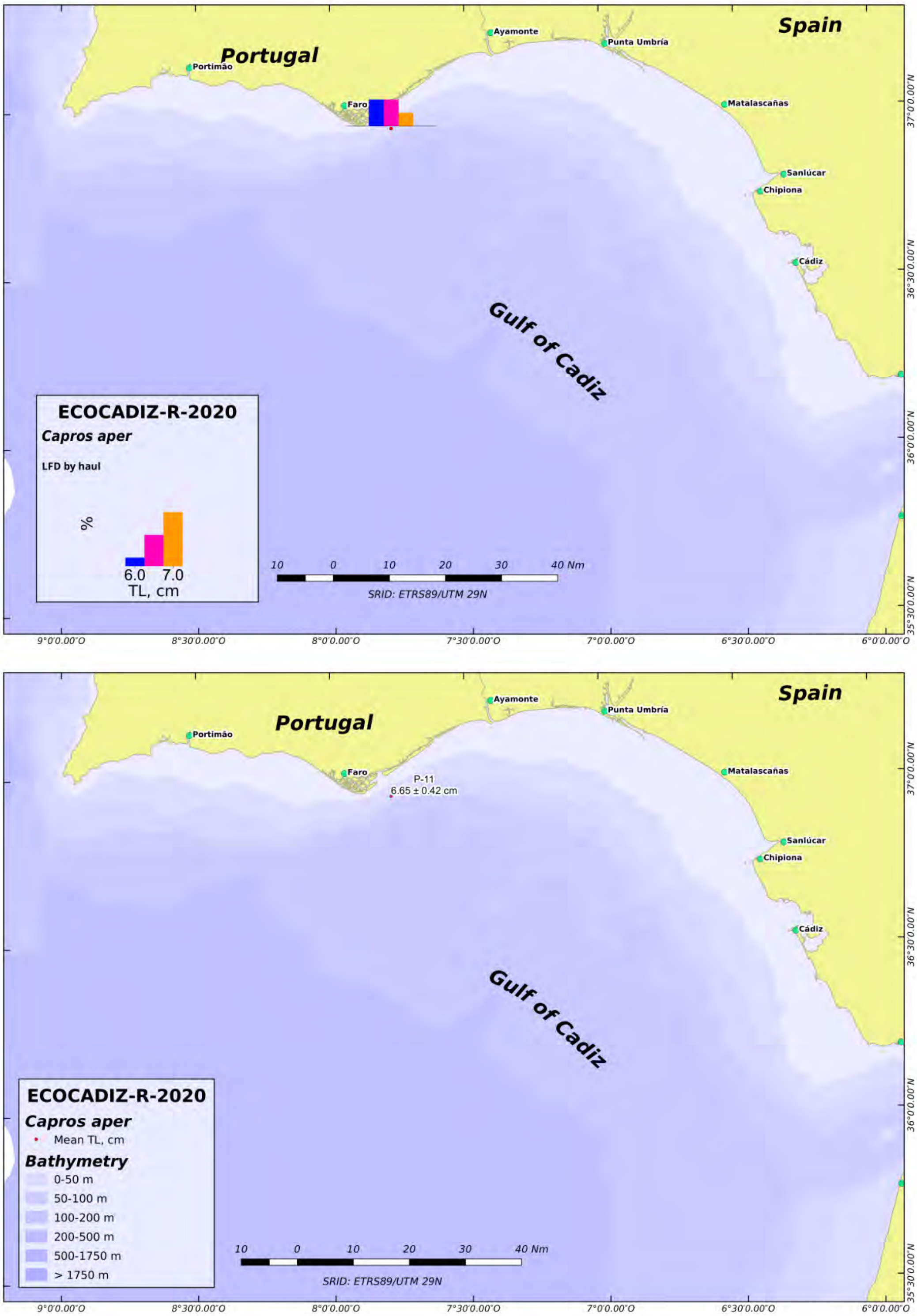


Figure 33. *ECOCADIZ-RECLUTAS 2020-10* survey. Boarfish (*Capros aper*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

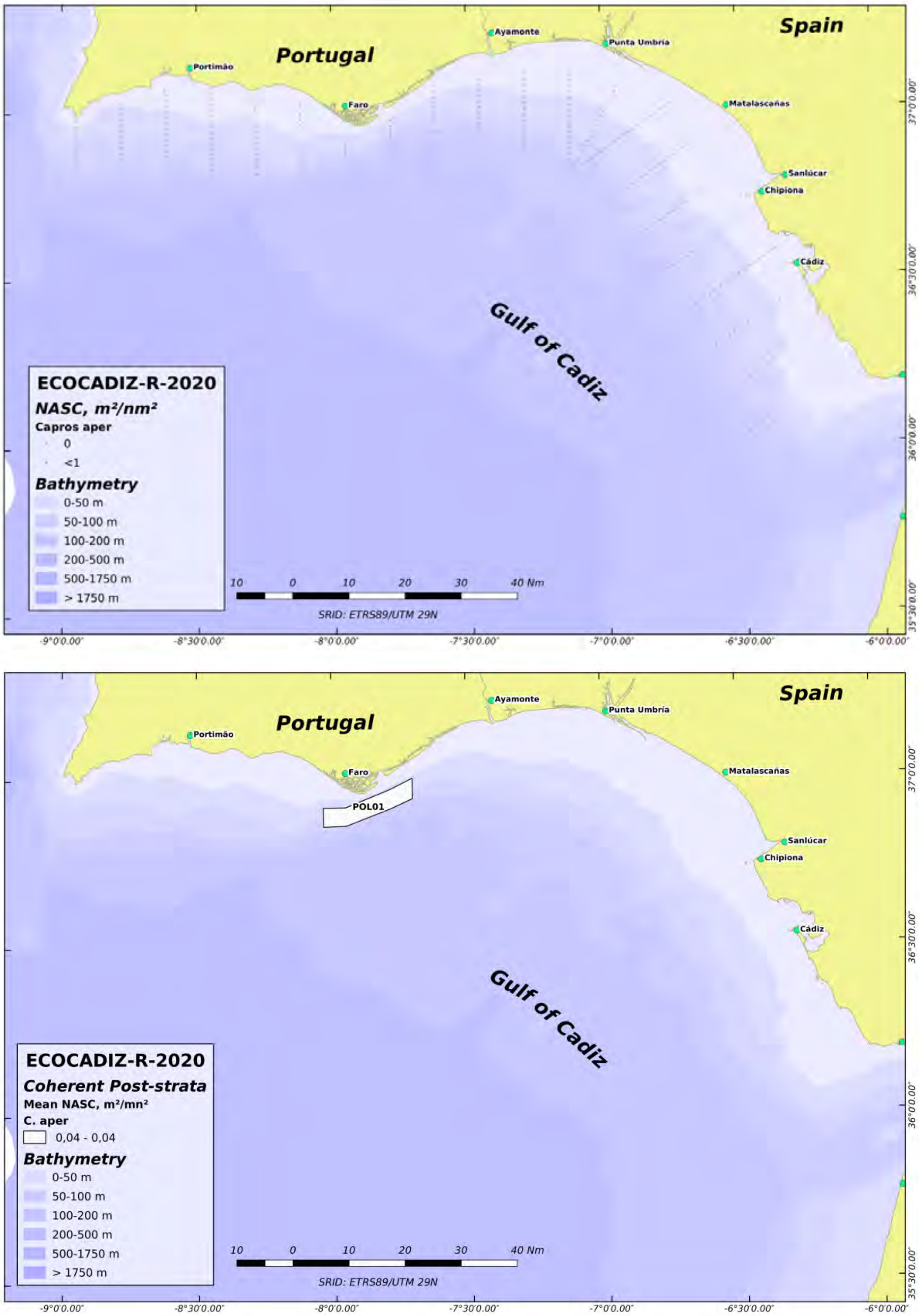


Figure 34. *ECOCADIZ-RECLUTAS 2020-10* survey. Boarfish (*Capros aper*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

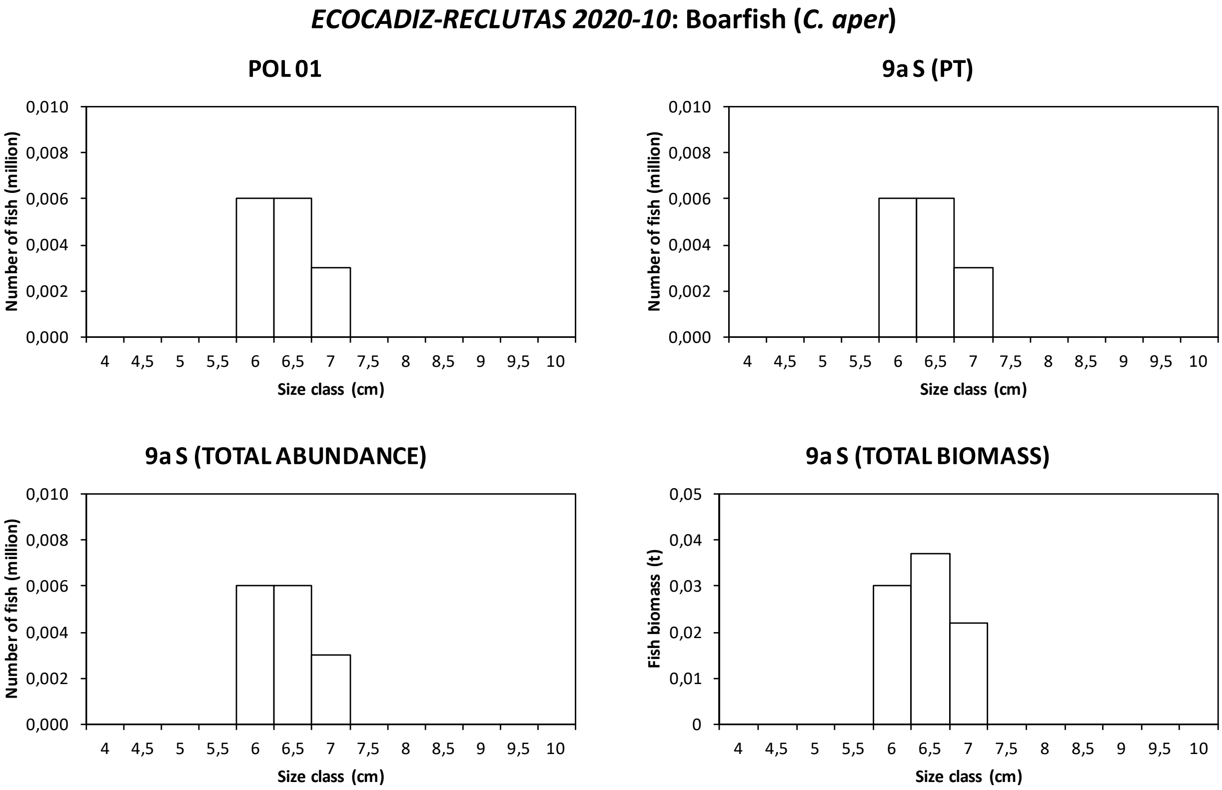


Figure 35. *ECOCADIZ-RECLUTAS 2020-10* survey. Boarfish (*Capros aper*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 34**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

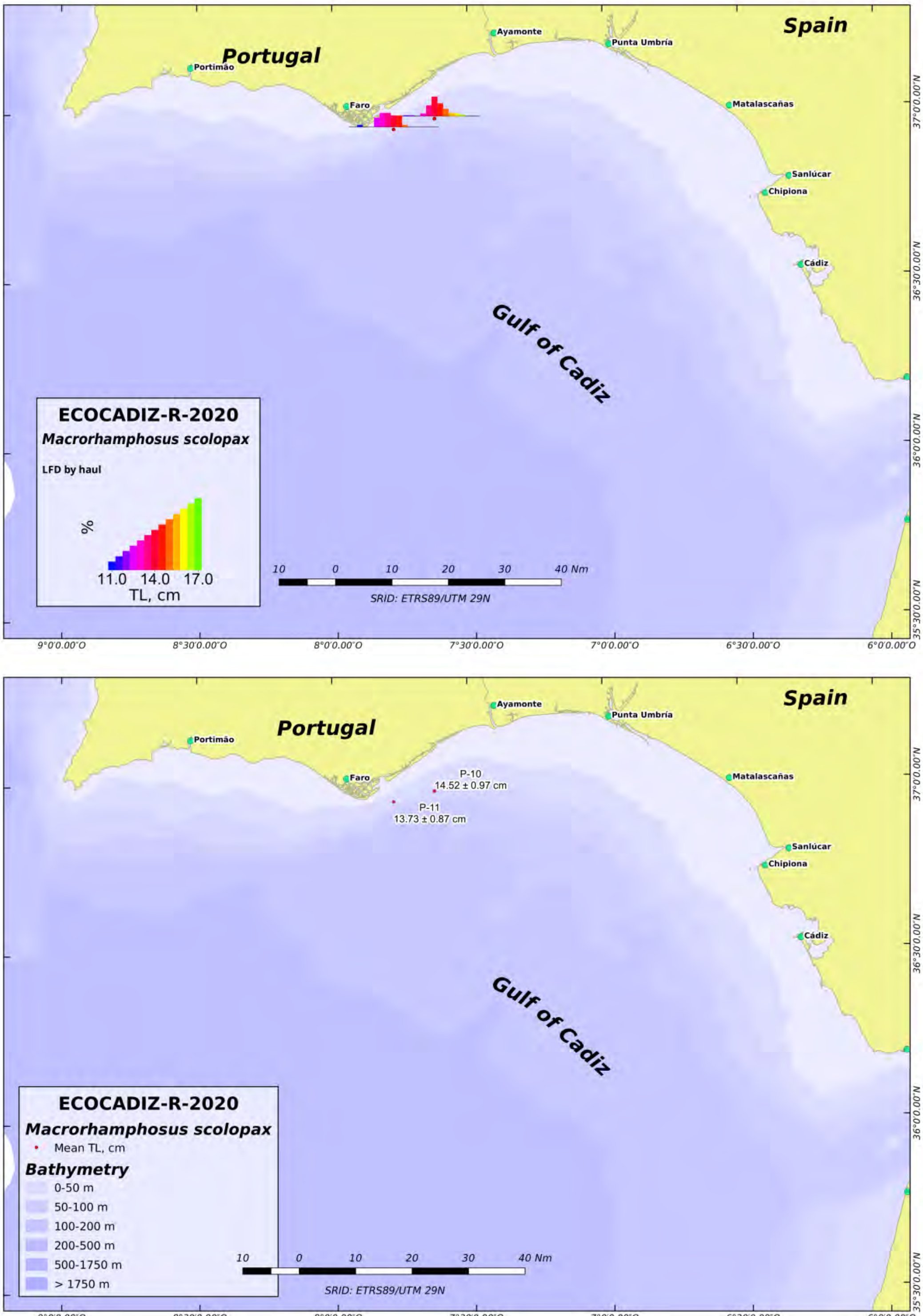


Figure 36. *ECOCADIZ-RECLUTAS 2020-10* survey. Longspine snipefish (*Macroramphosus scolopax*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

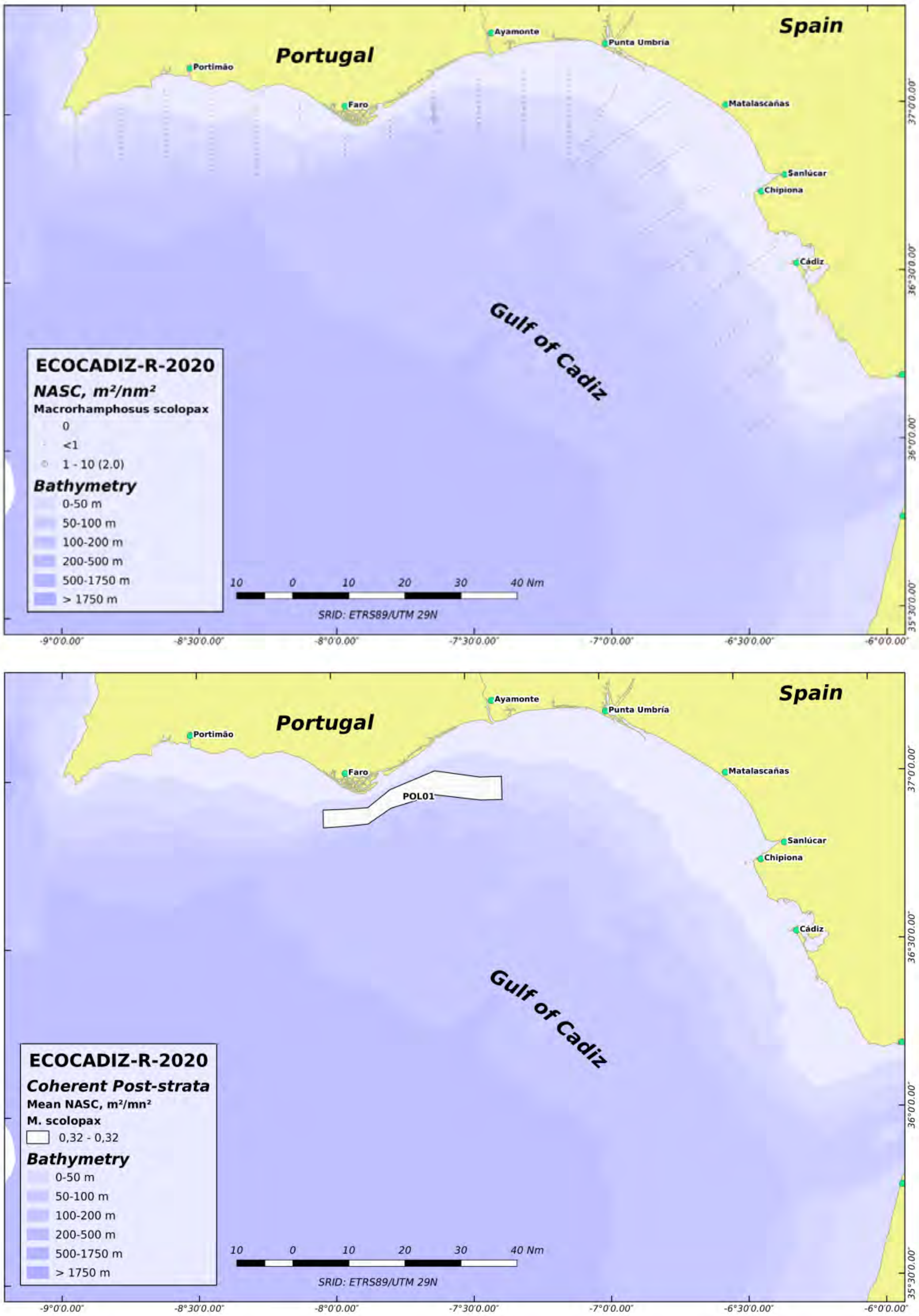


Figure 37. *ECOCADIZ-RECLUTAS 2020-10* survey. Longspine snipefish (*Macroramphosus scolopax*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

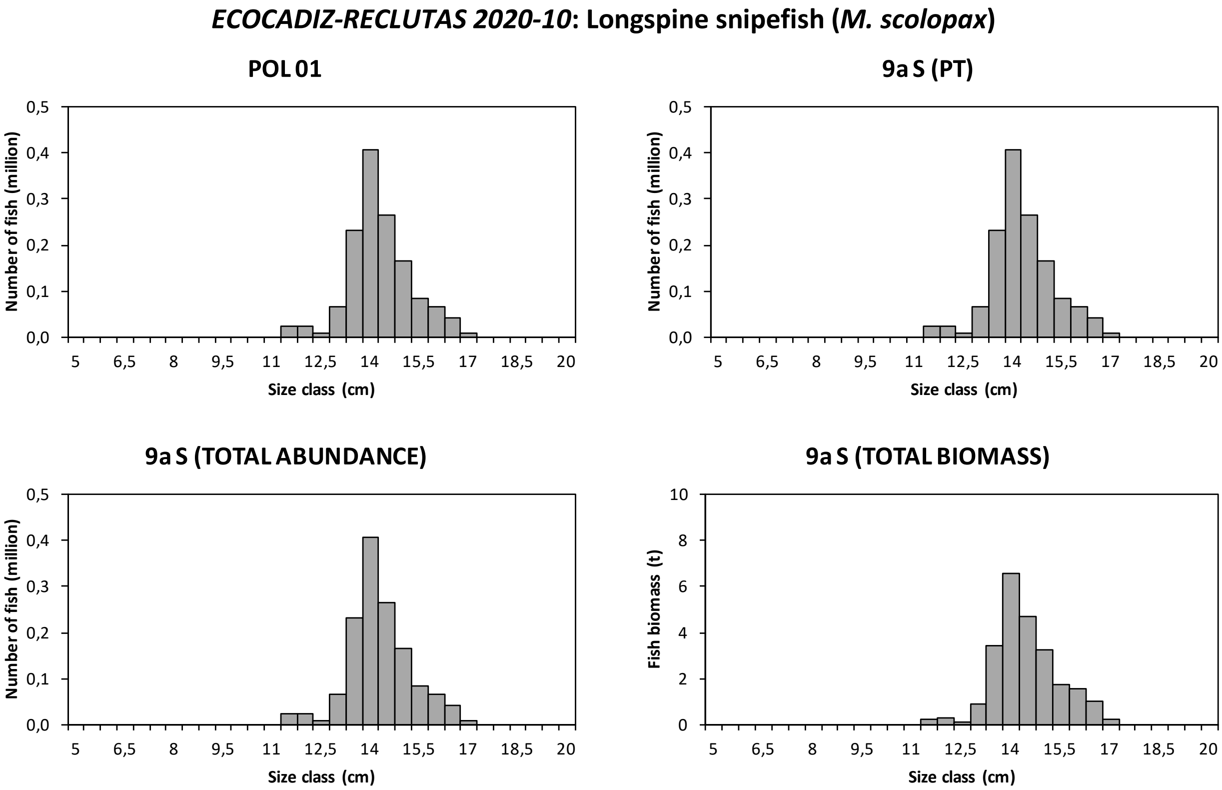


Figure 38. *ECOCADIZ-RECLUTAS 2020-10* survey. Longspine snipefish (*Macroramphosus scolopax*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 37**) and total sampled area. Post-strata ordered in the W-E direction. 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.

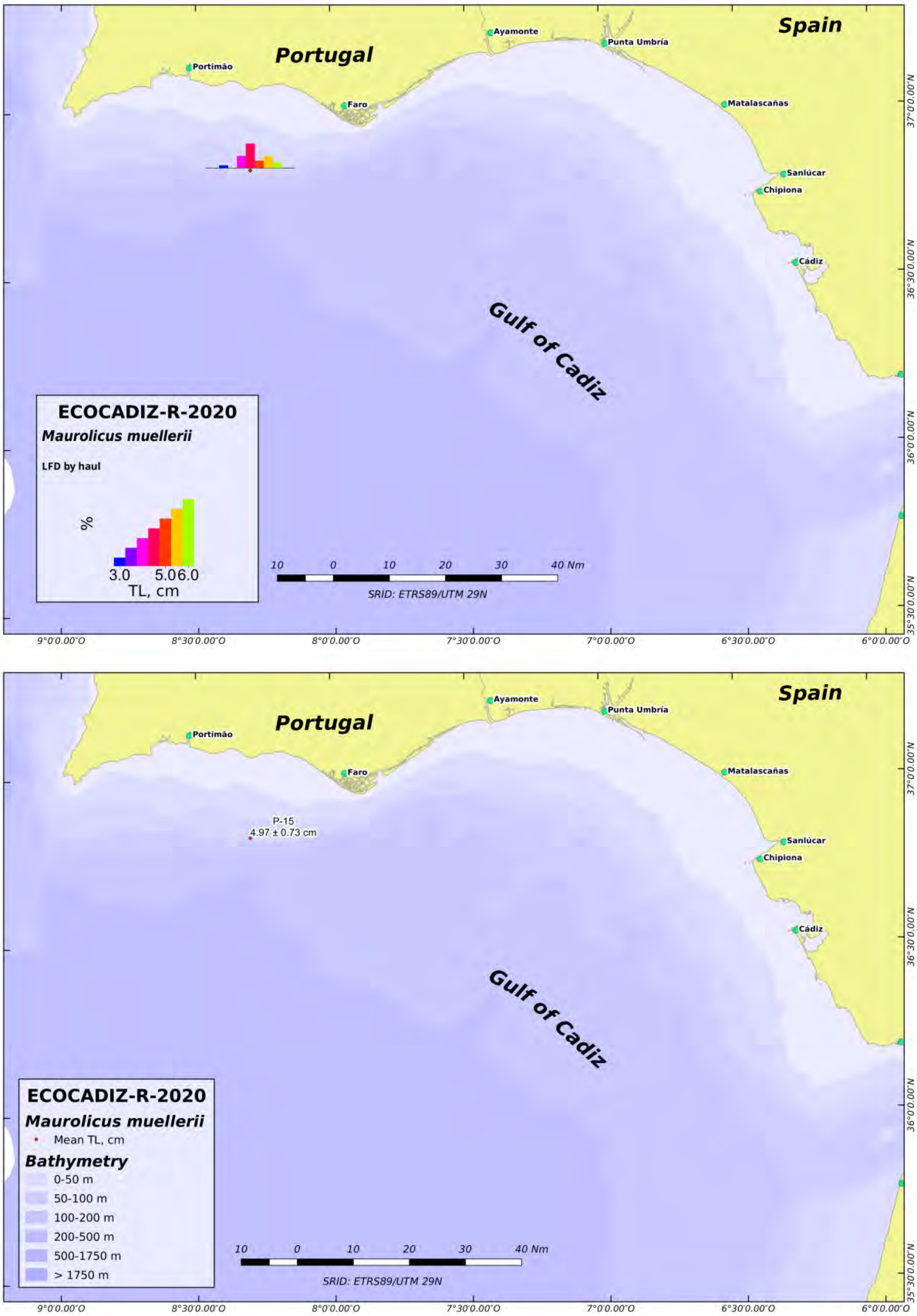


Figure 39. *ECOCADIZ-RECLUTAS 2020-10* survey. Pearlside (*Maurolicus muelleri*). Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

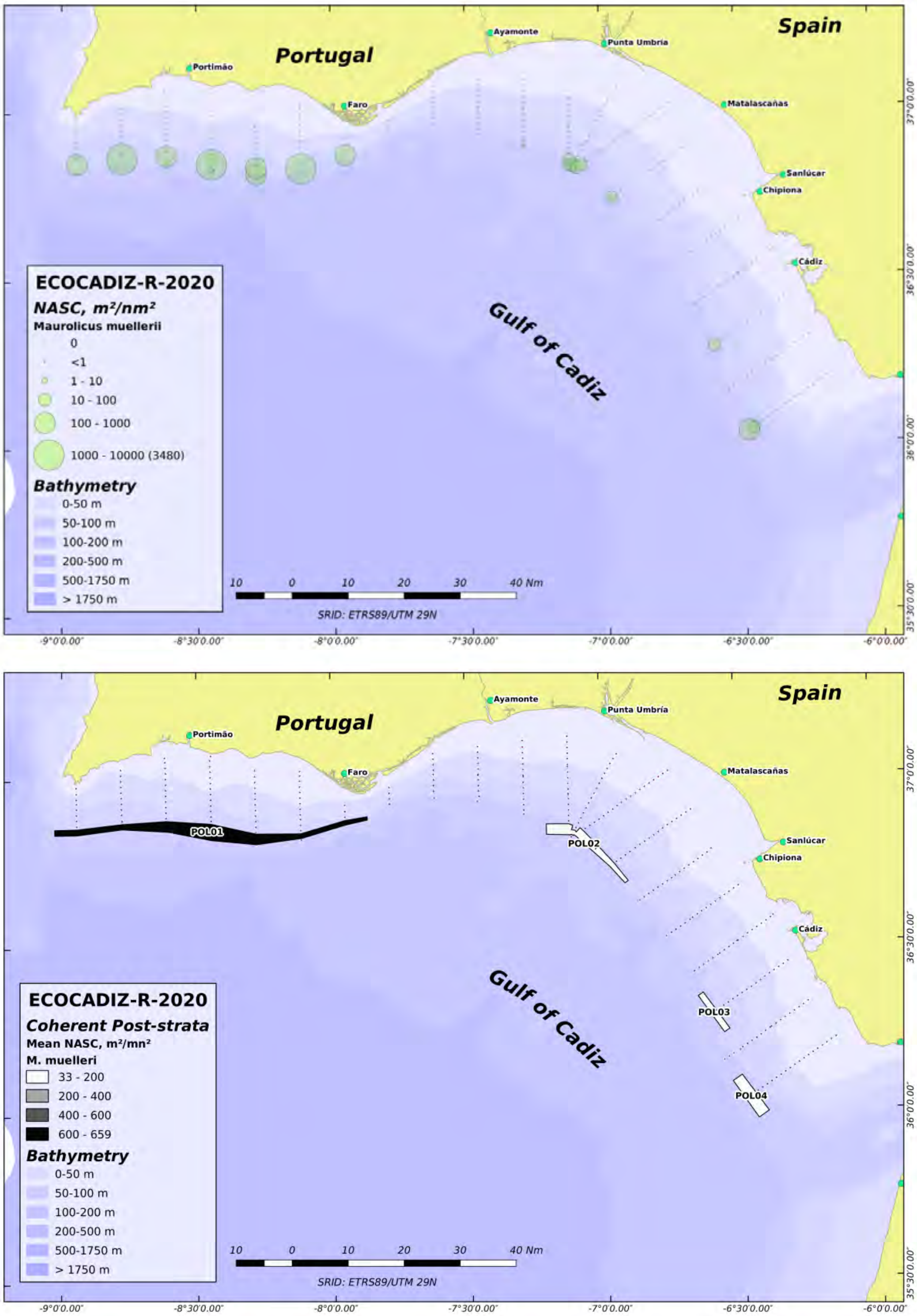


Figure 40. *ECOCADIZ-RECLUTAS 2020-10* survey. Pearlside (*Maurolicus muelleri*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

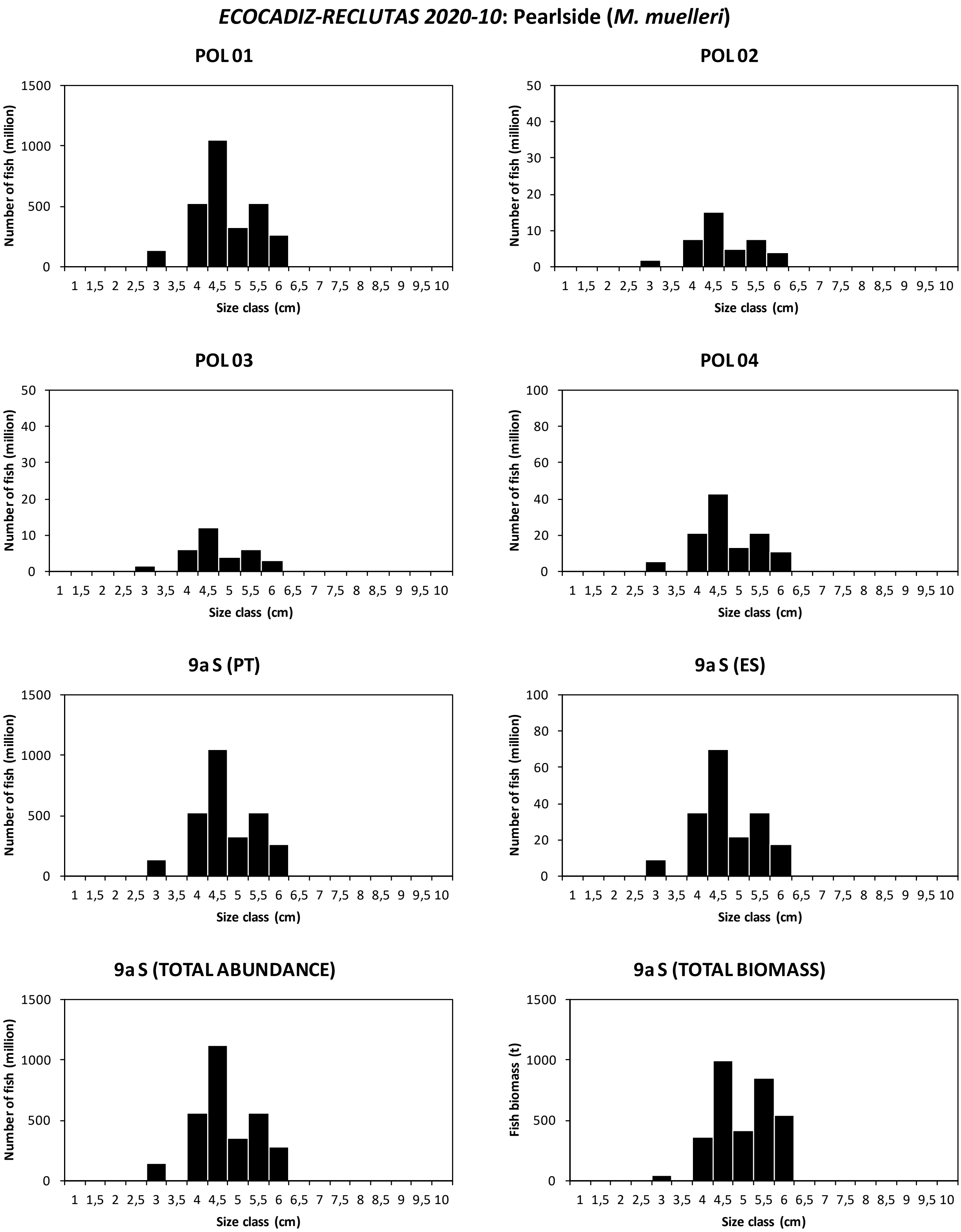


Figure 41. *ECOCADIZ-RECLUTAS 2020-10* survey. Pearlside (*Maurolicus muelleri*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous post-stratum (POL01-POLn, numeration as in **Figure 40**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

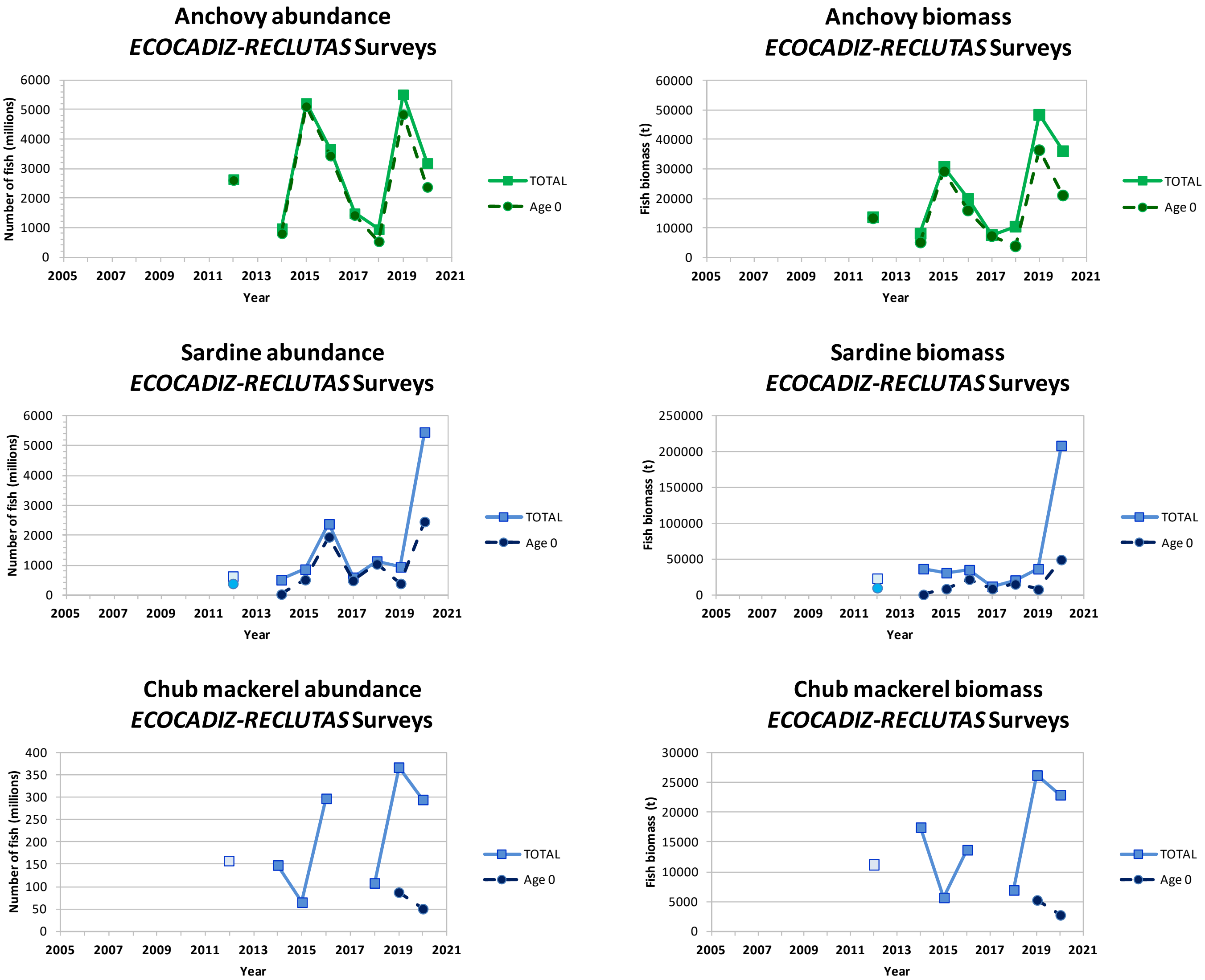


Figure 42. *ECOCADIZ-RECLUTAS* surveys series. Historical series of autumn acoustic estimates of anchovy, sardine and chub mackerel abundance (million) and biomass (t) in Sub-division 9.a South. The estimates correspond to the total population and age 0 fish. The 2012 survey only surveyed the Spanish 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. Age data for chub mackerel started to be available since 2019 on.

Gadget for anchovy 9a South: Model description and results to provide catch advice and reference points (WGHANSA-1 2021)

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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. Specific model assumptions for this year are presented in section 2.2 and 3, as well as estimated parameters after optimization in Table 2.

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 benchmark in WKPELA 2018 is available at `http://prezi.com/j8rinhq5kstg/?utm_campaign=share&utm_medium=copy`.

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2.1. Simulation model

The model consists of one stock component of anchovy (*Engraulis encrasicolus*) in the ICES subdivision, 9.a South-Atlantic Iberian waters, Gulf of Cádiz. Gadget works by keeping track of the number of individuals, $N_{a,l,y,t}$, at age $a = 0, \ldots, 3$, at length $l = 3, 3.5, 4, 4.5, \ldots, 22$, at year $y = 1989, \ldots, 2018$, and each year divided into quarters $t = 1, \ldots, 4$.. The last time step of a year involves increasing the age by one year, except for the last age group, which its age remains unchanged and the age group next to is added to it, like a 'plus group' including all ages from the oldest age onwards (Taylor et al., 2007).

Growth

The growth function is a simplified version of the Von Bertalanffy growth equation, defined in Begley (2004) as the LengthVBSimple Growth Function (*lengthvbsimple*). Length increase for each length group of the stock is given by the equation below:

$$\Delta l = (l_\infty - l)(1 - e^{k\Delta t}), \tag{1}$$

where Δt is the length of the timestep, $l_\infty = 19\ cm$ (fixed) is the terminal length and k is the growth rate parameter.

The corresponding increase in weight (in Kg) of the stock is given by:

$$\Delta w = a((l + \Delta l)^b - l^b), \tag{2}$$

with $a = 3.128958e^{-6}$ and $b = 3.277667619$ set as fixed and extracted from all the samples available in third and fourth quarters from 2003 to 2017. The growth functions described above calculate the mean growth for the stock within the model. In a second step the growth is translated into a beta-binomial distribution of actual growths around that mean with parameters β and n. The first is fitted by the model as described in Taylor et al. (2007) and the second represents the number of length classes that an individual is allowed to grow in a quarter and it is fixed and equal to 5.

Initial abundance and recruitment

Stock population in numbers at the starting point of the simulation is defined as:

$$N_{a,l,1,1} = 10000\nu_a q_{a,l}, \quad a = 0, \ldots, 3, l = 3, \ldots, 20$$

Where ν_a is an age factor to be calculated by the model and $q_{a,l}$ is the proportion at lengthgroup l that is determined by a normal density with a specified mean length and standard deviation for each age group. Mean length at age (μ_a) and its standard deviation (σ_a) were extracted from all the data available from 1989 to 2018 including three surveys that are not included in the model: ARSA, ECOCADIZ-RECLUTAS and SAR survey (See table 2). The mean weight at age for this initial population is calculated by multiplying a reference weight corresponding to the length by a relative condition factor assumed as 1. This reference weight at length was calculated using the formula $w = al^b$, with a and b as defined before. In Gadget files this was specified as a normal condition distribution (*Normalcondfile*).

@

Similarly to the process of calculate the initial abundance described above, the recruitment specifies how the stock will be renewed. Recruits enter to the age 0 population at quarters 2, 3, 4 (because of the Gadget order of calculations for each time step this is equivalent to have recruitment one quarter later, i.e. in quarters 3,4 and 1 of the next year) of all years, respectively, as follows:

$$N_{0,l,y,t} = p_{l,t} R_{y,t}, \quad t = 2, 3, 4, l = 3, \ldots, 15,$$

where $R_{y,t}$ represents recruitment at year y and quarter t, and $p_{l,t}$ the proportion in lengthgroup l that is recruited at quarter t which is sampled from a normal density with mean (μ) and standard deviation (σ_t) calculated by the model. The mean weight for these recruits is calculated by multiplying the reference weight corresponding to the length by a relative condition factor assumed as 1. Reference weight at age was the same used to calculate the initial population mean weight at age explained above. In Gadget files this was specified also as a normal condition distribution (*Normalcondfile*).

Fleet operations

In the model the fleets act as predators. There are three fleets inside the model: two for surveys (ECOCADIZ acoustic survey and PELAGO acoustic survey) and one for commercial landings including all fleets: Spanish purse-seine, trawlers, Portuguese purse-seine, and others. The main fleet is Spanish purse-seine representing more than a 90 % of all the catches from 2001 to 2016 and more than a 80 % from 1989 to 2000. It is also the only fleet with a lenght distribution available, then we decide to include all commercial reported data in the same fleet which is mostly the Spanish purse-seine.

Surveys fleets are assumed to remove 1 Kg in each of the quarters when the surveys take place while the commercial fleet is assumed to remove the reported number of individuals each quarter. This total amount of biomass (for the surveys) or numbers (for the commercial fleet) landed is then split between the length groups according to the equations 3 and 4 respectively, as follows:

$$C_{l,y,t} = \frac{E_{y,t} S_{l,T} N_{l,y,t} W_l}{\sum_l S_{l,T} N_{l,y,t} W_l}, \tag{3}$$

and

$$C_{l,y,t} = \frac{E_{y,t} S_{l,T} N_{l,y,t}}{\sum_l S_{l,T} N_{l,y,t}}, \tag{4}$$

where $E_{y,t}$ represents biomass landed (in Kg) at year y and quarter t in equation 3 and numbers landed in equation 4, W_l corresponds to weight at length and $S_{l,T}$ represents the suitability function that determines the proportion of prey of length l that the fleet is willing to consume during period $T, T = 1, 2, 3$ where $T = 1$ corresponds to the period 1989-2000, $T = 2$ to 2001-2018 and $T = 3$ to 1989-2018.

For this model the suitability function chosen for the fleet and surveys is specified in Gadget manual as an ExponentialL50 function (*expsuitfuncl50*), and it is defined as follows:

$$S_{l,T} = \frac{1}{1 + e^{\alpha_T (l - l_{50,T})}} \tag{5}$$

where $l_{50,T}$ is the length of the prey with a 50% probability of predation during period T and α_T a parameter related to the shape of the function, both parameters are estimated from the data within the Gadget model. The whole model time period (1989-2018) has been splited into two different periods for suitability parameters of the commercial fleet because of changes in size regulation for the fishery around 1995 that become effective around 2001.

2.2. Observation model

Data are assimilated by Gadget using a weighted log-likelihood function. The model uses as likelihood components 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 calculations 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 $SS_{i,r}, i = 1, \ldots, L$, the likelihood score of component i after run r. First, a Gadget optimization run is performed to get a likelihood score ($SS_{i,1}$) for each likelihood component assuming that all components have a weight equal to one, i.e., $\mathbf{w_1} = (1, 1, \ldots, 1)$. Then, a separated optimization run for each of the components (L optimization runs) is performed using the following weight vectors:

$$\mathbf{w_{i+1}} = (1/SS_{1,1}, \ldots, (1/SS_{i,1}) * 10000, 1/SS_{i+1,1}, \ldots, 1/SS_{L,1}), i = 1, \ldots, L.$$

Resulting likelihood scores $SS_{i,i+1}$ are then used to calculate the residual variance, $\hat{\sigma}_i^2 = SS_{i,i+1}/df^*$ for each component, that is used to define the final weight vector as

$$\mathbf{w} = (1/\hat{\sigma}_1^2, \ldots, 1/\hat{\sigma}_L^2).$$

Where degrees of freedom df^* are approximated by the number of non-zero data points in the observed data for each component. Finally, the total objective function is the sum of all likelihoods components multiplied by their respective weights according to the vector $\mathbf{w}$.

In order to assign weights to the individual likelihood components (See table 2.2) in the procedure described above, all the survey indices were grouped together.

2.5. Initial parameters and optimization

Initial parameter values with their boundaries and settings for the optimising algorithms can be found in `https://github.com/mmrinconh/recovery-results-2020/blob/main/Anchovy2021_withLD2018_2019_1_2_andALKpelago2020_optBjarki2M_copy/params.in` and `https://github.com/mmrinconh/recovery-results-2020/blob/main/Anchovy2021_withLD2018_2019_1_2_andALKpelago2020_optBjarki2M_copy/optfile`. The optimization algorithms converged in individual and weighted runs.

3. **Remarkable Model Assumptions (in bold the terms associated to the more recent assumptions)**

- Due to lack of information of length distributions and Age-length keys for commercial catches in the first and second quarter of 2020, for **2021** assessment the length distribution was approximated using the joint distribution of 2018 and 2019 and the Age-length key used was the one for the PELAGO 2020 survey.
- The model was implemented quarterly from 1989 to the second quarter of **2021**.
- 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 **2021**, provisional catches estimations of Spanish (until May 18th) purse-seine fleet were used and catches for June were estimated as the **37%** of January to May catches based on historical records from 2009 to **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.

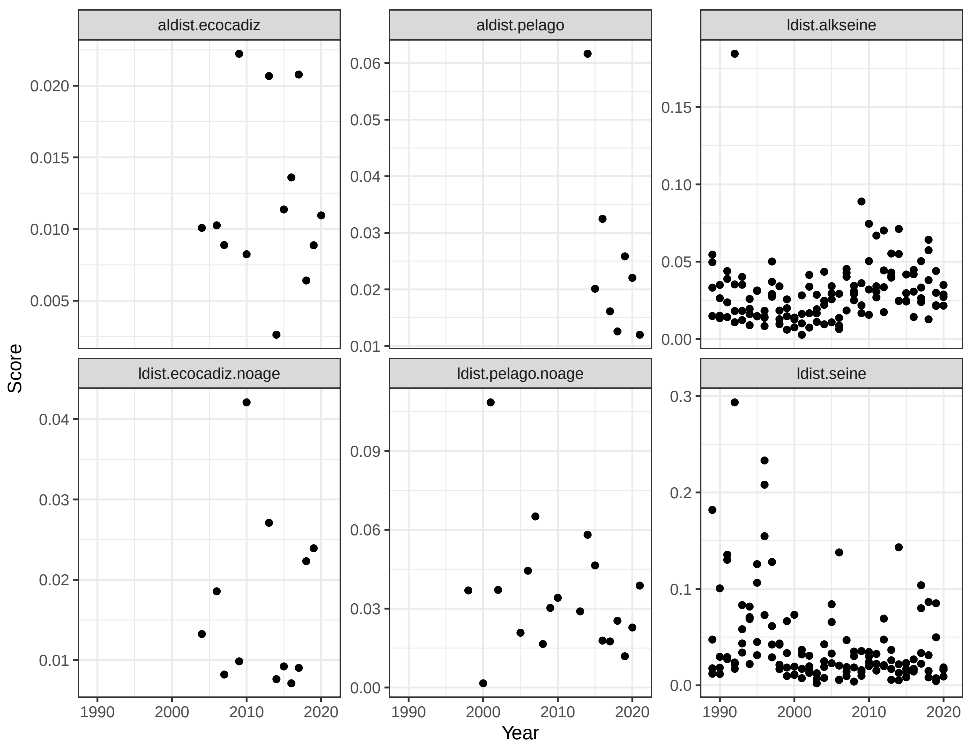

Figure 1: Likelihood scores for age-length key of ECOCADIZ survey, PELAGO survey and commercial landings (Upper panel) and length distribution of ECOCADIZ survey, PELAGO survey and landings. Dots represent the score for each quarter.

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_∞=28.7556
k	Annual growth rate, $k = 0.0740307$
β	Beta-binomial parameter, $\beta = 3809.63$
ν_a	Age factor, $\nu_0 = 51000, \nu_1 = 37700,$
	$\nu_2 = 37000, \nu_3 = 4.88e-07$
μ	Recruitment mean length, $\mu = 9.89097$
σ_t	Recruitment length standard deviation by quarter, $\sigma_2 = 3.33598$, $\sigma_3 = 1.69371$, $\sigma_4 = 3.82192$
$l_{50,T}$	Length with a 50% probability of predation during period T,
	$l_{50,1}^{seine} = 10.6$, $l_{50,2}^{seine} = 10.7$, $l_{50,3}^{ECO} = 12.7$, $l_{50,3}^{PEL} = 14.2$
α_T	Shape of function, $\alpha_1^{seine} = 0.393$, $\alpha_2^{seine} = 0.945$, $\alpha_3^{ECO} = 1.52$, $\alpha_3^{PEL} = 0.484$
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, 1989-2020	See eq. 7
ECOCADIZ acoustic survey	Biomass survey indexes	Second quarter 2004, 2006	see eq. 6
		third quarter 2007, 2009, 2010, 2013-2020	
	Length distribution	Second quarter 2004, 2006	see eq. 7
		third quarter 2007, 2009, 2010, 2013-2020	
	Age-length key	Second quarter 2004, 2006	see eq. 7
		third quarter 2007, 2009, 2010, 2013-2020	
PELAGO acoustic survey	Biomass survey indexes	First quarter 1999, 2001-2003	see eq. 6
		second quarter 2005-2010 and 2013-2021	
	length distribution	First quarter 1999, 2001-2003	see eq. 7
		second quarter 2005-2010, 2013-2021	
	Age-length key	second quarter 2014-2021	see eq. 7

Table 2: Overview of the likelihood data used in the model. Important remark: Due to lack of information of length distributions and Age-length keys for commercial catches in the first and second quarter of 2020, the length distribution was approximated using the joint distribution of 2018 and 2019 and the Age-length key used was the one for the PELAGO 2020 survey.

Figure 2: Comparison between observed and estimated catches length distribution. Black lines represent estimated data while gray lines represent observed data

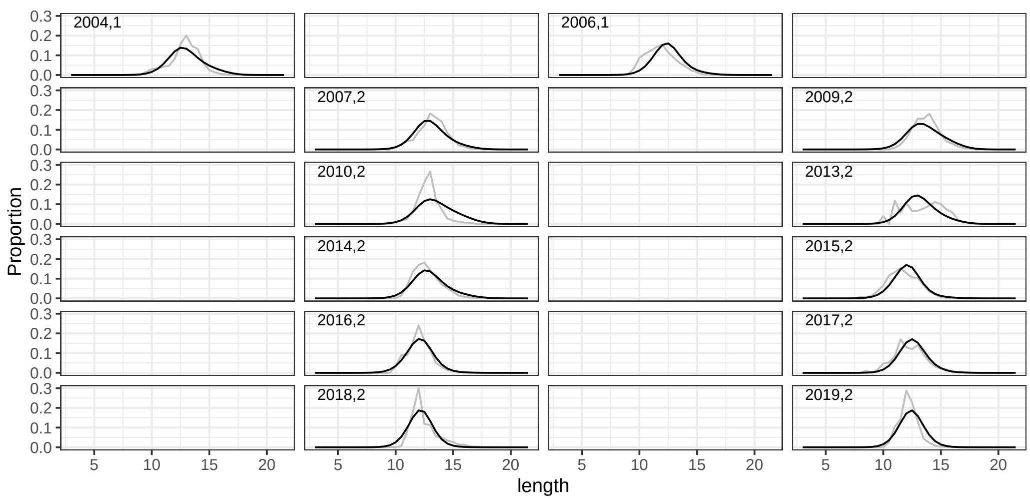

Figure 3: Comparison between observed and estimated catches length distribution for ECOCADIZ survey. Black lines represent estimated data while gray lines represent observed data

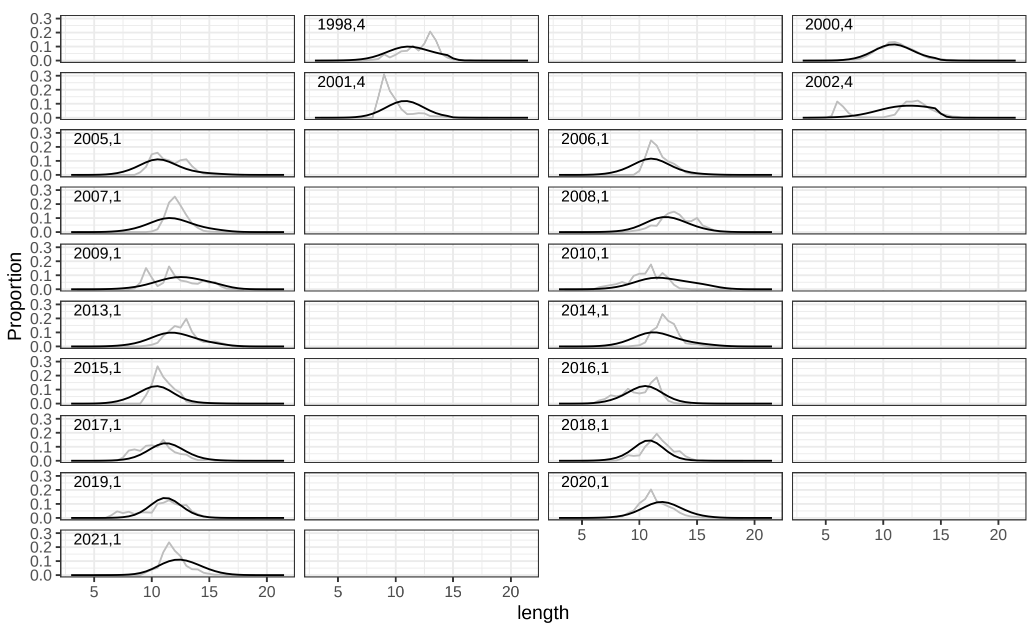

Figure 4: Comparison between observed and estimated catches length distribution for PELAGO survey. Black lines represent estimated data while gray lines represent observed data

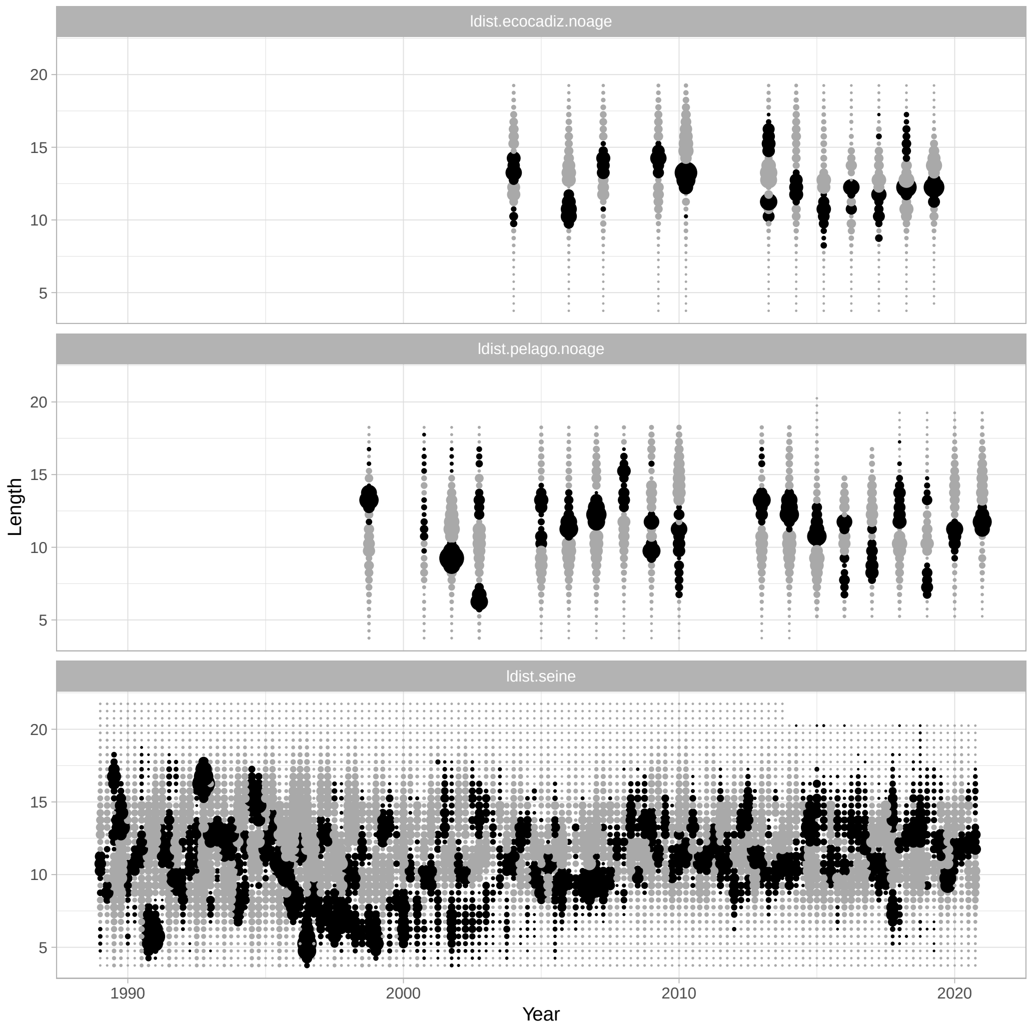

Figure 5: Standardised residual plots for the fitted length distribution from the ECOCADIZ survey, PELAGO survey and commercial landings. Black points denote a model underestimate and gray points an overestimated. The size of the points denote the scale of the standardised residual.

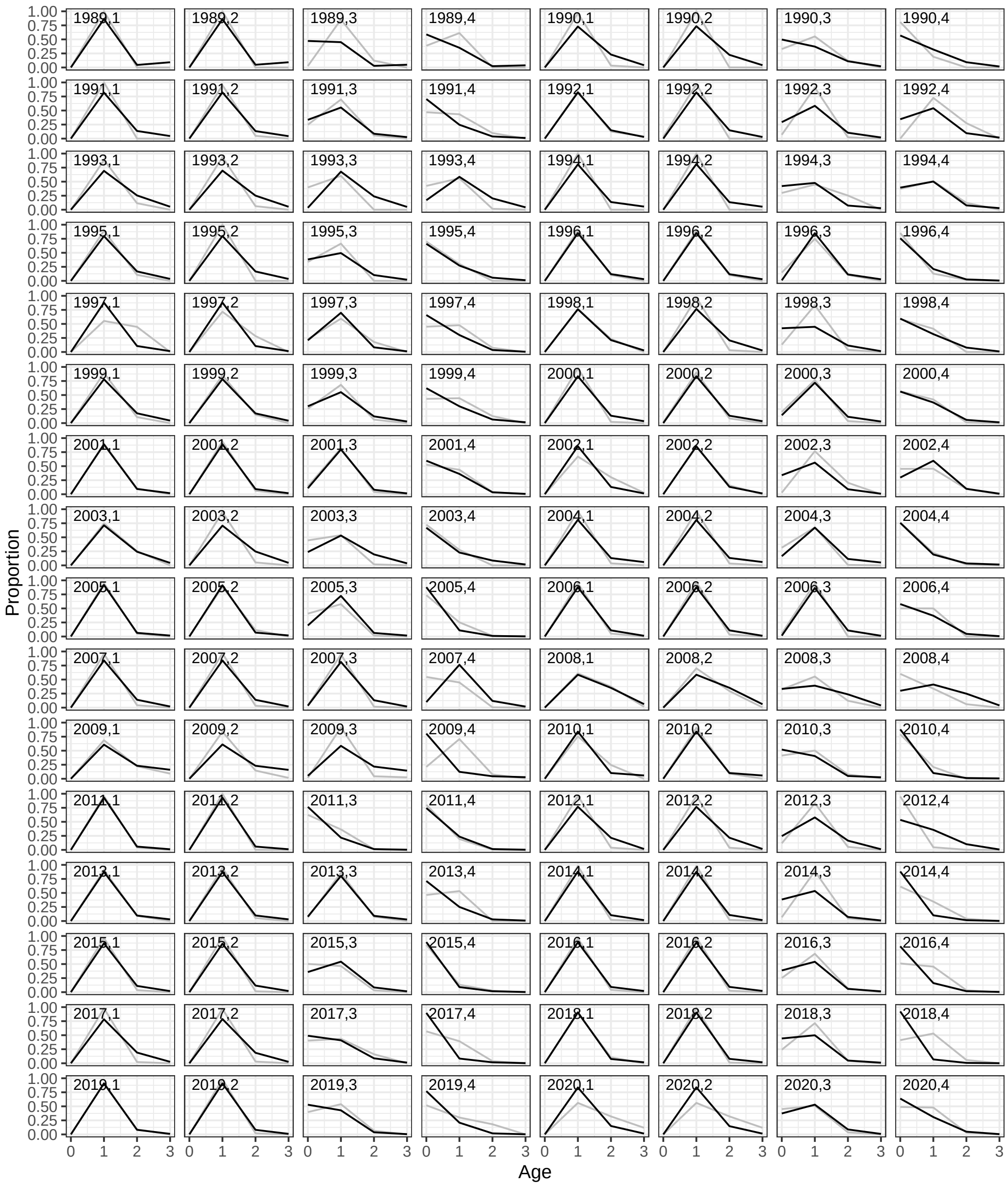

Figure 6: Comparison between observed and estimated catches age distribution. Black lines represent estimated data while gray lines represent observed data.

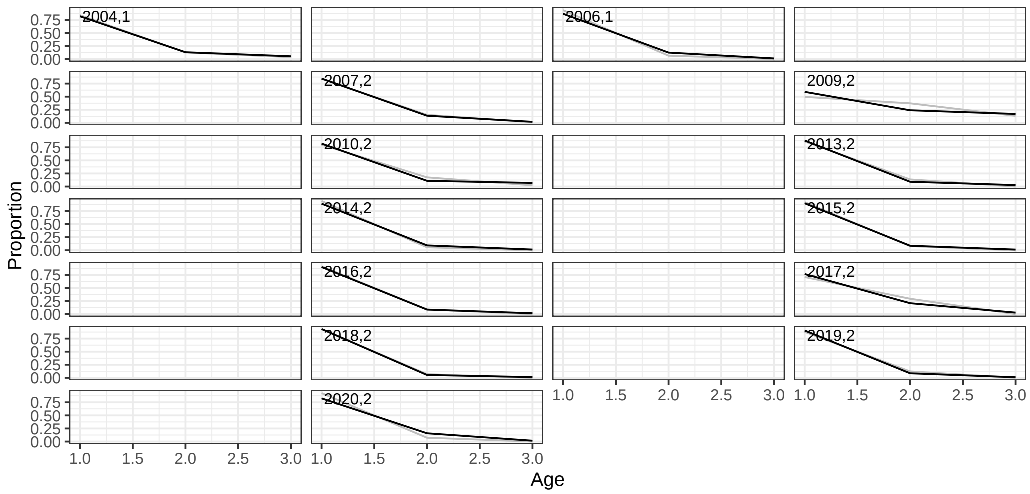

Figure 7: Comparison between observed and estimated ECOCADIZ survey age distribution. Black lines represent estimated data while gray lines represent observed data.

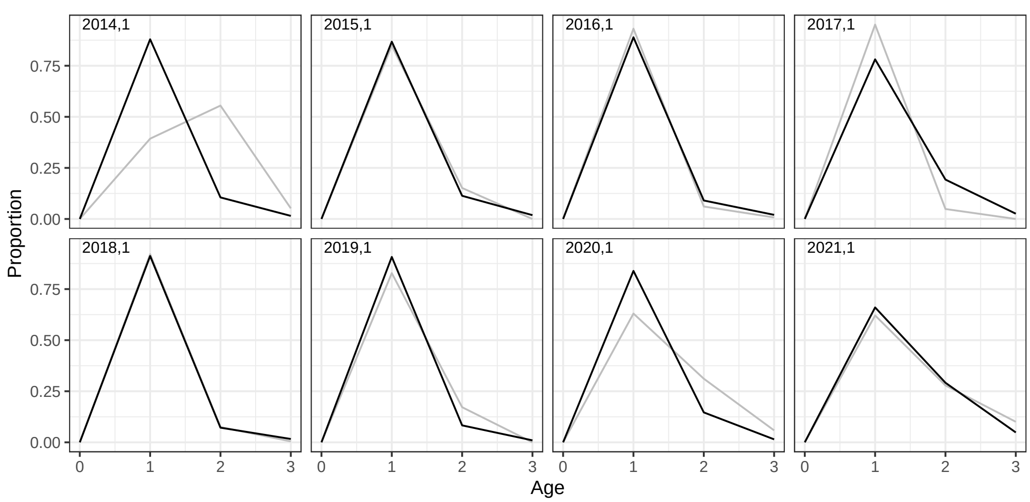

Figure 8: Comparison between observed and estimated PELAGO survey age distribution. Black lines represent estimated data while gray lines represent observed data.

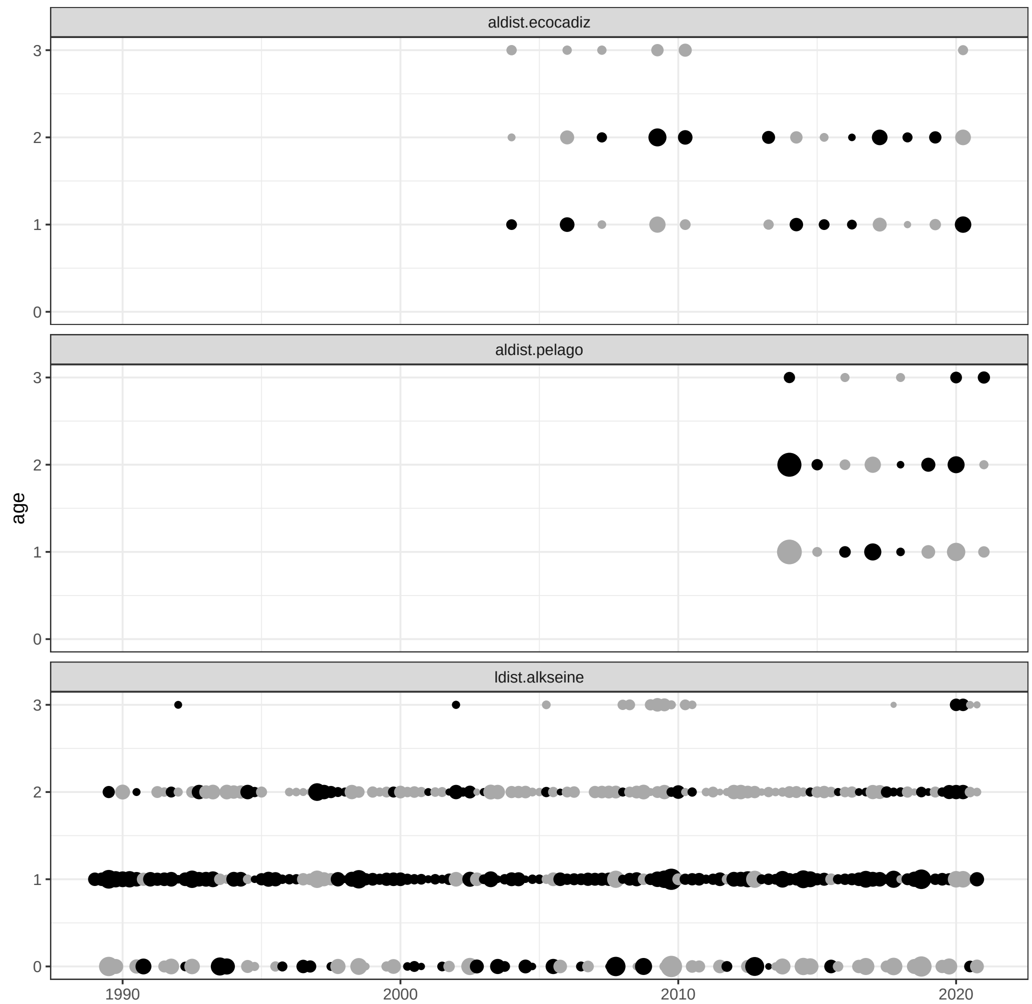

Figure 9: Standardised residual plots for the fitted age distribution from the ECOCADIZ survey, PELAGO survey and commercial fleet. Black points denote a model underestimate and gray points an overestimated. The size of the points denote the scale of the standardised residual.

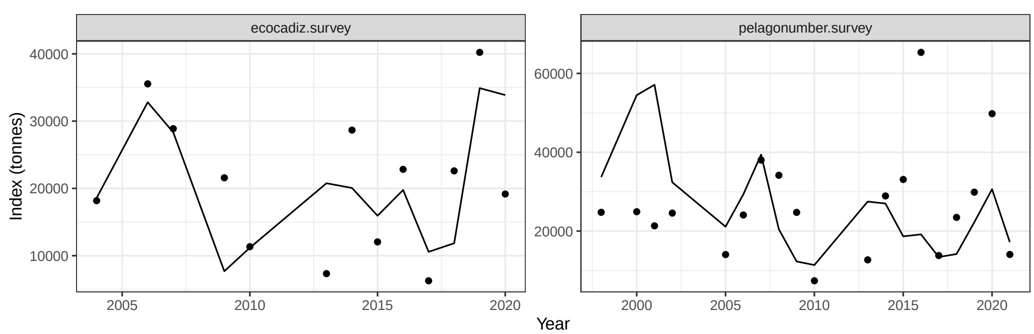

Figure 10: Comparison between observed and estimated survey indices. Black points represent observed data while black line represent estimated data

6. Model estimates

Parameter estimates after optimization are presented in Table 2. Detailed model outputs are available `https://github.com/ices-taf/2021_ane.27.9a_assessment/tree/main/results`, where each file corresponds to the following description:

- sidat: Model fit to the surveyindices
- suitability: Model estimated fleet suitability
- stock.recruitment: Model estimated recruitment
- res.by.year: Results by year
- catchdist.fleets: Data compared with model output for the length and age-length distributions
- stock.full: Modeled abundance and mean weight by year,step, length and stock
- stock.std: Modeled abundance, mean weight, number by age consumed by the fleet, stock and year
- stock.prey: Consumption of the fleet by length, year and step
- fleet.info: Information on catches, harvest rate and harvestable biomass by fleet, year and step
- params: parameter values used for the fit

6.1. Catchability

Figure 11 shows the catchability estimated by the model for the different surveys indices

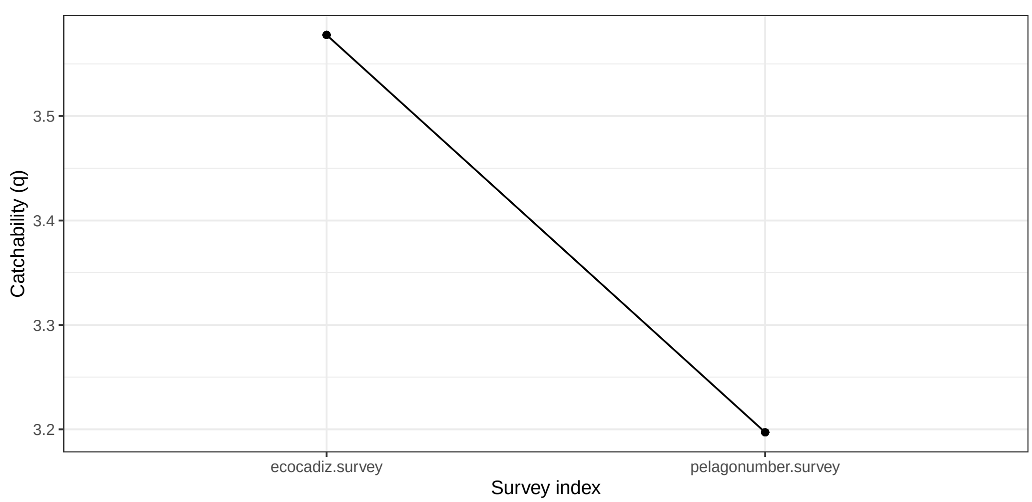

Figure 11: Estimated catchability parameters for the different survey indices

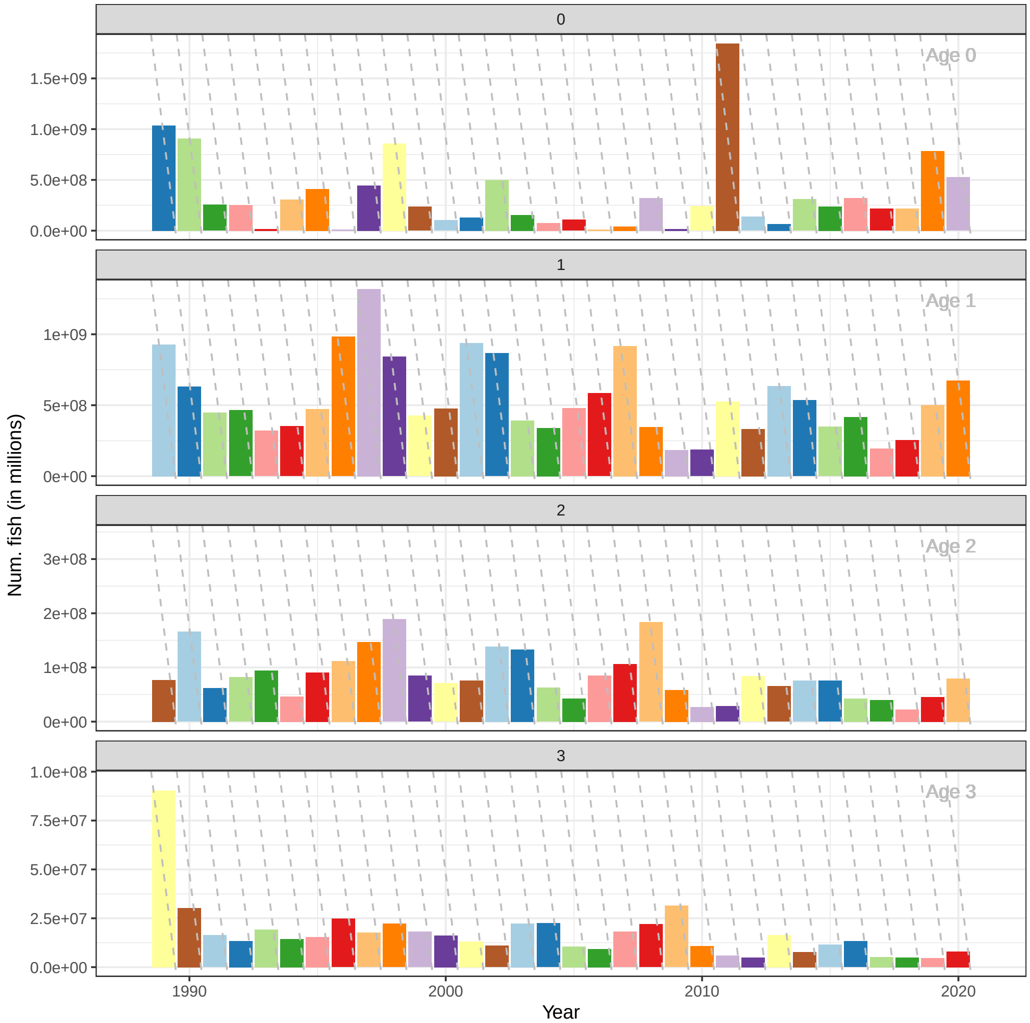

Figure 12: Estimated age composition of the population at the end of the second quarter for each year

6.2. Estimated age composition

Figure 12 shows the estimated age composition of the population.

6.3. Suitability

Figure 13 shows the fleet suitability functions estimated by the model for the commercial fleet and different surveys

6.4. Abundance, recruitment and Fishing mortality

Figure 14 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 15 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

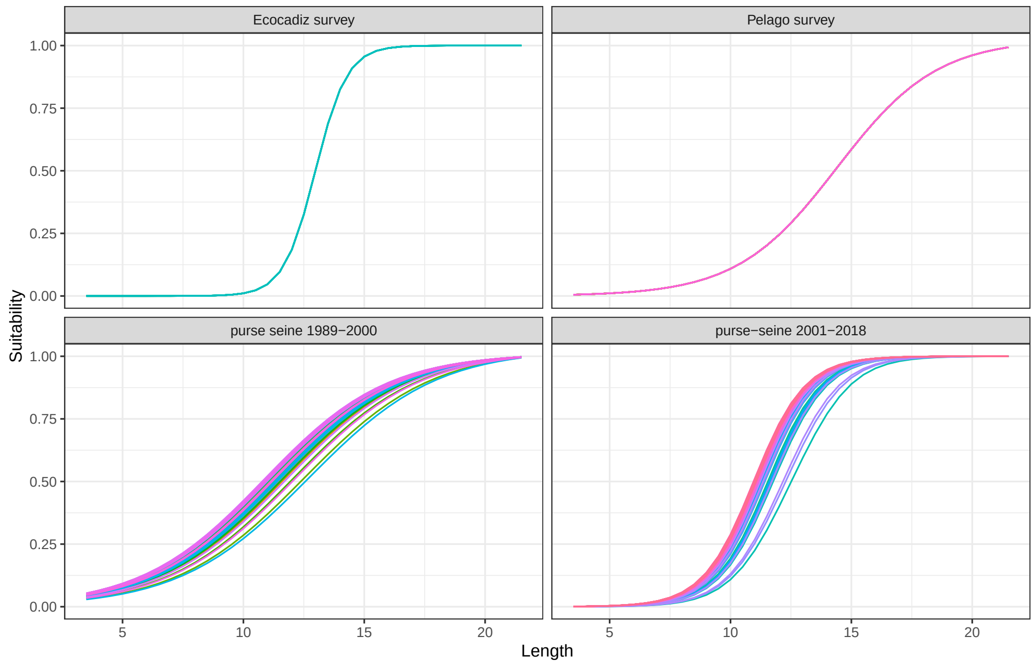

Figure 13: Estimated fleet suitability functions for the commercial fleet and different surveys.

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.

6.5. Comparison with last year estimated time series and sensitivity analysis regarding the assumption made for length and age-length distributions of the commercial catches in first and second quarters of 2020

A comparison with last year estimated time series, and also with those estimated by a model implementation without including length and age-length distribution for commercial catches in first and second quarters of 2020 is presented in Figure 16. It was observed that the estimated biomass for the last three years is higher when assuming the join length distribution of 2018 and 2019 together with the age-length key of PELAGO 2020 survey for first and second quarters of 2020 (green line), than assuming no data available for those quarters (pink line). Nevertheless, the estimates for those years are lower than the last year estimated biomass time series (blue line).

7. Catch advice for July 2021 to June 2022

The ratio between the last year biomass estimate and the mean of the two previous years is:

$$\frac{B_y}{\overline{B_{y-1} + B_{y-2}}} = \frac{3280}{(5891 + 4426)/2} = 0.6351$$

for B representing the estimated abundance by the model as shown in Figure 15. 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:

$$C_{y+1} = \hat{C}_y * \min 1.8, \frac{B_y}{(B_{y-1} + B_{y-2})/2}$$

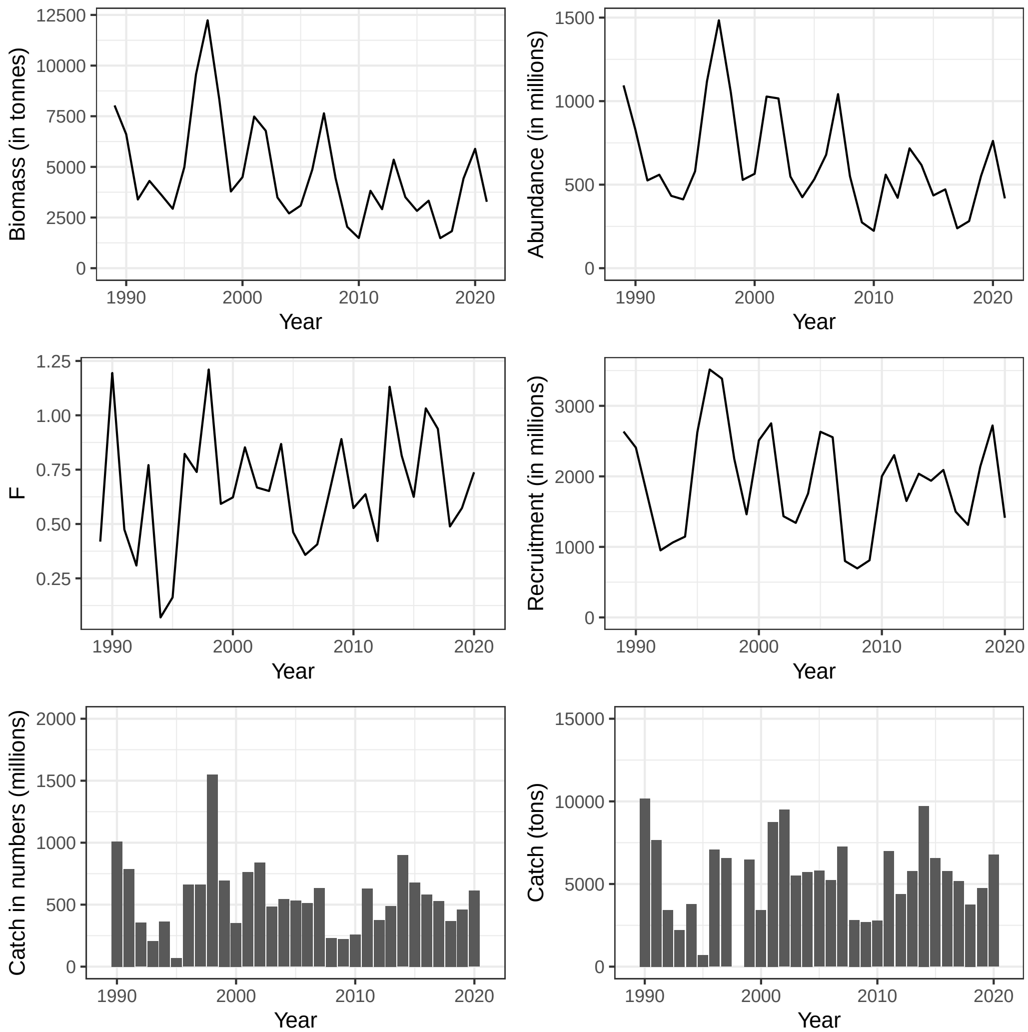

Figure 14: Annual catches time series (in numbers and biomass) compared with annual model estimates for abundance of individuals with more than one year of age(in numbers and biomass) recruitment and fishing mortality. Measures were summarized at the end of June each year, assuming that a year starts in July and ends in June of the next year. Recruitment was calculated including all the recruits of the previous year according to calendar year

where $\hat{C}_y$ is the value of adviced catches in 2019. Then the adviced catches (in tonnes) for the next year (July 2021 to June 2022) would be:

$$C_{y+1} = 11322 * 0.635 = 7190.9.$$

This procedure was not specified in the Stock annex for 2021 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

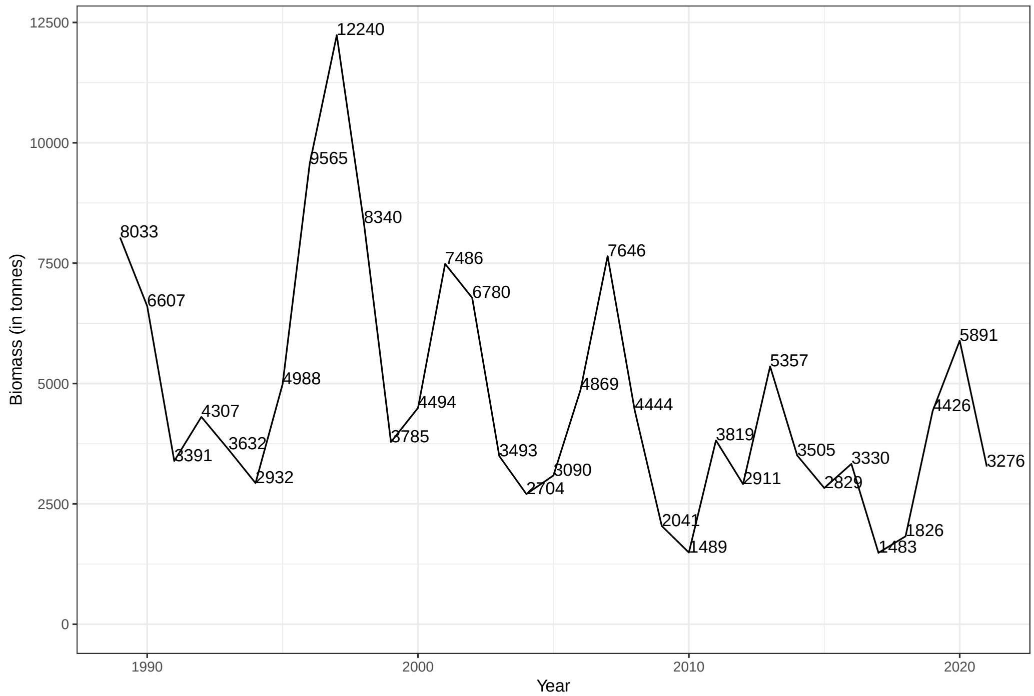

Figure 15: Estimated biomass time series at the end of quarter two (Age 0 removed to be consistent with recruitment at the end of the second quarter of the year). Note that under the assumption that all individuals in $B1+$ class are mature, this biomass is equivalent to SSB

the workshop to review the ICES advisory framework for short lived species ICES WKMSYREF5 2017 (ICES, 2017).

According to the above ICES guidelines and the S-R plot characteristics (Figure 17), 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 2021 the value of $Bloss$ for the 9a South anchovy corresponds to the estimated SSB in 2017 (1483.48 t), hence $Blim$ is set at 1483.48 t and the relative $Blim$ (divided by the mean value of B_1+) results equal to 0.316. 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 6.4 above).

ICES recommends to calculate Bpa as follows:

$$Bpa = e^{(1.645\sigma)}Blim,$$

where σ is the estimated standard deviation of $ln(SSB)$ in the last year of the assessment, accounting for the uncertainty in SSB for the terminal year. If σ is unknown and for short living species, as it is in our case, it can be assumed that $\sigma = 0.30$ (see page 34 of ICES WKMSYREF5 2017 report (ICES, 2017)), then $Bpa = e^{(1.645\sigma)}Blim = 1.64Blim$. According to this Bpa is set at 2432.9072 t.

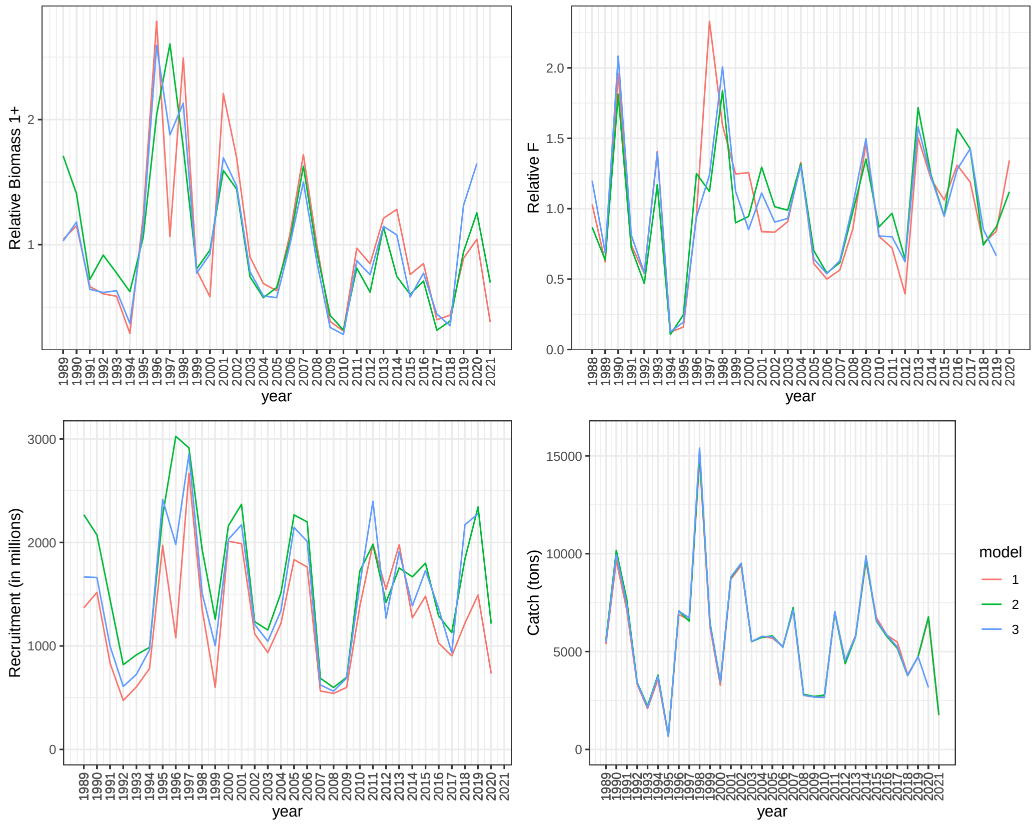

Figure 16: Comparison of estimates from different model implementations. 1. Without data for age-length key and length distribution in first and second quarters of 2020 (pink), 2. Assuming the join length distribution of 2018 and 2019 together with the age-length key of PELAGO 2020 survey for first and second quarters of 2020 (green), 3. Model used for the assessment in June 2020 (blue): Annual model estimates for relative abundance of individuals with more than one year of age, relative fishing mortality, recruitment and catches (in numbers). 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.

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.

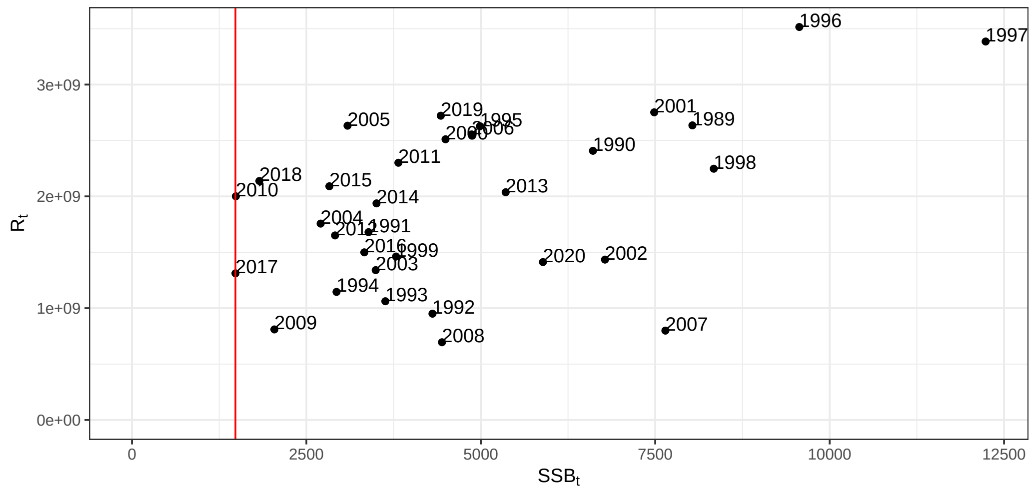

Figure 17: Estimated Stock Spawning biomass (SSB_t) vs. Recruitment (R_t), SSB_t corresponds to the Stock Spawning Biomass at the end of quarter 2 of year t, while R_t corresponds to the sum of the recruitment at the beginning of quarters 3,4 and 1 of years t and $t+1$, respectively.

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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)	May 2021	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)	May 2021	Sardine 8c and 9a

Annex 4: Audits

Audit of Bay of Biscay anchovy stock (ane.27.8)

Date: 28/11/2021
Auditor: Manuela Azevedo

General

The anchovy stock in the Bay of Biscay was benchmarked in 2013. The stock assessment is performed with a Bayesian biomass dynamic model. Population dynamics are described in terms of biomass with two distinct age groups: fish at age 1 and fish at age 2+. Inputs to the model are the total catch in weight, catch-at-age in numbers and weight-at-age by semester and total biomass estimated by two surveys conducted in spring (DEPM and an acoustic survey) and one juvenile abundance index, estimated by the autumn acoustic survey. The stock assessment output provides stock-key parameter estimates and 95% credible intervals.
Due to the Covid-19 disruption the spring acoustic survey (PELGAS) was not conducted in 2020 and the sampling of the landings length/age composition in 2020 was also affected. Therefore, deviations in the assessment from the stock annex are related to the lack of biomass and age structure estimates in 2020 by the PELGAS survey and to the usage of anchovy sales notes by commercial size category (size grading) to estimate the length/age composition of some of the 2020 Spanish catches.
However, sensitivity analysis to the lack of PELGAS data in 2020 was performed during last year´s assessment (ICES, 2020), showing that the impact of the increased uncertainty in R, SSB and HR estimates on the advised catches was minimal because the HCR has a cap on the advised catch, of 33 000 tonnes, when SSB is above 89 000 tonnes. SSB in 2021 is estimated to be highest in the time series, of 206 215 tonnes. Moreover, species sales notes by commercial size category can yield precise estimates of the species landings length/age composition (Azevedo et al., 2021) and this approach is currently used to estimate the Portuguese catch-at-age of the Iberian horse mackerel (ICES, 2020). Since anchovy is included in the EU size grading regulation [EU regulation (EC) No. 2406/96] it is likely that the assignment of fish length to the commercial size categories is consistent across site-days, hence the alternative solution used to fill the data gap may be considered appropriate. Therefore, the deviations in this year´s assessment are not expected to have a significant impact in the assessment estimates and in the catch advice for 2022.

For single-stock summary sheet advice

1) Assessment type: update
2) Assessment: presented
3) Forecast: presented
4) Assessment model: Bayesian two-stage biomass dynamic model. Inputs to the model are the total catch in weight, catch-at-age in numbers and weight-at-age
5) Consistency: The assessment is consistent with last year´s assessment. Recruitment (age 1) in 2021 was significantly revised upwards.
6) Stock status: $SSB > B_{lim}$ since 2009, and is estimated to be the highest in the time-series in 2021 (B_{pa}, MSY $B_{trigger}$ and F_{MSY} not defined for this stock).
7) Management plan: harvest control rule evaluated as precautionary by ICES and agreed in 2016. According to this HCR, $TAC_{y+1}=0$ if the estimated $SSB_{y+1} \leq 24\ 000$ tonnes, $TAC_{y+1}=-2600+0.4*SSB_{y+1}$ if $24\ 000 \leq SSB_{y+1} \leq 89\ 000$ tonnes and $TAC_{y+1}=33\ 000$ tonnes if $SSB_{y+1}>89\ 000$ tonnes.

General comments

The assessment is well documented, and deviations from the stock annex are detailed and justified in the report. The stock assessment input data and the assessment run code was available for the audit. Checking was performed by confronting the input data files for the assessment and for the short-term forecast.

Technical comments

None

Conclusions

The assessment and short-term forecast have been performed correctly, giving a valid basis for advice.

Azevedo, M., Silva, C. and Vølstad, J.H. 2021. Onshore biological sampling of landings by species and size category within auction sites can be more efficient than trip-based concurrent sampling. ICES Journal Marine Science, https://doi.org/10.1093/icesjms/fsab151.

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.

Audit of SARDINE IN 8c9a (2021 ASSESSMENT)

Review of ICES Scientific Report of WGHANSA 2021 (22-26 Nov 2021)
Reviewer: Andrés Uriarte 26/11/2021

Expert group Chair: Leire Ibaibarriaga

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

Assessment made according to the benchmarked assessment procedure agreed in 2017 (WKPELA2017) and updated in 2021 (ICES WKIBIS being currently pending final publication) which accounts for the inclusion of a recruitment index during the interim year to inform on the strength of the age 1 in the management year. This has supposed a neat improvement in the forecast capability of the managed population.

In 2019, the stock was considered by ICES (ICES 2019) to be a low productivity regime which had started in 2006 when a series of poor recruitment began. The reference points were accordingly then updated (ICES 2019).

The last assessment was carried out in May 2021 to update the advice for this year 2021 as requested by member states to ICES (which was published on July 2021). Current new assessment is very much consistent with that in May 2021, though they both revised upward the 2020 SSB estimate. The stock is currently assessed to be well above Blim as a result of the strong year class born in 2019, however the two following year classes occurring in 2020 and 2021 are assessed to be weak again, more aligned with the poor recruitment levels since 2006.

Due to the Covid-19 disruption, in 2020 the Spanish PELACUS acoustic survey was not conducted however as this is part of a combined survey with the Portuguese PELAGO survey which covers the major part of the population, the missing coverage was inferred from the fraction the PELACUS survey input supposed over the portugues estimates in previous years. The 2020 DEPM survey suffered from a parallel lack of coverage of the northern Spanish areas and similar inferences were applied. In 2021 no problem has arisen in survey coverages due to the Covid-19 disruption.

Stock Sardine in Divisions 8c9a (pil.27.8c9a)

Short description of the assessment as follows (examples in grey text):

1) **Assessment type**: *Update (after the benchmarking in 2021 for the inclusion of a new survey index on recruits)*
2) **Assessment**: *accepted*
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) (last input from 2020, made available in the first half of 2021 on the basis of the PT-DEPM survey only as the SP-DEPM was missing due to COVID disruption) 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), though in 2020 due to Covid disruption the Spanish coverage provided by the PELACUS survey was missing. Such missing input was replaced from the fraction the PELACUS biomass estimates supposed over the PELAGO biomass estimates on average in previous years. Similarly, the Spanish component of the 2020 DEPM surveys was inferred following the same approach as for the acoustics. In addition, this year according to the Interbenchmark IBIS in October 2021, the recruitment index provided by IBERAS survey from area 9aCN was included in the assessment to allow the estimate of recruitment at age 0 in 2021. Finally, the total catch and age proportions in the catch are used, including provisional estimates of the total catch in tonnes for 2021.
5) **Consistency**: *There is a global consistency between the assessments, though with some tendency of the most recent assessments in recent years to underestimate the SSB (as this is upward revised in subsequent years) and particularly in 2020. The reason for the major revision of the 2020 SSB is that the strength of recruits in 2019 is being revised upward as the new catches at age and survey age structured and DEPM estimates have been added to the assessment.The Mohn rho value of -0.255*
6) **Stock status**: *B > Blim and above Bpa reference points, and Flim < F < Fpa; The high recruitment in 2019 has restored the population to higher levels than Bpa for the last two years, which had not been observed since 2009. However recruitments in 2020 and 2021 are low. Therefore, the scenario of low productivity of this stock was not revised.*
7) **Management plan**: There is no official TAC for this stock. ICES advice is based on the MSY approach. However, ICES in 2021 has evaluated a set of Harvest Control Rules proposed by Portugal and Spain as part of a management plan for 2021–2026 and found them to be precautionary with maximum allowed catches between 30 000 and 50 000 tonnes (ICES, 2021a).

General comments

The assessment was well documented and deviations from the stock annex that were caused by the Covid-19 disruption (as for inferring the partial missing coverages of the 2020 acoustic and DEPM surveys, were duly justified and explained in the report).

Technical comments

The new Iberas survey index has allowed estimating the strength of the interim year class. This recruitment index has entered the assessment as a Power model with an extra standard error. With the new assessment the power parameter has changed from about 1 (in the interim benchmark in 2021) to about 0.9, and the extra standard error has changed from about 0.58 (in the interim benchmark) to about 0.71. These changes are the result of a too high recruitment index obtained in the 2020 survey which has not been confirmed at such high level in the current assessment according to the Spring acoustic surveys.

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 in 2020. Everything is well justified and documented in the report.

Audit for sardine in divisions 8.a-b and 8d (Bay of Biscay)

Review of ICES Scientific Report, Working Group on Southern Horse Mackerel Anchovy and Sardine (WGHANSA), 2021, 22-26 November 2021
Reviewers: Leire Ibaibarriaga
Expert group Chair: Leire Ibaibarriaga

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

The stock was benchmarked in 2017 and inter-benchmarked in 2019, when the stock was upgraded from Category 2 to Category 1. The stock assessment is conducted using Stock Synthesis (version 3.24f). The assessment is an age-based assessment assuming a single area, a single fishery, a single season per year and genders combined. Input data include catch (in biomass), age composition of the catch, total abundance (in numbers) and age composition from the annual PELGAS acoustic survey, annual total egg abundance and triennial SSB from the DEPM (Daily Egg Production Method) BIOMAN survey.

Consistent with ACOM's 2020 decision, the value of Fpa for this stock has been updated to Fp.05.

In 2020 the PELGAS survey that forms one of the pillars of this stock assessment, couldn't be conducted due to the Covid-19 disruption. Last year the working group conducted a thorough sensitivity analysis of the implications of this missing data source. This year the usual sources of information were available (surveys and commercial sampling) and no additional deviations occurred.

The stock assessment provided this year deviates from the one provided last year. Potential reasons might be the lack of PELGAS 2020 and the contrast with the results from PELGAS 2021 (large age 1 proportion, low mean weight-at-age and very low maturity at age 1). To study the impact of the low maturity, the working group conducted a sensitivity analysis for the maturity at age 1 (mat1=0.25 instead of mat1=0.33) but the differences between the two assessment runs were small.

The Mohn's rho statistics have deteriorated in comparison from previous years. This needs to be further studied in the next years.

For single-stock summary sheet advice

Stock: sardine in divisions 8.a-b and 8d (Bay of Biscay) pil.27.8abd

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Update
2) Assessment: Accepted
3) Forecast: Accepted
4) Assessment model: Stock Synthesis using commercial catches (total and age frequencies), three survey indices (PELGAS acoustic biomass,

BIOMAN egg counts and DEPM Triennial SSB) and age composition from the PELGAS survey.

5) Consistency: there are some differences between the assessment results from this year and the year before. Potential reasons are the lack of PELGAS 2020 and the results from PELGAS 2021.
6) Stock status: Fishing mortality is above F_{MSY} and F_{pa} and below F_{lim}; spawning-stock size is below MSY $B_{trigger}$, B_{pa}, and B_{lim}. Next year recruitment is uncertain.
7) Management plan: There is no management plan evaluated by ICES. There is no official TAC for this stock. ICES advice is based on the MSY approach.

General comments

The stock assessment and short-term forecast is well documented in the report. The stock assessment input data and the assessment run code were available for the audit. Input data files for the assessment and for the short-term forecast and the report tables were checked for consistency.

Technical comments

None

Conclusions

The assessment and short-term forecast have been performed correctly according to the stock annex. Everything is well documented in the report.

Audit of Sardine (Sardina pilchardus) in Subarea 7 (2021 ASSESSMENT)

Review of ICES Scientific Report, WGHANSA *2021* 22-26 November
Reviewers: Susana Garrido

Expert group Chair: Leire Ibaibarriaga

Secretariat representative: David Miller

General

The sardine stock in the southern Celtic Seas and the English Channel was benchmarked in 2021 (ICES, 2021) and was upgraded to category 3. A SPiCT model based on quarterly landing data and a biomass index derived from the acoustic survey PELTIC was developed. There is a high uncertainty of the MSY reference points of absolute biomass and fishing mortality obtained from the SPiCT model, which are considered unreliable, and therefore the advice is based on the 1-over-2 rule with an uncertainty cap of 80% and a biomass safeguard (ICES, 2020). The biomass derived from the PELTIC acoustic survey, for which there are yearly estimates of sardine biomass for the total area since 2017 to present, was used as the biomass index. The relative fishing mortality and biomass were used as indicators of the status of the stock.
The ICES framework for category 3 short-lived stocks (ICES, 2020) used for the advice of this stock consists of multiplying the most recent advised catches by the ratio between the last biomass index value (index A) and the average of the two preceding biomass values (index B). Since this is the first time it is used, the general approach is to multiply the 1-over-2 rule by the average catch of the two most recent years. Several alternative options were considered for this particular stock because it has a large variability of harvest rates and those corresponding to the last two years and are the lowest of the short time series and finally the general approach was implemented.

For single-stock summary sheet advice

1) Assessment type: benchmark 2021
2) Assessment: accepted
3) Forecast: not presented (In-year advice using Catch Advice Rule for category 3 short lived data limited stocks)
4) Assessment model: SPICT + 1 over two rule 80% cap, survey trend
5) Consistency: This new assessment is carried out accordingly to stock annex.
6) Stock status: Fishing pressure on the stock is below FMSY and stock size is above MSY Btrigger.
7) Management plan: No management plan.

General comments

The biomass index was estimated to have decreased by 36% and thus the uncertainty cap was not applied. The 1-over-2 rule with an uncertainty cap of 80% and a biomass safeguard is considered precautionary and for that reason a PA buffer was not applied (ICES 2020). The mean biomass index of 2019 and 2020 was 353358 tonnes and the biomass index of 2021 was estimated to be 227177 tonnes. The mean catches of 2019 and 2020 were 10 745 tonnes. This resulted in an advice that catches in 2022 should be no more than 6 906 tonnes.

Technical comments

The expert group considers that this rule for short-lived species category 3 stocks, based on the 1over2 ratio with uncertainty cap of 80% can only be taken as an interim approach while a better formulation for providing advice can be established.

Conclusions

The assessment has been performed correctly, giving a valid basis for advice. Everything is well justified and documented in the report.

References

ICES. 2020. Tenth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE X). ICES Scientific Reports. 2:98. 72 pp. http://doi.org/10.17895/ices.pub.5985

ICES. 2021c. Benchmark Workshop on selected stocks in the Western Waters in 2021 (WKWEST). ICES Scientific Reports. 3:31. 504 pp. https://doi.org/10.17895/ices.pub.8137

Audit of Anchovy 9a

Date: 28/05/2021

Auditor: Andrés Uriarte

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 1-over-2 trend rule subject to an uncertainty cap of +/- 80% (maximum relative allowable change between years).

- For both components the stock annex has been followed.
- However, there is an increasing amount of auxiliary information which is not yet taken into account for the assessment.

In particular for anchovy in 9aSouth, information from acoustic survey ECOCADIZ-Reclutas series and from the DEPM (carried out every three years) is not used. The DEPM assess the anchovy Spawning Biomass, and the series started in 2005 and a total of six surveys have already been reported to the group. Ecocadiz Reclutas aims at assessing the strength of anchovy recruitment (juveniles); the series started in 2012 and nowadays there is a total of eight surveys available to the group.

Recommendation: Testing the potential utility of these surveys to improve the assessment and provision of advice deserves a benchmark and a recommendation was put forward for consideration of ACOM.

For the western component the information on recruits coming from IBERAS acoustic survey in autumn is not used, though preliminary analysis of its consistency versus the PELAGO age 1 estimates in the following year, shows it to be weak.

- The COVID19 disruption has caused that the first half of the year catches were not sampled in Spanish waters.

The decisions taken by the group aimed at making the major use of the information actually available from the different surveys and market samplings carried out in 2020:

For gaps on anchovy information in 2020 in Anchovy in 9a, the following decisions were taken:

- Western component:

  Quarterly LFDs and ALKs in 9a CN (which was sufficiently sampled) will be propagated to the Portuguese catches in 9a CS and Spanish catches in 9a N (where no LFD & ALK were available for any quarters). Advices is not dependent on such assumption, as it is based on trends from the survey index.

- Southern component:

  For Spanish 2020 catch data on Q1 and Q2 (no LFD & ALK) use the sum of the 2018–2019 LFD (which were rather similar between them) + ALK borrowed from PELAGO survey in 2020.

  The resulting LFDs and age structure in Spanish catches will be then propagated to the (very low) Portuguese catches (Algarve; no LFDs, no ALK in Q2-Q4, only ALK of PELAGO 2020).

Audit for 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 2nd quarter, as estimated from the GADGET model. This is the fourth year where advice will be provided and the third subject to the 80% Uncertainty cap.

The assessment of Anchovy 9a South:

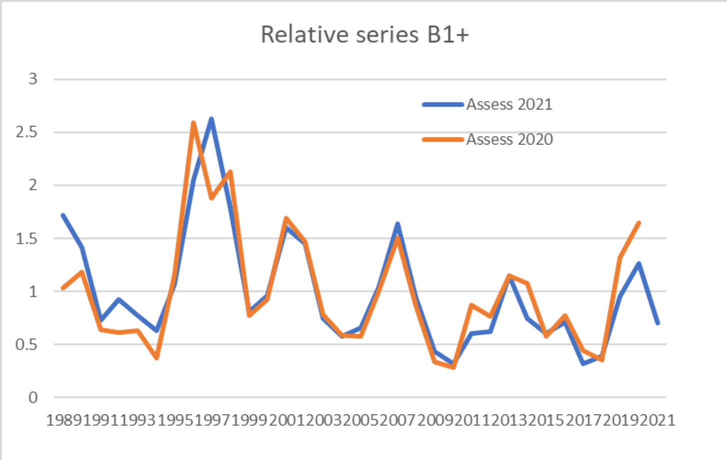
- It was carried out as expected (SALY) incorporating the new information from surveys (ECOCADIZ 2020 and PELAGO2021), and commercial catch in the last year (2020) with their quarterly ALKs when available (or with inferences on age composition, mainly for the first half of the year, as explained before), and finally the total catch for the first half of the year 2021 (assuming historical % of catches in May and June).

For single stock summary sheet advice:

1. Assessment type: SALY (benchmarked in 2018)
2. Assessment: Accepted. Analytical assessment, but for a Category 3 stock used only as relative indicator of stock trends (not as absolute estimates). Results rather consistent with past year, though with some small corrections of biomass estimates in 2019 and 2020.
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, 2021 index included) and ECOCADIZ (Summer 2020 index included).
5. Consistency: This new assessment is carried out accordingly to stock annex.

   Compared to last year's assessment, there is a large global consistency, even though there has been some revision of the series in absolute terms, whereby biomass has been rescaled globally slightly upward and Fishing mortality inversely downwards. However, in particular the two most recent years (2019, 2020) have the biomass rescaled downward (by about 20%). The revision of 2020 estimate, was somehow expected according to the new information from surveys and catches in year 2020 and 2021 made now available. However, the change of the 2019.

   However as regards this category 3 stock, the assessment is taken in relative terms and from that point of view the assessment of the relative series of B1+ is not much changed compared to past assessment output year (see the figure below). Nevertheless, the ratios between recent years of B1+ estimates have changed slightly and this affects the advice procedure which uses those ratios to correct the former catch advices (see technical comments at the end of this subsection on anchovy in 9a).



6. **Stock status**: Although the assessment of B1+ is not taken in absolute terms but as relative indicator of stock abundance, current B1+ is about 70% of the historical mean well above the historical lowest value (taken as B_{lim}= B_{loss} in 2010 in this assessment i.e. at about 29% of the historical mean) and it is as well above B_{pa} (deduced from B_{lim} at 0.47 of historical mean, in relative terms).
7. **Management Plan**: There is no management plan.
8. **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 2020 to 30 June 2021). This is like in-year advice as approved in the stock annex for this category 3 stock. As the 1over2 ratio was 0.63 there was no need for this year standard recommendation of applying the 80% uncertainty cap This implied a catch advice for the 2020 management period 80% lower than in 2020.
9. **Data issues:** There was a lack of length and biological in the first half of the year in 2020 both in Spain and Portugal which has been replaced for Spain by the length in catches from the two previous years and the ALK from the spring survey PELAGO (and the small Portuguese catches were assumed equal to those in Spain during the first half of the year.

   All available and inferred catch data as well as survey inputs were fully used for the assessment.

   Some additional surveys (Ecocadiz-Reclutas and Bocadeva), though available, are not used in the assessment as agreed in the benchmark because of their time-series being considered by then too short (e.g. Bocadeva) or because of being in a testing phase of performance (e.g. Juvesar, Ecocadiz-Reclutas). Though time has reached to test for their reliability as to be used in future assessments.

General comments

The assessment was well documented and the stock annex was followed.

Technical comments

The group acknowledges that the estimated SSB (=B1+) time series are being updated every year with the addition of new data. This causes some changes in the relative changes of B1+ estimates between the most recent years which affects the consistency of the ratios used for the provision of advice with the (of 1-over-2 rule) between updated assessments. Last year such inconsistencies were shown to affect the advices would have been provided for year 2019 if this would have been based on the assessment carried out in 2019 or if based on the 2020 assessment, with propagations to the expected advice for the seasonal management year 2020/2021. Current draft advice for the season 2021/2022 is also being affected for the same updated changes in the assessment.

All this derives from the fact that the trend advisory rule (1-over-2) assumes implicitly 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 previous years were partially biased (as far as the biomass series of B1+ estimates have 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. But, 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 do not deviate from the standard ICES guidelines for category 3 short-lived stocks.

Conclusions

- The assessment has been performed correctly SALY.
- Missing information in catches due to the lack of fishery monitoring in 2020 were covered with reasonable and justified assumptions on length frequency distributions from past years and ALK from an acoustic survey from the same season and year.
- The stock is assessed to be below historical mean in 2021, but above B_{pa} and B_{lim}.
- The revision of the estimates of B1+ in recent years, according to the updated assessment, would have induced some changes in the advice produced this year for 2020/2021.
- The advice does not deviate from the recently adopted standard ICES guidelines for category 3 stocks advice which allows a 80% uncertainty cap for short-lived species.

Audit for 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:

- It was carried out as expected (SALY) incorporating the new information from PELAGO 2021 + PELACUS 2021, plus the commercial catch in the second half of year 2020 and the first half of the year 2021 catches (assuming catches in May and June). This is not an analytical assessment and catches-at-age are not used for the assessment or provision of advice. For the surveys in 2020, PELAGO was the only survey available, and for the missing coverage of the 9aNorth (usually made by PELACUS) the PELAGO estimate was raised up with the typical % of biomass in such Northern area compared to the area coverage by PELAGO.

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 the survey estimates of stock biomass 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. **Consistency**: This new assessment is carried out accordingly to stock annex.

   This year 2021 the PELAGO+PELACUS spring acoustic estimates are similar (slightly higher) that the one obtained in 2020.

6. **Stock status**: Although the assessment is not taken as absolute but as relative, current B1+ around 65 683 t is actually the highest of the historical series. No B_{lim} or $B_{trigger}$ has been defined for this western component.
7. **Management Plan**: There is no management plan
8. **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 2020 to 30 June 2021). This is like in-year advice as approved in the stock annex for this category 3 stock. The One-over-two ratio is 2.166 and therefore a maximum increase of up to 80% (the uncertainty cap) was applied. This implied a catch advice for the 2021/2022 management year of 7824 tonnes, corresponding to a Harvest rate HR=0.12.
9. **Data issues:** For this component there was a poor sampling level for length and age composition in 2020. To overcome this, Quarterly LFDs and ALKs in 9a CN (which was sufficiently sampled) was propagated to the Portuguese catches in 9a CS and Spanish catches in 9a N (where no LFD & ALK were available for any quarters). In any case, advice is not dependent on such assumption, as it is based on trends from the survey index.

   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.

General comments

In 2020, the acoustic index has reached its highest value (65 683 t) very similar to the second highest (65 096 tonnes record in 2018) that corresponded to an advice of 13 308 tonnes (HR=0.16). This year the advice will be 7824 tonnes, corresponding to a HR=0.12.

Technical comments

This year and in the previous year 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. The 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.

Further work is planned to be carried out in the WKDLSSLS3 testing the performance of HCRs based on either fixed or gradually changing harvest rates to manage these highly fluctuating 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 well above historical mean value in 2021 (at the highest biomass levels).
- The advice does not deviate from the recently adopted standard ICES guidelines for category 3 stocks advice which allows a 80% uncertainty cap for short-lived species, though the groups considers this an interim approach until finding a better way to manage these oscillating anchovy resources.

Audit of Southern Horse Mackerel (hom.27.9a)

Date: 02/06/2021

Auditor: Leire Citores

General

The southern horse mackerel stock is analytically assessed every year using annual Spanish and Portuguese catch and survey data, for which some missing data were reported in years 2019 and 2020: Due to the Covid-19 disruption in 2020 Portuguese auction market sampling in the 2nd quarter was affected and the catch length distribution was obtained by an alternative solution. The length distribution sampling of the Spanish catches was also affected assuming for 2020 the same length distribution by gear as in 2019. Official catches were appropriated reported for both countries. Concerning survey indices, in 2019 (technical/legal issues) and 2020 (technical and covid-19 issues) the Portuguese IBTS survey was not carried out so a combined (Portuguese + Spanish) survey index for 2019 and 2020 was not available for the assessment model fitting. As last year, the assessment was accepted without the missing survey index values. As a result of the missing data, uncertainty in the 2018, 2019 and 2020 recruitment was very high and the recruitments for these three years assumed in the short-term forecast were replaced by the geometric mean of 1992 to 2017 (instead of taking the whole time-series as detailed in the stock annex).

Concerning biological reference points for this stock, due to the ICES redefinition of F_{pa} as $F_{p.05}$, the F_{MSY} was also redefined to 0.15, which is different from the previous one (previous F_{MSY}=0.11). The stock annex was updated accordingly.

For single-stock summary sheet advice

1. Assessment type: update (SALY)
2. Assessment: accepted
3. Forecast: accepted
4. Assessment model: AMISH (Assessment Method for the Ibero-Atlantic Southern Horse mackerel)– as in stock annex – tuning by time-series of total catch, catch-at-age, biomass index of IBTS survey, abundance-at-age from IBTS survey and mean weight-at-age in the catch and stock.
5. Consistency: The assessment is consistent with last year's assessment; Fishing mortality and SSB in 2019 remain basically the same as in the last assessment, no significant upward or downward revisions have been observed.
6. Stock status: SSB >> $MSYB_{trigger}$; F << F_{MSY}; R uncertain since 2018 due to data issues.
7. Management plan: A management plan was proposed and evaluated as precautionary by ICES (ICES, 2018). However, ICES was requested by the EU to base its advice for 2022 on the ICES MSY approach and include the MP as a catch scenario.

General comments

The assessment was well documented, and deviations from the stock annex were detailed and justified in the report. Input data for stock assessment and short-term forecast was checked by confronting the report tables and the input data files.

Technical comments

None.

Conclusions

- The assessment has been performed correctly SALY.
- The update assessment gives a valid basis for advice.
- Missing information was covered with justified assumptions.
- The perception is consistent with previous years with fishing mortalities below F_{MSY} and SSB above MSY $B_{trigger}$.
- There is a concern about the assumption of constant selectivity for catch-at-age on the last period of the assessment due to the continued and significant shift in relative catch contribution from bottom trawls to purse-seines in the last years, that has led to a change in the age composition of catches, with an increase in the proportion of age 1–2 individuals. It is noted that the possible violation of this assumption needs immediate investigation.

Audit of Sardine in divisions 8.c and 9.a

Auditor: Rosana Ourens

Date: 02/06/2021

General

The last assessment of this stock was carried out in May 2020 and the ICES advice for 2021 was published in June 2020. Since then, new data have become available, including both fishery-dependent data (i.e. total catch and catch-at-age for 2020) and fishery-independent data (results from the acoustic surveys PELAGO and PELACUS, and the Portuguese DEPM survey). In addition, the reference points F_{MSY} and MSY $B_{trigger}$ were revised for this stock in 2021 using a management strategy evaluation framework (ICES, 2021). Consequently, ICES received a special request from Spain and Portugal to update the scientific advice for 2021 using the most recent data available. The stock was assessed in May 2021 accordingly.

Due to the COVID pandemic, some of the input data of the model were missed in 2020 and the WG had to make some assumptions to deal with this issue and carry out the assessment (see below). All decisions were deeply discussed and are well documented in the report.

The advice for 2021 is based on the MSY approach like in previous years, as requested by the EU Commission. The updated catch advice for 2021 has increased by 272% respect the advice provided for 2021 in June 2020 (40 434 tonnes vs. 10 781 tonnes). This increase is a consequence of a raised biomass derived from the acoustic surveys and of the re-estimation of the MSY reference point F_{MSY}.

The report, the stock annex updated in May 2021, and the advice sheet were used for this audit.

For single-stock summary sheet advice

Stock: Sardine in divisions 8.c and 9.a (Cantabric Sea and Atlantic Iberian waters)

Short description of the assessment as follows:

1. **Assessment type**: age-based analytical model. The stock was benchmarked in 2017 (ICES, 2017) and the reference points were revised in 2021 using a management strategy evaluation framework (ICES, 2021).
2. **Assessment:** accepted
3. **Forecast**: Forecast for 2021 presented. Short-term predictions for 2022 will be presented in November 2021.
4. **Assessment model:** The stock is assessed using Stock Synthesis 3, version 3.24f. It is an age-based model assuming a single area, a single fishery, a yearly time-step, and both sexes combined. 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.

   The data collection from the commercial fishery and research surveys during 2020 were affected by the COVID pandemic, which negatively impacted on the quality of the data used in the assessment. The main issues with the data and the approaches to deal with them were the following:

   - The Spanish DEPM survey was cancelled in 2020. Different approaches were tested by WGACEGG to compensate the lack of the survey. It was decided that the

Portuguese index could be raised to estimate the total SSB of the stock, given the high correlation between Spanish and Portuguese DEPM surveys.

- Length distributions of catches were missed for some of the subdivisions and quarters, as well as the age–length keys. A sensitivity analysis was conducted to evaluate different options to tackle this issue. Based on the results of the sensitivity analysis, the proportions-at-age from adjacent subdivisions were used in areas without data. In those cases where the length composition was available but not the age–length key, the latter was either borrow from other subdivision or assumed to be an average of the age–length keys from previous years.

5. **Consistency:** The assessment is consistent with last year assessment. The incorporation of the new data led to an increase in recruitment and biomass estimates for 2019, 2020 and 2021 compared with the previous assessment, whereas fishing mortality has been slightly revised downwards.
6. **Stock status:** Fishing pressure on the stock is below F_{MSY} and spawning–stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}. Recruitment in 2020 was similar to previous values, excluding the high recruitment observed in 2019.
7. **Management plan:** Spain and Portugal developed a multiannual management plan (2021–2026) for this stock. ICES has recently evaluated a harvest control rule that will be part of that plan as requested by Spain and Portugal (ICES, 2021). ICES found that the generic harvest control rule was precautionary with maximum allowed catches between 30 000 and 50 000 tonnes. For 2021, the EU Commission requested ICES to provide advice based on the MSY approach. It must be noted that currently there is no official TAC for this stock.

General comments

None.

Technical comments

None.

Conclusions

The assessment has been performed correctly. Deviations from the stock annex were due to the lack of data occasioned by the Covid pandemic. A new section to deal with the problems caused by the Covid pandemic has been added to the report. Everything is well justified and documented in the report.

References

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

ICES, 2021. Request from Portugal and Spain to evaluate a new Harvest Control Rule for the management of the Iberian sardine stock (divisions 8.c and 9.a). In Report of the ICES Advisory Committee, 2021. ICES Advice 2021, sr.2021.05. https://doi.org/10.17895/ices.advice.8163.

Annex 5: Joint session WGACEGG-WGHANSA

On the first day of WGHANSA, 24th May, a joint WGACEGG-WGHANSA session took place. The objective was to present and discuss the abundance indices of the PELAGO and PELACUS acoustic surveys and the Iberian sardine biological parameters from the Portuguese DEPM survey before their inclusion in the stock assessment.

Apart from the WGHANSA participants, the joint session was attended by the following WGACEGG members:

Maria Manuel Angelico (Chair)

Jeroen Van der Kooij (Chair)

Pedro Amorim

Pablo Carrera

Paz Díaz

Rosario Domínguez

Ana Moreno

Cristina Nunes

Silvia Rodrigues

Some participants (Fernando Ramos, Isabel Riveiro, Andrés Uriarte, Gersom Costas and Leire Ibaibarriaga) are members of both groups.

The following presentations were carried out:

- "PELAGO 21 Acoustic survey. Preliminary Results" by Pedro Amorim and Ana Moreno.
- "PELACUS 0321: Sardine and anchovy results" by Pablo Carrera.
- "Maturity and weights-at-age Iberian Sardine stock (27.9a+27.8c) (DEPM 2020)" by Cristina Nunes.

WGACEGG approved the abundance indices from PELAGO and PELACUS 2021 surveys for their inclusion in the stock assessment. The maturity and weights-at-age for the Iberian sardine stock were also approved. The main results of these presentations are briefly summarised in the stock assessment input data sections of the WGHANSA report. However, these surveys will be discussed more extensively within WGACEGG in the meeting that will take place in November 2021 and a detailed description will be available in the corresponding WGACEGG report.

Annex 6: Sardine in 8c and 9a

This annex corresponds to the work done during WGHANSA-1 to address the special request from Portugal and Spain on a revised advice on fishing opportunities for 2021 for sardine in divisions 8c and 9a (Tor b for WGHANSA).

3.1 ACOM Advice Applicable to 2020, STECF advice and Political decisions

ICES advises that when the MSY approach is applied that catches in 2020 should be no more than 9 660 tonnes (ICES, 2020a). This advice for 2020 replaces the advice provided in December 2019 (ICES, 2019a) and was issued in June 2020 after ICES received a special request from Portugal and Spain to review the catch advice for 2020 based on the most recent available data (ICES, 2020a). ICES responded to this request by updating the advice, based on the results of the stock assessment conducted in 2020 (ICES, 2020b).

In 2020 the fishery was managed according to a bilateral agreement between Portugal and Spain (Despacho 5713-A/2020; BOE-A-2020-4947) stating that they would manage the fishery following a harvest control rule, HCR12, evaluated as precautionary by ICES (ICES, 2019b).

Portugal and Spain set a provisional catch quota until the end of July of 9500 tonnes, from which 3182.5 tonnes corresponded to Spain. After July advice, Spain and Portugal agreed to implement the total catch allowed by the HCR12 for 2020, 19 106 tonnes.

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 6 300 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). From the 1st of August onwards a catch limit of 6 405 tonnes was allowed (Despacho n.º 7424-A/2020, Diário da República, 2ª série - N.º 143 - 24 de Julho de 2020). In Portugal the fishery closed on the 10th of October (Despacho n.º 9747-A/202, Diário da República, 2ª série - N.º 196 - 8 de Outubro de 2020) when the quota limit was reached.

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 of 2020. The purse-seine fishery was closed on 17th July in 8c and 9a subdivisions (Resolución de la Direccción General de Pesca y Acuicultura). From this date, sardine continued to be landed in Cádiz area until the allowed catches were finished (small quantities were transferred from Cadiz to the Cantabrian fleet in the third and fourth quarters). Likewise, as in Portugal, landings of sardines smaller than 15 cm are limited and on-board observers programme continues.

3.2 The fishery in 2020

3.2.1 Fishing fleets in 2020

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 2020 indicate that the number of purse-seiners taking sardine were 453, with mean power of 229 Kw.

In Portuguese waters, fleet data indicate that 175 vessels landed sardine with mean vessel tonnage of 70.0 GT and engine power category of 358 Kw.

3.2.2 Catches by fleet and area

The WG estimates of landings and catches are shown in Tables 3.2.2.1 and 3.2.2.2.

Total sardine landings in 2020 are shown in Tables 3.2.2.1, 3.2.2.2 and Figure 3.2.2.1. Total 2020 landings in divisions 8c and 9a were of 22 143 tonnes, which represents an increase of 61% with respect to total 2019 landings (13 760 tonnes). The bulk of the landings (99%) were made by purse-seiners.

In Spain, sardine landings, 6727 tonnes, represent a 70% increase in relation to values from 2019 (3964 tonnes). In all ICES subdivisions catches experienced a large increase, but especially in the northern areas (8c and 9aN, with increases of 75% and 81% respectively), compared to a 53% increase in Cádiz.

In Portugal, sardine landings were of 15 416 tonnes, which represents an increase of 57% compared with 2019 landings, 9796 tonnes. The increase in landings was generalized, with an increase of 41% in the Algarve and especially important in the areas in which landings had decreased in 2019, 9aCN (which experienced a 43% increase this year) and 9aCS, which increased catches by 76%.

Table 3.2.2.1 summarises the quarterly landings and their relative distribution by ICES subdivisions. In 2020, due to management regulations implemented in Spain and Portugal (see Section 3.1.), the sardine fishery opened late in the year (May) and it closed at the beginning of the 4th quarter for having reached the total catches admitted. 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 to the total catch was similar to 2019, being the western Portuguese Atlantic coast (9aCN and 9aCS subdivisions) the areas that obtained almost 60% of the total catches of the stock.

Figure 3.2.2.2 shows the historical relative contribution of the different subareas to the total catches.

It was not possible to estimate a total discard rate due to the COVID-19 pandemic disrupting onboard sampling. However, discards are generally negligible for this stock.

3.2.3 Effort and catch per unit of effort

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

3.2.4 Catches by length and catches-at-age

Sampling programmes coordinated by the IEO, Spain (on-shore, observers on board and biological sampling) were suspended in most of 2020 due to administrative problems and to the COVID-19 disruption. No length distribution was available for subdivision 8cE in quarter 3, Subdivision 8cW for quarters 1, 2 and 3, Subdivision 9aN in all quarters and Subdivision 9aS-Cadiz in quarters 1, 2, 3. In some quarters of subdivisions 8cW, 9aCN, 9aCS and 9aS-Algarve, it was possible to have a length distribution but based on very small number of samples and individuals measured.

The COVID pandemic also affected, but to a lesser extent, some of the biological samplings (including otolith samples for age readings) made by IEO in Spain and IPMA in Portugal.

During the WG, several options were explored to solve the problem of lack of sampling in some areas and quarters during 2020. Results were presented and discussed during the WGHANSA 1 meeting and are detailed in the Section 3.9.

Length distribution of the available sampling during 2020 (Table 3.2.4.1) show that, as usual, smaller individuals were caught in 9aS-Cadiz subdivision. Length distributions were unimodal in all subdivisions, for both Spain and Portugal. In Spain modes were 13.5 cm in 9aS-Cadiz and 17.5 cm in 8cE. In Portugal, smaller individuals were caught in 9aCN subdivision (mode at 16 cm), in Algarve mode was at 17.5 cm and bigger individuals were present in 9aCS subdivision (mode at 20 cm).

Tables 3.2.4.1a,b,c,d show the quarterly length distributions of landings from each subdivision.

Table 3.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision for the year 2020, while Table 3.2.4.3 shows the historical catch-at-age data. In Table 3.2.4.4 and Figure 3.2.4.1, the relative contribution of each age group in each subdivision is shown as well as their relative contribution to the catches. Age 1, as usual, has the highest percentage in the catch. In 2020, however, the relative contribution of the 2019 year class (age 2) is much more important than in previous years, representing 58% of catches which reflects the strong 2019 recruitment. In the northernmost areas of the Atlantic coast of the stock (9aN and 9aCN), this age accounts for almost all of the catches. Age 0 was mainly caught in one of the main recruitment areas of this stock: 9aS-Cadiz (69%), but was barely landed in the northern areas of 9a division (9aN and 9aCN subdivisions), traditional recruitment areas and in which a large part of the juveniles were located during the IBERAS 2020 survey.

3.2.5 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 3.2.5.1 and 3.2.5.2.

3.3 Fishery-independent information

Figures 3.3.1 and 3.3.2 show the time-series of fishery-independent information for the sardine stock.

3.3.1 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 2020), where final results were presented and fully discussed (ICES, 2021a).

In 2020, IPMA DEPM Portuguese survey was successfully conducted, however, the Spanish survey; SAREVA0320, was cancelled due to the COVID-19 health crisis and the posterior declaration of the national state of alarm in March of 2020.

The cancellation of Spanish spring DEPM survey has led to a lack of sardine data for estimating the total stock SSB in 2020, with impact on the 2021 assessment, the first year in which this 2020 index is used in the evaluation model.

Different solutions were tested to compensate for the lack of the SAREVA survey data and WGACEGG in November 2020 (ICES, 2021a) decided that the Portuguese index could be raised by a linear regression model to estimate the total SSB in the Iberian sardine stock, considering the high correlation between Spanish and Portuguese surveys (with a higher contribution to the SSB of the Portuguese in the Cantabrian Sea and Atlantic Iberian waters - mean = 78%). DEPM parameters derived from the 2020 sardine DEPM survey with their CV (%) in brackets by institution and strata are shown in Table 3.3.1.

3.3.2 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, 2020). 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 9a and 8c using acoustic methods: PELAGO and PELACUS. For the first time, in 2021, both surveys were carried out on the same vessel, RV Miguel Oliver. The PELAGO survey was carried out in March, followed by the PELACUS survey. This same work scheme had been planned for 2020, but PELACUS could not be carried out due to the COVID pandemic.

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

During the first day of the WGHANSA-1, in a joint extraordinary meeting with the WGACEGG, the 2021 PELAGO and PELACUS results were presented, discussed and approved for use in the update of the sardine advice for 2021 (Appendix 5).

3.3.2.1 Portuguese spring acoustic survey

The PELAGO acoustic surveys have sampled the Portuguese and Bay of Cadiz continental shelves, since 1995 and until 2019 with the RV Noruega, a 49 m trawl vessel. In 2020 and 2021 this survey was carried out on board RV Miguel Oliver.

The PELAGO2021 survey was conducted between the 3rd and 21st of March. Seventy-one (71) transects were acoustically sampled between Caminha and Cape Trafalgar.

Figure 3.3.2.1.1 shows the acoustic transect along the surveyed area and Figure 3.3.2.1.2. shows the fishing operations conducted during the survey and the proportion of species in each fishing station. A total of 38 pelagic trawl hauls were carried out by the research vessel and 26 additional hauls were done by two purse-seiners. Sardine was present in most of the fishing hauls (89%) and represented 36% of the total catch in weight and 19% in number.

Figure 3.3.2.1.3. shows the NASC values allocated to sardine. The energy attributed to this species was distributed throughout the coast, with the highest concentrations in the north, between Porto and Aveiro, and in the 9aCS subdivision.

Figures 3.3.2.1.4., 3.3.2.1.5. and Table 3.3.2.1.1. show the abundance in number and biomass by length and age class, respectively. In 9aCN the modal age was 16 cm, representing age 2 individuals (accounting for the 84% of the abundance in this area), reflecting the strength of the 2019 year class, already detected last year during the IBERAS20 survey.

In 9aCS, the length distribution is bimodal with a main mode at 16 cm of age 2 individuals. The second mode of larger individuals includes mainly 5 years old sardines of the 2016 cohort. In 9aS-Algarve, the length distribution is bimodal, with a mode at 15 cm (age 1) and also larger fish of 18.5 cm, corresponding to age 3 sardines. In 9aS-Cadiz, most sardines (83% of the abundance) belong to age 1, with a mode at 14 cm length.

During 2021 PELAGO survey, age 0 sardine individuals were not detected.

In relation to total abundance in PELAGO2020, 2021 sardine estimation (10 901 million individuals) showed a decrease by 42%. Compared to the abundance of age 1 individuals last year, this represents a decrease by 34%.

The sardine B1+ was estimated to be 416.5 thousand tonnes for the whole area, representing a significant increase of 8% in relation to the PELAGO2020 survey (5% increase in total biomass comparing to the 2020 survey).

3.3.2.2 Spanish spring acoustic survey

The Spanish PELACUS 0321 survey was carried out from 25th March to 18th April in the RV Miguel Oliver. Sampling design and methodology was similar to that of the previous surveys and is summarised in Massé *et al*. (2018) with supplementary material available online. Tracks were placed at 10 nmi, with a random start and only steamed during day hours. The survey progressed eastwards (Figure 3.3.2.2.1).

Weather conditions were good in 9aN but becoming worse northwards. As a consequence, half of the 8cW subdivision was steamed at the end of the survey. In general, in Cantabrian Sea (8c and 8b subdivisions) Northeast winds were predominant at a force 5–8.

A total of 15 362 echotraces were extracted, accounting for a total NASC (sA) of 513 355 m^2 nmi^{-2}, an important increase from that recorded in 2019 (210 114 m^2 nmi^{-2}).

A total of 44 fishing stations were carried out, yielding about 31 kt of fish. Of them, 11 corresponding to sardine (40% in number), which was present in 64% of the fishing stations. In 9aN a very significant increase of sardine schools was recorded. They mainly occured within the Rias and surrounding (near shore) areas. Schools were mainly located close to the surface with high densities. Figure 3.3.2.2.2 shows the species proportion (% in number) in the fishing stations, with circles proportional to the total catch in weight.

The bulk of the sardine NASC distribution was recorded in 9aN subdivision (Figure 3.3.2.2.3.). The amount of backscattering energy allocated to sardine is the highest of the time-series in Spanish waters, which also shows an increasing trend since 2013, when the minimum value was observed. Besides, as the amount of fish is increasing, the center of gravity of the distribution is moving towards the western area (Galician area), and consistently going to shallower waters.

A total of 348 thousand tonnes, corresponding to 6770 million fish were estimated, most of them in the western part (9aN) (Table 3.3.2.2.). Although the significant increase in biomass in relation to that estimated in 2019, age group 1 only accounted for l4% of the total biomass, with the bulk of the fish belonging to age group 2 (60%); age 5 accounted for 14% of the biomass, which is consistent with the results obtained in 2019, when this cohort achieved the 48% of the total biomass (and number) at age of 3. The very scarce estimates of age group 1 in western waters (9aN and 8cW), with less than 2% of the total abundance did not match with the results obtained in the Cantabrian Sea where this cohort accounted for the 59% of the abundance (8cE) and up to 81% in 8b (Figure 3.3.2.2.4.).

3.3.3 Other regional indices

Although not included as an input in the sardine assessment, ECOCADIZ survey (fully described in Section 2, 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 (specially for age-0 individuals), although they have interannual differences (Figure 3.3.3.1.).

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. 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 since 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). Since 2019, in general terms, the change from November to September improved the survey strategies and the assessment itself. IBERAS survey in 2020 showed an important increase of the recruitment ($136x10^3$ mt $6.8x10^9$ fish), much higher than that of 2019 (102×10^3 mt 5.5×10^9). In addition, during IBERAS, the strong 2019 year class was confirmed.

In the 2021 spring surveys, this great abundance of juveniles detected in IBERAS20 did not correspond to an abundance of age 1 greater than that estimated in 2020. However, the relationship between the abundance of juveniles in the JUVESAR-IBERAS survey series versus age 1 estimated in spring in acoustic PELAGO-PELACUS continues to show a good correlation (Figure 3.3.3.2.) and these promising results support the inclusion of the survey in the assessment model of this stock.

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

Mean weight-at-age in the catch are shown in Table 3.3.4.1a.

According to the stock annex, mean weights-at-age in the stock (Table 3.3.4.1b) 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 (2020) are assumed.

3.3.5 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 (2020) are assumed. Those estimates were presented during a joint session of WGHANSA-WGACEGG during the first day of the meeting (Annex 5).

3.3.6 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

3.3.7 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 3.3.7.1 and 3.3.7.2.

3.4 Assessment data of the state of the stock

3.4.1 Stock assessment

The table below presents an overview of the assessment model settings. Deviations from the stock annex caused by missing information due to the COVID-19 disruption are described in detail in Section 3.9. Deviations were in the input catch-at-age data from the fishery and the SSB estimate from the DEPM surveys. 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 2021
Catch	Catch biomass 1978–2020 (tonnes)
	Catch-at-age 1978–2020 (thousands of individuals)
Acoustic survey (Joint SP+PT) *	Total numbers 1996–2021 (thousands of individuals)
	Numbers-at-age 1996–2021 (thousands of individuals)
DEPM survey (Joint SP+PT)	SSB 1997, 1999, 2002, 2005, 2008, 2011, 2014, 2017, 2020 (tonnes)
Weight-at-age in the catch	Yearly averages 1978–2020 (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, 2020 onwards), kg
Maturity-at-age	From DEPM surveys in DEPM years, linear interpolation for years in-between (constant 1978–1998, 2020 onwards), 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–onwards. 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:	

Input data	WGHANSA 2021
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 3.4.1.1 shows the parameters estimated by the assessment model. Fishing mortality-at-age and numbers-at-age are presented in Tables 3.4.1.2 and 3.4.1.3. Parameters estimated in the 2021 assessment are also comparable to those from the 2020 assessment, virgin recruitment ($R_{0,2021}$ = 15 060 000 vs $R_{0,2020}$ = 14 901 700, CV = 3%) and the initial F ($initF_{2021}$ = 0.73 year^{-1} versus $initF_{2020}$ = 0.75 year^{-1}). Catchability parameters are close to 1 for both the acoustic (Q = 1.27, RMSE = 0.30) and the DEPM (Q=1.19, RMSE=0.30) surveys. Correlations between the assessment parameters range from -0.87 to 0.46 although the majority are very close to zero. Negative correlations below -0.50 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 highest positive correlation (below 0.50) is between the $Q_{acoustic\ survey}$ and the $Q_{DEPM\ survey}$.

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 both the acoustic and the DEPM index. The harmonic mean of the fishery age composition sample size, 72, suggests that the data are slightly less precise than assumed (mean initial sample size = 67 for the whole period). In the case of the survey, the sample size of 25 is consistent with the precision indicated by the model (the harmonic mean for the acoustic survey is estimated to be 21).

Figures 3.4.1.1 and 3.4.1.2 show the fit of the model to the acoustic survey and DEPM indices of abundance. Both are similar to the fit of the 2020 assessment model. The assessment of 2021 still shows a poor fit to the 2020 point estimate of the acoustic survey index and also a poor fit to the 2021 point estimate for this 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. It seems that the model has a tendency to underestimate abundance in years when the survey index is large. This is also the case for the DEPM survey index, where the model shows a poor fit to the 2020 point estimate and other high values (2008).

Figure 3.4.1.3 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 2020 have decreased, when compared to 2019, for the younger ages (until age 3) and increased for the older ages. Residuals are positive for ages 1, 2 and 3 and negative for all the other ages. The acoustic survey residuals in 2021 are positive for age two, four and five and negative for all other ages.

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 3.4.1.4). The patterns over age are dome-shaped in the three periods with the early (1978–1987) and recent periods (2006–2020) 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 2021 assessment results is shown in Table 3.4.1.4 and Figure 3.4.1.5 (in the figure compared to the 2020 assessment model results). The estimate of B1+ in 2021 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 2021 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 2021 is predicted to be 451 177 t (CV = 13.6%), assuming that the stock weights are equal to the mean of the last six years. This represents an increase of 3% when compared with B1+ in 2020 = 436 594 t (CV = 12.8%). B1+ is above B_{lim} = 196 334 t, B_{pa} = 252 523 t and MSY $B_{trigger}$ = 252 523 t of the current low productivity regime of the stock (see Section 3.7). The increase of 3%

in B1+ is a consequence of the growth of individuals and not of an increase in the total numbers of individuals. Total numbers of individuals decreased by 8% from 2020 to 2021.

$F_{bar\ 2–5}$ in 2020 is estimated to be 0.061 year^{-1} (CV = 14%) which represents an increase of 26% when compared to $F_{bar\ 2–5}$ in 2019. $F_{bar\ 2–5}$ is now below F_{MSY} since reference points were updated (see Section 3.7).

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} = 26 291 600, CV = 15.5%) constitutes the highest value since 2004 and is above the long-term geometric mean (geometric mean 1978–2020 = 13 976 425). The 2020 recruitment estimate (R_{2020} = 8 395 340, CV = 29%) represents a decrease of 68% when compared to the recruitment estimate of 2019.

3.5 Retrospective pattern

Retrospective patterns for Biomass 1+, $F_{ages2\text{-}5}$ and recruitment were computed for years 2016–2021. 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 (2021). This range of runs include runs prior and after the benchmark (ICES, 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 3.5.1). The model slightly underestimates Biomass 1+ (Mohn's rho of -0.188) and recruitment (Mohn's rho of -0.34) while it overestimates $F_{ages2–5}$ (Mohn's rho of 0.166). 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.

3.6 Short-term predictions

Short-term predictions for 2022 will take place in WGHANSA-2 in November when catch advice for 2022 will be provided.

3.7 Reference points

Reference Points for this stock were re-evaluated in 2021, during the **Workshop for the evaluation of the Iberian sardine HCR (WKSARHCR, ICES, 2021b).** For stocks where an appropriate management strategy evaluation (MSE) methodology has already been developed, with careful consideration of the uncertainties involved for the stock, the MSE framework should be the preferred one for the calculation of reference points (WKGMSE3, ICES, 2020c). Therefore, Maximum Sustainable Yield (MSY) and Precautionary Approach (PA) reference points were re-examined during WKSARHCR workshop with the MSE framework used to evaluate a generic HCR proposed by Portugal and Spain EU members within a management plan for 2021–2026.

Following ICES (2021c) guidelines the stock–recruitment (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. B_{pa} was derived as $B_{pa} = B_{lim} * exp(1.645 * \sigma)$. In this particular case, with σ the coefficient of variation $of\ B1+$ from the stock assessment data used to estimated B_{lim}. Since this stock has not been fished at F_{MSY} for at least 5 years, MSY $B_{trigger}$ is set at B_{pa}. Simulations were conducted with the MSE framework to estimate the MSY and PA reference points for fishing mortality (F), namely F_{lim}, F_{MSY} and F_{pa} (ICES, 2021c). A detailed analysis is presented in ICES (2021b).

ICES adopted new reference points for the stock based on data from the period 2006–2019 which is considered representative of a low productivity state. The recomputed values, using the management strategy evaluation framework, are presented in Table 3.7.1.

Table 3.7.1. Previous and updated Reference Points. The previous biological reference points were estimated during WKSARMP (ICES, 2019c) based on the period 2006-2017 and the current were estimated during WKSARHCR (ICES, 2021b) based on the state of low productivity (2006–2019). Weights are in tonnes.

BRP	2006–2017	2006–2019	Technical basis
B_{lim}	196 334	196 334	B_{lim} = Hockey-stick change point
B_{pa}	252 523	252 523	$B_{pa} = B_{lim} * \exp(1.645 * \sigma)$, σ = 0.17 (ICES, 2021b)
F_{lim}	0.156	0.26	Stochastic long-term simulations (50% probability SSB < B_{lim}) (MSE)
$B_{trigger}$	252 523	252 523	$B_{trigger} = B_{pa}$
F_{pa}	0.032	0.092	$Fp_{.05}$; the F that leads to SSB ≥ B_{lim} with 95% probability (MSE).
F_{MSY}	0.224	0.22	Median F_{target} which maximizes yield without $B_{trigger}$ (MSE)
Adopted F_{MSY}	0.032	0.092	If $F_{pa} < F_{MSY}$ then $F_{MSY} = F_{pa}$

3.8 Management considerations

A new management and recovery plan for the Iberian sardine stock (divisions 8.c and 9.a) (Multiannual Management Plan for the Iberian Sardine 2021–2026) was developed by Spain and Portugal. In February 2021, ICES received a request from Portugal and Spain EU members to evaluate a generic harvest control rule (HCR) within that management plan. The new HCR is defined by three reference levels for fishing mortality, F = 0, F = 0.064 and F = 0.12 and, three reference levels for B1+, B_{low} = 112 943 t, defined as the lowest observed time-series B1+ according to the 2018 assessment (ICES, 2018), MSY $B_{trigger}$ = 252 523 t, under a low productivity regime and MSY $B_{trigger}$ = 446 331 t, under a medium productivity regime (Figure 3.8.1.).

The proposed HCR was described as follows:

i. If B1+ ≤ 112 943 t, then F = 0.
ii. If 112 943 t < B1+ ≤ 252 523 t, then F increases linearly from 0 to 0.064.
iii. If 252 523 t < B1+ ≤ 446 331 t, then F increases linearly from 0.064 to 0.12.
iv. If B1+ > 446 331 t, then F = 0.12.

Conditions ii) to iv) are overridden if the forecast catch in any given year exceeds the maximum allowed catches of 30 to 50 kt.

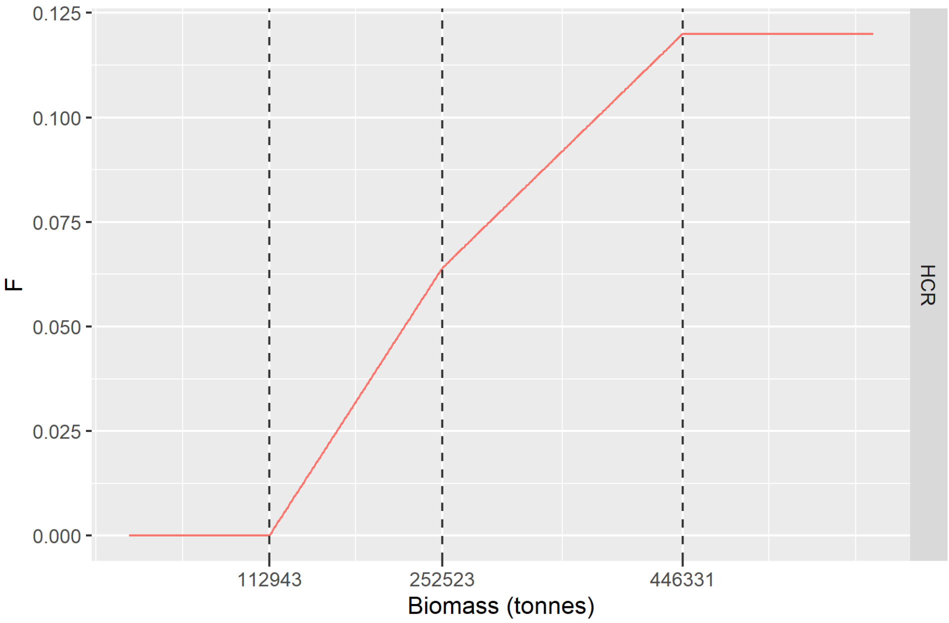


Figure 3.8.1. Proposed HCR. The biomass reference levels of biomass (B1+) reported correspond to $B_{loss(2018)}$ = 112 943 t, MSY $B_{trigger\_low}$ = B_{pa_low} = 252 523 t and MSY $B_{trigger\_medium}$ = B_{pa_medium} = 446 331 t.

ICES found that the generic harvest control rule was precautionary in a persistent low productivity regime with maximum allowed catches between 30 and 50 kt (ICES, 2021d). For 2021, the EU Commission requested ICES to provide advice based on the MSY approach.

3.9 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.

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.

2021 acoustic surveys (included in 2021 assessment) were not affected by the COVID disruption.

3. Missing or deteriorated catch data:

Sampling programmes coordinated by the IEO, Spain (on-shore, observers on board and biological sampling) were suspended in most of 2020 due to administrative problems and to the COVID-19 disruption. Sampling by IPMA, Portugal was also affected by the COVID-19 pandemic: (i) market sampling in Portuguese ports of ICES 9a was suspended during the period March–June 2020 and resumed after that; (ii) on-board sampling in Portuguese waters of ICES 9a was suspended in March 2020 and was not resumed in that year.

Official catches were appropriately reported for both countries, but length distribution was missing in some of the subdivisions/quarters. Table 3.9.3 shows the number of length samples collected in 2020 for all subdivisions.

4. Missing or deteriorated commercial LPUE/CPUE data:

Not applicable.

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

The COVID pandemic also affected, but in a less extent, some of the biological samplings made by IEO in Spain and IPMA in Portugal. Table 3.9.5 shows the number of biological samples collected in 2020 for all subdivisions. For subdivisions were length distributions were available, there are missing age readings and estimation of mean weight for subdivisions 8cE in quarter 4, 9aCN in the second quarter and in all quarters of Subdivision 9aCS.

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

The length distributions of the last three years (2017–2019, Figure 3.9.6.1) were analysed by subdivision, and it was found that the differences were notable between years. For example, the proportion at length in the year 2018 is very different from the two other years.

In the assessment model of the Iberian sardine, the sum of all subdivisions catch-at-age numbers is an input data. The proportions by age in the previous years (2017–2019) were analysed and for subdivisions where we lacked enough samples to extrapolate numbers-at-age for the catch, by quarter, we compared the proportion-at-age in those subdivisions to proportion-at-age in adjacent subdivisions (Figures 3.9.6.2 to 3.9.6.5):

- For 8cW, age composition is based on age composition of 8cE subdivision.
- For 9aN, age composition is based on age composition of 9aCN subdivision.
- For 9aS-Cádiz, age composition is based on age composition of 9aS-Algarve subdivision.

Differences at-age in the last three years are shown in Tables 3.9.6.1 to 3.9.6.3. and Figures 3.9.6.6 to 3.9.6.8.

The differences in percentages are small when comparing the age percentages from the original data to the adjacent data approach (Figure 3.9.6.9).

Sensitivity analysis

In order to evaluate the effect on the assessment of the different possible catch assumptions, runs were made for past assessments without the vector for catch-at-age in the year previous to the terminal year (NoCatch) and with a modified vector for catch-at-age (OtherCatch and MeanCatch). Outputs of these assessments were compared to the 'real' assessment (Figures 3.9.6.10. to 3.9.6.12). In the OtherCatch run, the catch-at-age vector was modified according to the assumption that number of individuals at age in a subdivision lacking length sampling was equal to the number of individuals of an adjacent subdivision and weight-at-age were unchanged. In the MeanCatch run, the catch-at-age vector was modified with the assumption that number of individuals at-age are the mean of the last three years catch-at-age vectors and weight-at-age are also the mean of the last three years. Percentual differences between the 'real assessment' and the other runs are shown in Tables 3.9.6.4 to 3.9.6.6. for the last four years of each time-series.

Uncertainty, measured as the width of the confidence interval, is higher for the runs without any input data of age composition of catches in the last year where catch information is available. The highest difference observed in Recruitment and B1+ are from the NoCatch scenario: 98.1% for Recruitment, 42.6% for B1+ in the 2020 assessment (Figure 3.9.6.9 and 3.9.6.10, Table 3.9.6.4.).

Most often the run Othercatch estimates are closer to the 'real' assessment with the exception of the 2019 Assessment where the recruitment in the terminal year is estimated to be 19.4% lower and B1+ is estimated to be 5.6% lower (Figure 3.9.6.10 and Table 3.9.6.5.).

For Biomass 1+ differences are higher in the assessment of 2020 for scenario NoCatch in the interim year where B1+ is estimated to be 42.6% higher (Figure 3.9.6.9 and Table 3.9.6.4.).

Conclusion:

- It is always better to use catch data in the terminal year than to use not catch at all. The use of proportions-at-age based on the adjacent subdivision worked better in the simulations than the mean proportion of the last years (less differences versus the real assessment).

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

For catch data, when age–length keys (ALK) are not complete or not available, the group approved the use of the following assumptions:

Subdivision 9aCN	Quarter 2: PELAGO ALK in 9aCN combined with ALK in 9aN Quarter 3 and Quarter 4: joint ALKs
Subdivision 9aCS	Quarter 2: PELAGO ALK in 9aCS
	Quarter 3: ALK were estimated with the Hoening *et al*. (1993, 1994) method, which uses an undefined number of datasets with known and unknown age information.
	Quarter 4: ALK were estimated with the Hoening *et al.* (1993, 1994) method.
Subdivision 9aS-Algarve:	Quarter 2: observed ALK
	Quarter 3: observed ALK
	Quarter 4: observed ALK

In all the cases, the ALKs will be completed by hand to avoid gaps. The resulting age distributions in 9aCN will be propagated to the 9aN Spanish catches and the resulting age distributions in 9aS-Algarve in Quarter 2 will be propagated to Spanish catches in 9aS-Cadiz Quarter 1 and Quarter 2.

Also, the resulting age distribution from 8cE will be propagated to 8cW (all quarters).

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.

3.10 Portugal and Spain request for updated advice on catch opportunities for 2021 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 2021 based on the most recent available data. ICES will respond to this request by updating the advice based on the results of the stock assessment conducted in May 2021 (see Section 3.4). The WG reviewed the catch scenarios for 2021 based on the results of the stock assessment and a one-year short-term forecast conducted during the meeting (d 3.10.2). The most recent data on catches (up to 2020) and surveys (up to 2021) were used.

Catch scenarios for 2021 were revised upwards as a consequence of updating the assessment with the most recent information but mainly because of the re-estimation of the MSY reference point F_{MSY} (see Section 3.7). The estimate of the 2020 Recruitment higher is now higher than the assumption made for the interim year in the previous advice (from 7 584 483 to 8 395 340 thousand individuals). Consequently, there is an upward revision of the 2021 biomass of fish of age one and older at the beginning of the year from 351 159 tonnes to 451 177 tonnes and the geometric mean of Recruitment (2016–2020) used as an assumption for 2021 is also revised upwards (from 7 584 483 to 9 515 637 thousand individuals). Catches corresponding to F_{MSY} were revised from 10 871 tonnes to 40 434 tonnes.

Table 3.10.1 Sardine in divisions 8.c and 9.a. The basis for the revised catch options for 2021.

Variable	Value	Notes
Fages 2–5 (2020)	0.061	Fages 2–5 estimated in the updated assessment; Year-1
B1+ (2021)	451 177	Estimated in the updated assessment; Tonnes
Rage 0 (2020)	8 395 340	Estimated in the updated assessment; Thousands
Rage 0 (2021)	9 515 637	Geometric mean (GM 2016–2020); Thousands
Total catch (2020)	22 143	Official catch; Tonnes
Discards (2020)	Negligible	-

Table 3.10.2 Sardine in divisions 8.c and 9.a. Annual catch scenarios for the revised catch advice for 2021.

Basis	Catch (2021)	F (2021)	Biomass 1+ (2022)
ICES advice basis			
MSY approach: F_{MSY}	40 434	0.092	429 076
Other scenarios			
$F = F_{MSY} = F_{pa}$	40 434	0.092	429 076
$F_{2021} = F_{2020}$	26 928	0.061	438 691
HCR30 ^	30 000	0.068	436 502
HCR35 ^	35 000	0.079	432 942
HCR40 ^	40 000	0.091	429 384
HCR45 ^	45 000	0.103	425 831
HCR50 ^	50 000	0.115	422 280
F_{lim}	107 104	0.26	638 980
B1+ (2021) = B_{lim} (196 334)	378 840	1.32	196 334
B1+ (2021) = B_{pa} = MSY $B_{trigger}$(252 523)	296 600	0.91	252 523

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Table 3.2.2.1. Sardine in 8c and 9a: Quarterly distribution of sardine landings (t) in 2020 by ICES subdivision. Above absolute values; below, relative numbers.

Subdivision	1st	2nd	3rd	4th	Total
8cE	134	447	152	164	896
8cW	0.5	1361	508	56	1925
9aN	9	1172	671	98	1950
9aCN		1170	3657	221	5049
9aCS		2197	5071	291	7560
9aS-Algarve		723	1977	107	2807
9aS-Cadiz	23	224	946	762	1955
Total	167	7295	12982	1699	22143

Subdivision	1st	2nd	3rd	4th	Total
8cE	0.61	2.02	0.68	0.74	4.05
8cW	0.00	6.15	2.29	0.25	8.70
9aN	0.04	5.29	3.03	0.44	8.81
9aCN	0.00	5.29	16.52	1.00	22.80
9aCS	0.00	9.92	22.90	1.31	34.14
9aS-Algarve	0.00	3.27	8.93	0.48	12.68
9aS-Cadiz	0.10	1.01	4.27	3.44	8.83
Total	0.75	32.95	58.63	7.67	100

Table 3.2.2.2. Sardine in 8c and 9a: Iberian Sardine Landings (tonnes) by subdivision for the period 1940–2020.

Year	Subdivision					
	8c	9a North	9a Central North	9a Central South	9a South Algarve	9a South 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	

Year	Subdivision					
	8c	9a North	9a Central North	9a Central South	9a South Algarve	9a South Cadiz
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	
1976	51901	10140	43435	16548	12538	

Year	Subdivision					
	8c	9a North	9a Central North	9a Central South	9a South Algarve	9a South Cadiz
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 3.2.2.2 (cont.). Sardine in 8c and 9a: Iberian Sardine Landings (tonnes) by subdivision for the period 1940–2020.

Year	Subdivision					
	8c	9aNorth	9a Central North	9a Central South	9a South Algarve	9a South 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

Year	Subdivision					
	8c	9aNorth	9a Central North	9a Central South	9a South Algarve	9a South Cadiz
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
2020	2822	1950	5049	7560	2807	1955

Table 3.2.4.3. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (t) by ICES subdivision in 2020.

Length	Subdivision							Total
	8c E	8c W	9a N	9a CN	9a CS	9a S Algarve	9a S Cadiz	
6.5			NA					
7			NA					
7.5			NA					
8			NA					
8.5			NA					

9			NA					
9.5			NA					
10			NA					
10.5			NA					
11			NA	170				170
11.5			NA	245				245
12	3		NA	716				719
12.5	32		NA	245			356	633
13	144		NA	94			1 572	1 810
13.5	398		NA	64			3 823	4 285
14	485		NA	1 356		224	2 720	4 785
14.5	884		NA	4 854		76	2 116	7 931
15	885		NA	17 831		287	1 408	20 411
15.5	814		NA	21 959	132	1 357	1 847	26 109
16	838	2	NA	25 365	1 194	2 853	2 166	32 418
16.5	1 484	5	NA	17 935	3 023	5 114	1 732	29 293
17	2 418	12	NA	17 847	7 113	11 513	1 588	40 491
17.5	3 138	18	NA	12 790	9 594	14 326	1 115	40 981
18	2 161	11	NA	4 827	10 902	12 250	911	31 061
18.5	1 383	14	NA	2 510	11 970	5 398	649	21 924
Length	Subdivision	Total						
	8c E	8c W	9a N	9a CN	9a CS	9a S Algarve	9a S Cadiz	
19.5	390	2	NA	674	15 537	243		16 846
20	264	3	NA	189	16 195	23		16 674
20.5	221		NA	158	9 268	79		9 725
21	147		NA	56	7 078	311		7 592
21.5	80		NA	1	2 491			2 572
22	17		NA		1 870			1 886
22.5	14		NA	15	705			734
23	23		NA		554			576

23.5			NA		189			189
24			NA		41			41
24.5			NA		44			44
25			NA					
25.5			NA					
26			NA					
26.5			NA					
Total	16 923	73		130 623	110 709	56 274	22 189	336 792
Mean L	17.3	18.1	NA	16.4	19.4	17.7	15.4	17.6
sd	1.66	0.93	NA	1.14	1.41	0.88	1.63	1.86
Catch	896	1925	1950	5049	7560	2807	1955	22143

Table 3.2.4.1a. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (t) by ICES subdivision in the first quarter 2020.

				First Quarter				
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S (Ca)	Total
6.5		NA	NA				NA	
7		NA	NA				NA	
7.5		NA	NA				NA	
8		NA	NA				NA	
8.5		NA	NA				NA	
9		NA	NA				NA	
9.5		NA	NA				NA	
10		NA	NA				NA	
10.5		NA	NA				NA	
11		NA	NA				NA	
11.5		NA	NA				NA	
12	3	NA	NA				NA	3

First Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S (Ca)	Total
12.5	32	NA	NA				NA	32
13	144	NA	NA				NA	144
13.5	398	NA	NA				NA	398
14	483	NA	NA				NA	483
14.5	881	NA	NA				NA	881
15	885	NA	NA				NA	885
15.5	764	NA	NA				NA	764
16	445	NA	NA				NA	445
16.5	256	NA	NA				NA	256
17	142	NA	NA				NA	142
17.5	114	NA	NA				NA	114
18	83	NA	NA				NA	83
18.5	91	NA	NA				NA	91
19	40	NA	NA				NA	40
19.5	43	NA	NA				NA	43
20	19	NA	NA				NA	19
20.5	8	NA	NA				NA	8
21	7	NA	NA				NA	7
21.5	1	NA	NA				NA	1
22		NA	NA				NA	
22.5		NA	NA				NA	
23		NA	NA				NA	
23.5		NA	NA				NA	
24		NA	NA				NA	
24.5		NA	NA				NA	
25		NA	NA				NA	
25.5		NA	NA				NA	
26		NA	NA				NA	

				First Quarter				
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S (Ca)	Total
26.5		NA	NA				NA	
Total	4 842	NA	NA					4 842
Mean L	15.5	NA	NA					15.5
sd	1.37	NA	NA					1.37
Catch	134	0. 5	9				23	144

Table 3.2.4.1b. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (t) by ICES subdivision in the second quarter 2020.

				Second Quarter				
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
7		NA	NA				NA	
7.5		NA	NA				NA	
8		NA	NA				NA	
8.5		NA	NA				NA	
9		NA	NA				NA	
9.5		NA	NA				NA	
10		NA	NA				NA	
10.5		NA	NA				NA	
11		NA	NA				NA	
11.5		NA	NA				NA	
12		NA	NA				NA	
12.5		NA	NA				NA	
13		NA	NA				NA	
13.5		NA	NA				NA	
14		NA	NA	1 038			NA	1 038
14.5		NA	NA	3 047		29	NA	3 076
15		NA	NA	8 821		116	NA	8 937

Second Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
15.5	41	NA	NA	8 395	132	202	NA	8 770
16	308	NA	NA	8 733	1 103	404	NA	10 548
16.5	1 027	NA	NA	2 783	2 468	173	NA	6 451
17	1 941	NA	NA	1 122	4 628	1 415	NA	9 106
17.5	2 622	NA	NA		4 023	3 611	NA	10 256
18	1 702	NA	NA		2 079	4 853	NA	8 634
18.5	881	NA	NA		1 132	1 906	NA	3 919
19	314	NA	NA		2 424	1 040	NA	3 778
19.5	107	NA	NA		4 504		NA	4 611
20	130	NA	NA		4 933		NA	5 063
20.5	141	NA	NA		3 013		NA	3 154
21	96	NA	NA		2 116	87	NA	2 299
21.5	57	NA	NA		618		NA	675
22	11	NA	NA		682		NA	693
22.5	11	NA	NA		324		NA	335
23	23	NA	NA		167		NA	189
23.5		NA	NA		73		NA	73
24		NA	NA		41		NA	41
24.5		NA	NA		44		NA	44
25		NA	NA				NA	
25.5		NA	NA				NA	
26		NA	NA				NA	
26.5		NA	NA				NA	
Total	9 412	NA	NA	33 940	34 503	13 836	NA	91 691
Mean L	17.9	NA	NA	15.7	19.1	18.	NA	17.6
sd	1.03	NA	NA	0.67	1.68	0.79	NA	1.89

Second Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
Catch	447	1 361	1 172	1 170	2 197	723	224	7 295

Table 3.2.4.1c. Sardine in 8c and 9a: Sardine length composition (thousands), mean length (cm) and catch (t) by ICES subdivision in the third quarter 2020.

Third Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
6.5	NA	NA	NA				NA	
7	NA	NA	NA				NA	
7.5	NA	NA	NA				NA	
8	NA	NA	NA				NA	
8.5	NA	NA	NA				NA	
9	NA	NA	NA				NA	
9.5	NA	NA	NA				NA	
10	NA	NA	NA				NA	
10.5	NA	NA	NA				NA	
11	NA	NA	NA	170			NA	170
11.5	NA	NA	NA	245			NA	245
12	NA	NA	NA	716			NA	716
12.5	NA	NA	NA	245			NA	245
13	NA	NA	NA	94			NA	94
13.5	NA	NA	NA	64			NA	64
14	NA	NA	NA	232		224	NA	456
14.5	NA	NA	NA	1 678		47	NA	1 725
15	NA	NA	NA	7 523		94	NA	7 617
15.5	NA	NA	NA	12 104		826	NA	12 930
16	NA	NA	NA	14 594	91	2 004	NA	16 689
16.5	NA	NA	NA	14 627	555	4 593	NA	19 775
17	NA	NA	NA	16 433	2 458	9 730	NA	28 622

Third Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
17.5	NA	NA	NA	12 687	5 527	10 387	NA	28 601
18	NA	NA	NA	4 827	8 635	7 281	NA	20 743
18.5	NA	NA	NA	2 510	10 734	3 395	NA	16 639
19	NA	NA	NA	721	10 044	1 122	NA	11 887
19.5	NA	NA	NA	674	10 378	243	NA	11 295
20	NA	NA	NA	189	10 370	23	NA	10 583
20.5	NA	NA	NA	158	5 412	79	NA	5 649
21	NA	NA	NA	56	4 532	224	NA	4 812
21.5	NA	NA	NA	1	1 702		NA	1 703
22	NA	NA	NA		1 138		NA	1 138
22.5	NA	NA	NA	15	353		NA	369
23	NA	NA	NA		337		NA	337
23.5	NA	NA	NA		116		NA	116
24	NA	NA	NA				NA	
24.5	NA	NA	NA				NA	
25	NA	NA	NA				NA	
25.5	NA	NA	NA				NA	
26	NA	NA	NA				NA	
26.5	NA	NA	NA				NA	
Total	NA	NA	NA	90 564	72 383	40 272	NA	203 218
Mean L	NA	NA	NA	16.7	19.5	17.6	NA	17.9
sd	NA	NA	NA	1.18	1.24	0.87	NA	1.68
Catch	152	508	671	3 657	5 071	1 977	946	12 982

Table 3.2.4.1d. Sardine in 8c and 9a: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2020.

Fourth Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
6.5			NA					
7			NA					
7.5			NA					
8			NA					
8.5			NA					
9			NA					
9.5			NA					
10			NA					
10.5			NA					
11			NA					
11.5			NA					
12			NA					
12.5			NA				356	356
13			NA				1 572	1 572
13.5			NA				3 823	3 823
14	2		NA	86			2 720	2 808
14.5	3		NA	129			2 116	2 249
15			NA	1 487		77	1 408	2 972
15.5	9		NA	1 460		329	1 847	3 645
16	85	2	NA	2 037		445	2 166	4 735
16.5	200	5	NA	524		348	1 732	2 810
17	336	12	NA	292	27	368	1 588	2 622
17.5	401	18	NA	103	44	329	1 115	2 010
18	377	11	NA		188	116	911	1 602
18.5	412	14	NA		104	97	649	1 275
19	346	6	NA		342	58	187	939

Fourth Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
19.5	239	2	NA		655			896
20	115	3	NA		892			1 010
20.5	72		NA		843			915
21	44		NA		429			474
21.5	22		NA		171			193
22	5		NA		50			55
22.5	2		NA		27			29
23			NA		50			50
23.5			NA					
24			NA					
24.5			NA					
25			NA					
25.5			NA					
26			NA					
Total	2 669	73*	NA	6 120	3 823	2 167	22 189	37 040
Mean L	18.4	18.1	NA	15.9	20.3	16.9	15.4	16.3
sd	1.22	.93	NA	.65	1.	.96	1.63	2.09
Catch	164	56	98	221	291	107	762	1 699

*** In 8cW, individuals correspond to 4.2 tonnes sampled.**

Table 3.2.4.2. Sardine in 8c and 9a: Catch in numbers (thousands) at-age by quarter and by subdivision in 2020.

							First Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C	Total
0							3	
1	3 601	12	265				32	3 910
2	1 033	4	9				242	1 288
3	154	1					127	282
4	22						31	53
5	25							25
6	4							4
7	3							3
8								
9								
10								
11								
12								
Total	4 842	17	274				435	5 565
Catch (Tons)	134	. 5	9				23	167

							Second Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C	Total
0						81	25	106
1	3 601	10 973	32 847	32 818	8 765	1 003	311	90 318
2	3 391	10 333	1 123	1 122	9 116	7 714	2 395	35 194
3	1 902	5 795			2 969	4 042	1 255	15 964
4	167	509			10 300	996	309	12 281
5	214	652			2 045			2 911
6	70	215			389			675
7	54	165			386			606
8	11	35			455			501
9					79			79
10								
11								
12								
Total	9 412	28 678	33 970	33 940	34 503	13 836	4 295	158 634
Catch (Tons)	447	1 361	1 172	1 170	2 197	723	224	4 928

							Third Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C	Total
0	3	9	313	1 707	2 622	6 747	15 890	27 290
1	949	3 179	15 933	86 939	21 704	21 485	8 180	158 369
2	837	2 804	312	1 703	22 981	10 031	3 133	41 801
3	713	2 388	14	75	13 527	1 568	337	18 622
4	92	307	15	81	5 706	441	29	6 669
5	34	115	6	33	2 216			2 404
6	4	15	5	27	1 915			1 967
7					1 005			1 005
8					518			518
9					189			189
10								
11								
12								
Total	2 632	8 816	16 597	90 564	72 383	40 272	27 569	258 833
Catch (Tons)	152	508	671	3 657	5 071	1 977	946	12 982

							Fourth Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C	Total
0	3	1	29	65	204	866	12 789	13 957
1	913	316	2 689	6 055	573	875	6 584	18 005
2	848	293			966	416	2 522	5 044
3	761	261			753		271	2 046
4	101	34			854	10	23	1 022
5	38	13			300			350
6	5	2						7
7					173			173
8								
9								
10								
11								
12								
Total	2 669	919	2 718	6 120	3 823	2 167	22 189	40 604
Catch (Tons)	164	56	98	221	291	107	762	1 699

							Whole Year	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C	Total
0	6	10	342	1 772	2 826	7 693	28 707	41 356
1	9 064	14 480	51 734	125 811	31 043	23 363	15 107	270 602
2	6 109	13 433	1 444	2 825	33 062	18 162	8 293	83 327
3	3 531	8 445	14	75	17 249	5 610	1 990	36 914
4	382	850	15	81	16 860	1 446	392	20 026
5	311	780	6	33	4 560			5 690
6	84	232	5	27	2 304			2 652
7	57	165			1 564			1 786
8	11	35			973			1 019
9					268			268
10								
11								
12								
Total	19 555	38 430	53 559	130 623	110 709	56 274	54 488	463 639
Catch (Tons)	896	1 925	1 950	5 049	7 560	2 807	1 955	22 143

Table 3.2.4.3. 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
2020	41356	270602	83327	36914	20026	5690	5725

Table 3.2.4.4. Sardine 8c and 9a: Relative distribution of sardine catches. Upper panel relative contribution of each age 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%	0%	1%	1%	3%	14%	53%	9%
1	46%	38%	97%	96%	28%	42%	28%	58%
2	31%	35%	3%	2%	30%	32%	15%	18%
3	18%	22%	0%	0%	16%	10%	4%	8%
4	2%	2%	0%	0%	15%	3%	1%	4%
5	2%	2%	0%	0%	4%	0%	0%	1%
6+	1%	1%	0%	0%	5%	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%	0%	1%	4%	7%	19%	69%	100%
1	3%	5%	19%	46%	11%	9%	6%	100%
2	7%	16%	2%	3%	40%	22%	10%	100%
3	10%	23%	0%	0%	47%	15%	5%	100%

4	2%	4%	0%	0%	84%	7%	2%	100%
5	5%	14%	0%	1%	80%	0%	0%	100%
6+	3%	8%	0%	0%	89%	0%	0%	100%

Table 3.2.5.1. Sardine 8c and 9a: Sardine Mean length (cm) at-age by quarter and by subdivision in 2020.

						First Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0							15.3
1	15.0	15.0	15.7				17.0
2	16.3	16.3	17.3				18.0
3	18.7	18.7					18.3
4	19.7	19.7					18.6
5	20.3	20.3					
6	21.0	21.0					
7	20.9	20.9					
8	22.8	22.8					
9							
10							
11							
12							

						Second Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0							15.3
1	17.5	17.5	15.7				17.0
2	17.6	17.6	17.3				18.0
3	18.4	18.4					18.3
4	19.7	19.7					18.6
5	20.7	20.7					
6	21.5	21.5					
7	21.4	21.4					
8	22.9	22.9					
9							
10							
11							
12							

						Third Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0	14.4	14.4	12.5				14.4
1	17.4	17.4	16.7				16.4
2	18.5	18.5	19.3				17.6
3	19.2	19.2	20.8				17.9
4	19.7	19.7	20.9				18.2
5	20.6	20.6	21.0				
6	19.8	19.8	22.1				
7							
8							
9							
10							
11							
12							

						Fourth Quarter	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0	14.4	14.4	14.3				14.4
1	17.4	17.4	16.0				16.4
2	18.6	18.6					17.6
3	19.2	19.2					17.9
4	19.7	19.7					18.2
5	20.6	20.6					
6	19.8	19.8					
7							
8							
9							
10							
11							
12							

						Whole Year	
Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0	14.4	14.4	12.6				14.4
1	16.5	17.5	16.0				16.4
2	17.6	17.8	17.7				17.7
3	18.8	18.7	20.8				18.2
4	19.7	19.7	20.9				18.5
5	20.7	20.7	21.0				
6	21.2	21.3	22.1				
7	21.4	21.4					
8	22.9	22.9					
9							
10							
11							
12							

Table 3.2.5.2. Sardine 8c and 9a: Sardine Mean weight (kg) at-age by quarter and by subdivision in 2020.

Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
						First Quarter	
0							0.0
1	0.025	0.025	0.034				0.046
2	0.033	0.033	0.046				0.052
3	0.052	0.052					0.054
4	0.063	0.063					0.056
5	0.069	0.069					
6	0.077	0.077					
7	0.076	0.076					
8	0.103	0.103					
9							
10							
11							
12							

Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
						Second Quarter	
0							0.0
1	0.044	0.044	0.034				0.046
2	0.044	0.044	0.046				0.052
3	0.052	0.052					0.054
4	0.066	0.066					0.056
5	0.078	0.078					
6	0.089	0.089					
7	0.088	0.088					
8	0.110	0.110					
9							
10							
11							
12							

Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
						Third Quarter	
0	0.026	0.026	0.018				0.027
1	0.048	0.048	0.040				0.041
2	0.059	0.059	0.060				0.052
3	0.066	0.066	0.074				0.055
4	0.071	0.071	0.074				0.058
5	0.083	0.083	0.076				
6	0.071	0.071	0.087				
7							
8							
9							
10							
11							
12							

Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
						Fourth Quarter	
0	0.026	0.026	0.026				0.027
1	0.050	0.050	0.036				0.041
2	0.062	0.062					0.052
3	0.070	0.070					0.055
4	0.076	0.076					0.058
5	0.088	0.088					
6	0.076	0.076					
7							
8							
9							
10							
11							
12							

Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
						Whole Year	
0	0.026	0.026	0.018				0.027
1	0.037	0.045	0.036				0.041
2	0.047	0.048	0.049				0.052
3	0.059	0.057	0.074				0.054
4	0.070	0.068	0.074				0.056
5	0.079	0.079	0.076				
6	0.087	0.088	0.087				
7	0.087	0.088					
8	0.110	0.110					
9							
10							
11							
12							

Table 3.3.1. DEPM parameters derived from 2020 sardine DEPM surveys with their CV (%) in brackets by institution and stratum (in 2020, only 9a South and 9a West estimates were based on the survey; cf. note below). Surveyed and positive areas (km²), Mortality Z (hour-1), Daily egg production P0 (eggs/m²/day), Total egg production P0 tot (eggs/day) (x1012),

Females mean weight (g), Batch fecundity (number of eggs spawned per mature females per batch), Sex ratio (fraction of population that are mature females by weight), Spawning fraction (fraction of mature females spawning).

Institute	IPMA	IPMA	TOTAL	Total (Iberian Península) (*)
Area	9a South	9a West	(9a S + 9a W)	
Survey area (Km2)	18689	29560	48249	
Positive area (Km2)	7844	9127	16971	
Z (hour-1)(CV%)	-0.030 (7.0)	-0.023(5.7)		
P0 (eggs/m2/day)(CV%)	450.85 (23.7)	243.95 (20.4)		
P0 tot (eggs/day) (x1012) (CV%)	3.54 (23.7)	2.23 (20.4)	5.77 (17)	
Female Weight (g) (CV%)	38.80 (14.7)	45.40 (16.2)		
Batch Fecundity (CV%)	14176 (15.3)	16637 (17.0)		
Sex Ratio (CV%)	0.568 (8.3)	0.587 (7.3)		
Spawning Fraction (CV%)	0.050 (22.0)	0.072 (23.8)		
Daily Fecundity (eggs/day.g female)	10.38	15.49		
Spawning Biomass (tons) (CV%)	341164 (39.4)	143984 (39.8)	485148 (30.2)	630692 (*)

(*) Eggs and adult parameters for the ICES Subdivision 9a North and divisions 8c 9a are not available in 2020 due to the cancelation of SAREVA 0320 DEPM survey because of the COVID-19 pandemic. The total Iberian Peninsula SSB was estimated raising the Portuguese SSB index (9a South and 9a West).

Table 3.3.2.1. Sardine in 8c and 9a: sardine abundance in number (millions of fish) and biomass (tons) by age groups and ICES subdivision in PELAGO2021. 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)	0	15066	157819	9286	1394	3121	1187	142	0	0	0	188016
%Biomass	0	8	84	5	1	2	1	0	0	0	0	100
Abundance (N in 10^3)	0	545162	4518507	228170	20101	43196	14285	1840	0	0	0	5371261
%Abundance	0.0	10.1	84.1	4.2	0.4	0.8	0.3	0.0	0.0	0.0	0.0	100
Mean Weight (gr)	NA	22.6	40.5	57.7	70.5	73.5	85.4	78.0	NA	NA	NA	
Mean Length (cm)	NA	14.6	17.7	19.8	21.3	21.6	22.7	22.0	NA	NA	NA	
AREA 9aCS												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	0	13873	16099	20600	15145	30118	8467	6704	2122	542	0	113670
%Biomass	0.0	12.2	14.2	18.1	13.3	26.5	7.4	5.9	1.9	0.5	0.0	100
Abundance (N in 10^3)	0	423611	461262	378026	249167	458021	117161	81218	24841	6676	0	2199982
%Abundance	0.0	19.3	21.0	17.2	11.3	20.8	5.3	3.7	1.1	0.3	0.0	100
Mean Weight (gr)	NA	29.6	36.4	53.0	60.1	68.7	76.5	84.9	86.0	83.8	NA	
Mean Length (cm)	NA	15.7	16.9	19.2	20.0	21.0	22.1	22.9	23.2	23.4	NA	
AREA 9aS-ALG												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	0	19196	15006	20951	14059	12943	1032	428	0	47	0	83662
%Biomass	0.0	22.9	17.9	25.0	16.8	15.5	1.2	0.5	0.0	0.1	0.0	100
Abundance (N in 10^3)	0	730601	421458	437869	266074	230794	15565	5726	0	641	0	2108728
%Abundance	0.0	34.6	20.0	20.8	12.6	10.9	0.7	0.3	0.0	0.03	0.0	100
Mean Weight (gr)	NA	25.0	35.1	49.3	58.5	62.4	66.8	76.2	NA	67.0	NA	
Mean Length (cm)	NA	15.0	16.8	18.8	19.9	20.5	21.4	21.9	NA	21.6	NA	
AREA 9aS-CAD												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	0	22887	4651	2571	775	284	0	0	0	0	0	31167
%Biomass	0.0	73.4	14.9	8.2	2.5	0.9	0.0	0.0	0.0	0.0	0.0	100
Abundance (N in 10^3)	0	1016779	129702	54149	15354	5224	0	0	0	0	0	1221208
%Abundance	0.0	83.3	10.6	4.4	1.3	0.4	0.0	0.0	0.0	0.0	0.0	100
Mean Weight (gr)	NA	21.1	37.8	48.5	54.2	59.9	NA	NA	NA	NA	NA	
Mean Length (cm)	NA	14.2	17.4	18.8	19.4	20.1	NA	NA	NA	NA	NA	
TOTAL PELAGO21												
AGE	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (ton)	0	71022	193575	53408	31373	46466	10686	7275	2122	589	0	416515
%Biomass	0.0	17.1	46.5	12.8	7.5	11.2	2.6	1.7	0.5	0.1	0.0	100
Abundance (N in 10^3)	0	2716152	5530929	1098213	550696	737235	147012	88784	24841	7317	0	10901179
%Abundance	0.0	24.9	50.7	10.1	5.1	6.8	1.3	0.8	0.2	0.1	0.0	100
Mean Weight (gr)	23.4	38.4	51.7	60.5	67.2	77.9	83.3	86.0	80.4	96.0		
Mean Length (cm)	14.7	17.4	19.1	20.1	20.9	22.2	22.7	23.2	23.0	24.1		

Table 3.3.2.2. Sardine in 8c and 9a: sardine abundance in number (millions of fish) and biomass (tons) by age groups and ICES subdivision in PELACUS0321. MW (mean weight) in grams and ML (mean length) in cm.

AREA 8cE									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (ton)	11908	15455	2541	4862	4884	2355	917		42922
%Biomass	28	36	6	11	11	5	2		100
Abundance (N in 10^3)	729447	325235	41250	59017	55070	23967	9965		1243951
%Abundance	58.6	26.1	3.3	4.7	4.4	1.9	0.8		100
Mean Weight (gr)	13.9	45.2	58.1	78.9	85.1	94.7	88.7		
Mean Length (cm)	12.5	18.2	19.7	21.7	22.2	23.0	22.5		
AREA 8cW									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (ton)	91	5147	1139	1374	1134	284	183		9352
%Biomass	1.0	55.0	12.2	14.7	12.1	3.0	2.0		100
Abundance (N in 10^3)	2634	99719	17987	17664	13950	3017	2099		157069.5
%Abundance	1.7	63.5	11.5	11.2	8.9	1.9	1.3		100
Mean Weight (gr)	32.2	49.2	60.1	74.5	78.0	90.8	84.0		
Mean Length (cm)	16.3	18.7	19.9	21.3	21.6	22.7	22.1		
AREA 9aN									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (ton)	3348	185986	35041	21438	44729	3355		939	294836
%Biomass	1.1	63.1	11.9	7.3	15.2	1.1		0.3	100
Abundance (N in 10^3)	95208	3770177	632882	264337	531290	37984		7349	5339226
%Abundance	1.8	70.6	11.9	5.0	10.0	0.7		0.1	100
Mean Weight (gr)	34.7	49.0	54.6	80.4	83.8	88.3		127.7	
Mean Length (cm)	16.7	18.6	19.3	21.8	22.1	22.5		25.3	
TOTAL PELACUS21									
AGE	1	2	3	4	5	6	7	8	TOTAL
Biomass (ton)	15347	206587	38721	27675	50747	5995	1100	939	347110
%Biomass	4.4	59.5	11.2	8.0	14.6	1.7	0.3	0.3	100
Abundance (N in 10^3)	827288	4195131	692119	341018	600310	64968	12064	7349	6740246
%Abundance	12.3	62.2	10.3	5.1	8.9	1.0	0.2	0.1	100
Mean Weight (gr)	15.6	46.9	52.9	77.6	81.1	88.9	87.8	123.8	
Mean Length (cm)	13.0	18.4	19.1	21.6	21.9	22.5	22.4	25.0	

Table 3.4.1a. Sardine in 8c and 9a: Mean weights-at-age (kg) in the catch. Weights-at-age in 1978–1990 are fixed.

Year	Age						
	0	1	2	3	4	5	6+
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	0.050	0.059	0.074	0.084	0.094	0.097
2020	0.031	0.042	0.057	0.065	0.075	0.084	0.095

Table 3.4.1b. Sardine in 8c and 9a: Mean weights-at-age (Kg) in the stock. Weights-at-age in 1978–1998 are fixed (see Stock Annex).

Year	Age						
	0	1	2	3	4	5	6+
1978	0	0.027	0.041	0.050	0.059	0.060	0.063
1979	0	0.027	0.041	0.050	0.059	0.060	0.063
1980	0	0.027	0.041	0.050	0.059	0.060	0.063
1981	0	0.027	0.041	0.050	0.059	0.060	0.063
1982	0	0.027	0.041	0.050	0.059	0.060	0.063
1983	0	0.027	0.041	0.050	0.059	0.060	0.063
1984	0	0.027	0.041	0.050	0.059	0.060	0.063
1985	0	0.027	0.041	0.050	0.059	0.060	0.063
1986	0	0.027	0.041	0.050	0.059	0.060	0.063
1987	0	0.027	0.041	0.050	0.059	0.060	0.063
1988	0	0.027	0.041	0.050	0.059	0.060	0.063
1989	0	0.027	0.041	0.050	0.059	0.060	0.063
1990	0	0.027	0.041	0.050	0.059	0.060	0.063
1991	0	0.027	0.041	0.050	0.059	0.060	0.063
1992	0	0.027	0.041	0.050	0.059	0.060	0.063
1993	0	0.027	0.041	0.050	0.059	0.060	0.063
1994	0	0.027	0.041	0.050	0.059	0.060	0.063
1995	0	0.027	0.041	0.050	0.059	0.060	0.063
1996	0	0.027	0.041	0.050	0.059	0.060	0.063
1997	0	0.027	0.041	0.050	0.059	0.060	0.063
1998	0	0.027	0.041	0.050	0.059	0.060	0.063
1999	0	0.030	0.043	0.050	0.054	0.059	0.062
2000	0	0.027	0.041	0.050	0.059	0.060	0.063
2001	0	0.024	0.039	0.051	0.064	0.061	0.064
2002	0	0.022	0.037	0.052	0.069	0.062	0.066
2003	0	0.021	0.041	0.054	0.068	0.065	0.072
2004	0	0.020	0.045	0.056	0.067	0.068	0.079

Year	Age						
	0	1	2	3	4	5	6+
2005	0	0.019	0.049	0.058	0.066	0.072	0.086
2006	0	0.024	0.052	0.060	0.067	0.072	0.084
2007	0	0.029	0.054	0.062	0.069	0.072	0.081
2008	0	0.033	0.057	0.064	0.070	0.072	0.079
2009	0	0.030	0.054	0.063	0.070	0.069	0.075
2010	0	0.027	0.051	0.062	0.070	0.067	0.072
2011	0	0.024	0.048	0.061	0.070	0.064	0.068
2012	0	0.027	0.048	0.062	0.068	0.068	0.073
2013	0	0.030	0.049	0.063	0.067	0.073	0.077
2014	0	0.032	0.049	0.065	0.066	0.077	0.081
2015	0	0.030	0.048	0.063	0.066	0.073	0.077
2016	0	0.029	0.046	0.062	0.065	0.070	0.072
2017	0	0.027	0.045	0.060	0.065	0.066	0.068
2018	0	0.027	0.044	0.056	0.063	0.066	0.071
2019	0	0.027	0.043	0.053	0.060	0.067	0.074
2020	0	0.027	0.042	0.050	0.058	0.068	0.078

Table 3.4.1.1. Parameters and asymptotic standard deviations estimated in the 2021 assessment model.

Label	**Value**	**Parm_StDev**	**Phase**	**Min**	**Max**	**Init**
SR_LN(R0)	16.528	0.032	1	1	20	16.0
Early_InitAge_4	0.512	0.586	2	-5	5	0.0
Early_InitAge_3	0.506	0.464	2	-5	5	0.0
Early_InitAge_2	0.494	0.283	2	-5	5	0.0
Early_InitAge_1	0.772	0.188	2	-5	5	0.0
Main_RecrDev_1978	0.913	0.159	2	-5	5	0.0
Main_RecrDev_1979	1.035	0.154	2	-5	5	0.0
Main_RecrDev_1980	1.146	0.145	2	-5	5	0.0
Main_RecrDev_1981	0.650	0.171	2	-5	5	0.0
Main_RecrDev_1982	0.029	0.233	2	-5	5	0.0
Main_RecrDev_1983	1.542	0.108	2	-5	5	0.0
Main_RecrDev_1984	0.299	0.183	2	-5	5	0.0

Label	Value	Parm_StDev	Phase	Min	Max	Init
Main_RecrDev_1985	0.173	0.177	2	-5	5	0.0
Main_RecrDev_1986	0.027	0.188	2	-5	5	0.0
Main_RecrDev_1987	0.827	0.123	2	-5	5	0.0
Main_RecrDev_1988	0.208	0.158	2	-5	5	0.0
Main_RecrDev_1989	0.172	0.156	2	-5	5	0.0
Main_RecrDev_1990	0.230	0.152	2	-5	5	0.0
Main_RecrDev_1991	1.316	0.087	2	-5	5	0.0
Main_RecrDev_1992	0.884	0.099	2	-5	5	0.0
Main_RecrDev_1993	0.046	0.140	2	-5	5	0.0
Main_RecrDev_1994	-0.081	0.134	2	-5	5	0.0
Main_RecrDev_1995	-0.307	0.135	2	-5	5	0.0
Main_RecrDev_1996	0.074	0.108	2	-5	5	0.0
Main_RecrDev_1997	-0.305	0.130	2	-5	5	0.0
Main_RecrDev_1998	-0.033	0.114	2	-5	5	0.0
Main_RecrDev_1999	-0.288	0.135	2	-5	5	0.0
Main_RecrDev_2000	0.870	0.086	2	-5	5	0.0
Main_RecrDev_2001	0.340	0.108	2	-5	5	0.0
Main_RecrDev_2002	-0.242	0.141	2	-5	5	0.0
Main_RecrDev_2003	-0.491	0.166	2	-5	5	0.0
Main_RecrDev_2004	0.972	0.075	2	-5	5	0.0
Main_RecrDev_2005	-0.104	0.113	2	-5	5	0.0
Main_RecrDev_2006	-1.266	0.175	2	-5	5	0.0
Main_RecrDev_2007	-0.928	0.137	2	-5	5	0.0
Main_RecrDev_2008	-0.638	0.114	2	-5	5	0.0
Main_RecrDev_2009	-0.451	0.098	2	-5	5	0.0
Main_RecrDev_2010	-0.976	0.120	2	-5	5	0.0
Main_RecrDev_2011	-1.080	0.126	2	-5	5	0.0
Main_RecrDev_2012	-0.901	0.112	2	-5	5	0.0
Main_RecrDev_2013	-0.769	0.109	2	-5	5	0.0
Main_RecrDev_2014	-1.057	0.128	2	-5	5	0.0
Main_RecrDev_2015	-0.451	0.112	2	-5	5	0.0
Main_RecrDev_2016	-0.204	0.109	2	-5	5	0.0
Main_RecrDev_2017	-1.074	0.163	2	-5	5	0.0
Main_RecrDev_2018	-0.303	0.144	2	-5	5	0.0
Main_RecrDev_2019	0.729	0.134	2	-5	5	0.0
Main_RecrDev_2020	-0.535	0.275	2	-5	5	0.0

Label	Value	Parm_StDev	Phase	Min	Max	Init
InitF_seas_1_flt_1purse_seine	0.733	0.124	1	-1	2	0.3
LnQ_base_Acoustic_survey(2)	0.243	0.079	1	-3	3	0.0
LnQ_base_DEPM_survey(3)	0.177	0.105	1	-3	3	0.0
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)	-0.174	0.167	2	-4	4	0.1
AgeSel_P7_purse_seine(1)	-0.205	0.512	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	0.086	0.139	2	-4	4	0.9
AgeSel_P3_purse_seine(1)_BLK1delta_1988	-0.032	0.167	2	-4	4	0.4
AgeSel_P3_purse_seine(1)_BLK1delta_2006	-0.204	0.135	2	-4	4	0.4
AgeSel_P4_purse_seine(1)_BLK1delta_1988	0.812	0.190	2	-4	4	0.1
AgeSel_P4_purse_seine(1)_BLK1delta_2006	-0.567	0.138	2	-4	4	0.1
AgeSel_P7_purse_seine(1)_BLK1delta_1988	-0.528	0.524	2	-4	4	-0.5
AgeSel_P7_purse_seine(1)_BLK1delta_2006	0.501	0.371	2	-4	4	-0.5

Table 3.4.1.1. 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	0.187	0.402	0.338	0.338	0.338	0.275	0.354
1979	0.028	0.149	0.320	0.269	0.269	0.269	0.219	0.282
1980	0.028	0.147	0.316	0.266	0.266	0.266	0.216	0.278
1981	0.027	0.141	0.303	0.255	0.255	0.255	0.208	0.267
1982	0.026	0.137	0.294	0.247	0.247	0.247	0.201	0.259
1983	0.026	0.135	0.291	0.245	0.245	0.245	0.199	0.256
1984	0.025	0.133	0.286	0.241	0.241	0.241	0.196	0.252
1985	0.023	0.121	0.261	0.219	0.219	0.219	0.178	0.229
1986	0.029	0.149	0.321	0.270	0.270	0.270	0.220	0.283
1987	0.033	0.172	0.370	0.311	0.311	0.311	0.253	0.326
1988	0.031	0.115	0.239	0.453	0.453	0.453	0.217	0.399
1989	0.030	0.110	0.229	0.433	0.433	0.433	0.208	0.382
1990	0.033	0.120	0.250	0.472	0.472	0.472	0.227	0.417
1991	0.030	0.110	0.230	0.435	0.435	0.435	0.209	0.384
1992	0.022	0.082	0.170	0.321	0.321	0.321	0.154	0.284
1993	0.021	0.079	0.164	0.311	0.311	0.311	0.149	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	0.090	0.186	0.353	0.353	0.353	0.169	0.311
1997	0.032	0.119	0.249	0.470	0.470	0.470	0.226	0.415
1998	0.036	0.133	0.278	0.525	0.525	0.525	0.252	0.463
1999	0.033	0.121	0.252	0.476	0.476	0.476	0.229	0.420

2000	0.029	0.107	0.223	0.422	0.422	0.422	0.203	0.372
2001	0.028	0.102	0.212	0.400	0.400	0.400	0.192	0.353
2002	0.023	0.085	0.177	0.334	0.334	0.334	0.161	0.295
2003	0.021	0.076	0.158	0.298	0.298	0.298	0.143	0.263
2004	0.023	0.084	0.174	0.329	0.329	0.329	0.158	0.291
2005	0.023	0.083	0.174	0.328	0.328	0.328	0.158	0.290
2006	0.024	0.098	0.166	0.178	0.178	0.178	0.141	0.175
2007	0.029	0.118	0.201	0.215	0.215	0.215	0.171	0.212
2008	0.047	0.188	0.319	0.343	0.343	0.343	0.272	0.337
2009	0.053	0.215	0.364	0.391	0.391	0.391	0.310	0.385
2010	0.067	0.270	0.458	0.492	0.492	0.492	0.390	0.484
2011	0.081	0.324	0.549	0.590	0.590	0.590	0.468	0.580
2012	0.064	0.257	0.437	0.469	0.469	0.469	0.372	0.461
2013	0.061	0.243	0.413	0.443	0.443	0.443	0.351	0.435
2014	0.039	0.155	0.263	0.282	0.282	0.282	0.224	0.277
2015	0.023	0.094	0.160	0.172	0.172	0.172	0.136	0.169
2016	0.023	0.092	0.156	0.168	0.168	0.168	0.133	0.165
2017	0.019	0.075	0.127	0.137	0.137	0.137	0.108	0.134
2018	0.010	0.040	0.067	0.072	0.072	0.072	0.057	0.071
2019	0.007	0.027	0.046	0.049	0.049	0.049	0.039	0.049
2020	0.008	0.034	0.057	0.062	0.062	0.062	0.049	0.061

Table 3.4.1.3. Sardine in 8c and 9a: Numbers-at-age, in thousands, at the beginning of the year estimated in the assessment. Estimates of survivors in 2021 are also shown. Age 0 in 2021 is the estimated of recruitment using the S–R model fitted within the assessment.

	Age						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
1978	36382900	11454300	3354040	1018430	370899	83764	56894
1979	42399400	13175400	5162290	1402200	486997	184596	73486
1980	48386800	15466400	6168660	2342490	718292	259651	142276
1981	29890200	17656700	7254630	2810240	1203960	384244	223511
1982	16009100	10919600	8331400	3347510	1459960	651003	341736
1983	71387100	5853260	5174490	3879810	1752540	795538	561206
1984	21205000	26107600	2777570	2416930	2036350	957377	772857
1985	18550600	7758450	12417100	1303710	1273760	1116990	991793
1986	15766900	6802710	3734130	5979140	701988	713850	1234790
1987	34407400	5750920	3183430	1692650	3060180	373946	1103850
1988	18642100	12495600	2630880	1374330	831540	1564710	815443
1989	17798500	6781640	6052440	1294390	585804	368907	1177550

	Age						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
1990	18632200	6483330	3300860	3008220	562448	264937	862856
1991	54620200	6768900	3124770	1607350	1257470	244704	615819
1992	37181800	19893700	3293200	1551660	697218	567708	474397
1993	16285400	13648900	9962210	1736630	754150	352697	585258
1994	14186100	5982560	6853680	5283390	853175	385621	548214
1995	11126800	5228830	3041290	3729160	2724610	457932	560026
1996	15899500	4101330	2658410	1655170	1923910	1463010	606966
1997	10699600	5823880	2037560	1378850	779636	943205	1096490
1998	13622700	3887530	2808200	993120	577397	339798	1050380
1999	10521300	4931010	1848730	1329810	393778	238284	734339
2000	32465500	3821240	2374160	898317	553634	170630	528480
2001	20097500	11835300	1865330	1187160	394825	253262	392169
2002	11315000	7337470	5809160	943451	533185	184563	354518
2003	8821960	4149910	3662430	3042650	452687	266274	312335
2004	37426200	3243580	2090390	1955080	1513390	234352	335750
2005	13003500	13731200	1621070	1097790	942805	759593	326939
2006	4221700	4771160	6864230	851754	529904	473667	588221
2007	5795130	1546310	2350990	3633850	477722	309336	650145
2008	7479270	2111900	746620	1202370	1963980	268730	573796
2009	8573310	2678510	950791	339054	571986	972421	451896
2010	4895460	3050070	1174320	412752	153676	269833	703994
2011	4059110	1717820	1265400	464161	169162	65553	462404
2012	4414100	1405400	675397	456532	172473	65423	235976
2013	4896510	1553680	590299	272607	191361	75244	146941
2014	3737170	1729730	662120	244204	117330	85723	109153
2015	6700910	1349540	805131	318195	123452	61734	108936
2016	9338230	2456520	667313	428765	179607	72527	105662
2017	4218480	3425330	1217510	356773	243043	105964	110398

	Age						
Year	0	1	2	3	4	5	6+
2018	8972500	1553940	1726780	670000	208603	147905	137070
2019	26291600	3334420	811568	1009070	417838	135402	190967
2020	8395340	9801050	1763280	484396	643759	277448	224152
2021	14456000	3124460	5148610	1040630	305310	422314	338854

Table 3.4.1.4. Sardine in 8c and 9a: Summary table of the WGHANSA 2021 assessment. Coefficient of variation (CV) 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	528196	479025	0.158	36382900	0.169	0.354	0.402	0.199	145609
1979	681938	624074	0.158	42399400	0.163	0.28175	0.32	0.188	157241
1980	854555	786521	0.151	48386800	0.152	0.27775	0.316	0.175	194802
1981	1022850	944971	0.142	29890200	0.176	0.267	0.303	0.165	216517
1982	950519	898509	0.144	16009100	0.238	0.25875	0.294	0.155	206946
1983	750671	722083	0.154	71387100	0.107	0.25575	0.291	0.149	183837
1984	1165910	1058700	0.106	21205000	0.184	0.2515	0.286	0.143	206005
1985	988419	944968	0.102	18550600	0.177	0.2295	0.261	0.11	208439
1986	797770	766825	0.102	15766900	0.189	0.28275	0.321	0.143	187363
1987	642958	616771	0.106	34407400	0.121	0.32575	0.37	0.146	177696
1988	708281	655668	0.093	18642100	0.159	0.3995	0.453	0.123	161531
1989	626856	593677	0.095	17798500	0.157	0.382	0.433	0.121	140961
1990	564237	535003	0.096	18632200	0.155	0.41625	0.472	0.12	149429
1991	518913	488713	0.102	54620200	0.088	0.38375	0.435	0.122	132587
1992	854819	771951	0.080	37181800	0.099	0.28325	0.321	0.112	130250
1993	966331	901773	0.070	16285400	0.142	0.27425	0.311	0.106	142495
1994	814712	783928	0.071	14186100	0.135	0.231	0.262	0.091	136582
1995	675839	651882	0.071	11126800	0.137	0.231	0.262	0.085	125280
1996	542019	522956	0.074	15899500	0.109	0.3115	0.353	0.089	116736
1997	481397	456064	0.074	10699600	0.132	0.4145	0.47	0.091	115814
1998	390384	372026	0.079	13622700	0.116	0.463	0.525	0.099	108924

Year	Biomass 1+	SSB	CV SSB	Recruits	CV Recruits	F (2-5)	F Apical	CV F Apical	Landings
1999	374768	363057	0.081	10521300	0.138	0.42	0.476	0.104	94091
2000	321627	303967	0.089	32465500	0.087	0.37225	0.422	0.107	85786
2001	483156	410279	0.077	20097500	0.109	0.35275	0.4	0.105	101957
2002	497053	432544	0.076	11315000	0.142	0.29475	0.334	0.106	99673
2003	472189	435327	0.079	8821960	0.167	0.26275	0.298	0.097	97831
2004	412281	384242	0.085	37426200	0.071	0.29025	0.329	0.095	98020
2005	549029	437559	0.073	13003500	0.11	0.28925	0.328	0.092	97345
2006	641571	589674	0.063	4221700	0.176	0.175	0.178	0.099	87023
2007	504992	493363	0.064	5795130	0.135	0.21125	0.215	0.075	96469
2008	391359	384276	0.065	7479270	0.11	0.337	0.343	0.076	101464
2009	294087	287779	0.068	8573310	0.093	0.38425	0.391	0.088	87740
2010	247357	244306	0.065	4895460	0.118	0.4835	0.492	0.098	89571
2011	177761	176043	0.073	4059110	0.126	0.57975	0.59	0.108	80403
2012	132073	130667	0.090	4414100	0.117	0.461	0.469	0.118	54857
2013	122338	120784	0.100	4896510	0.121	0.4355	0.443	0.133	45818
2014	126854	126854	0.111	3737170	0.145	0.27725	0.282	0.143	27937
2015	120221	119416	0.121	6700910	0.132	0.169	0.172	0.145	20595
2016	152878	152878	0.118	9338230	0.132	0.165	0.168	0.143	22704
2017	198977	197759	0.118	4218480	0.182	0.13475	0.137	0.145	21911
2018	188090	186537	0.125	8972500	0.165	0.07075	0.072	0.141	15062
2019	226681	220012	0.126	26291600	0.155	0.04825	0.049	0.132	13759
2020	436594	416992	0.128	8395340	0.288	0.061	0.062	0.14	22143
2021	451177	442904	0.136						

Table 3.9.1. Sardine in 8.c and 9.a: Comparison of the main parameters from the different runs with the 'true' assessment of the corresponding year.

Label	Advice	No catch data in year y	Catch data of adjacent areas	Mean of last 3 years
2018 advice				
TOTAL_like	123.02	120.81	121.76	155.28
Survey_like	-23.46	-23.97	-23.61	-23.94
Age_comp_like	120.21	119.20	119.26	154.10
Parm_priors_like	0.00	0.00	0.00	0.00
Recr_Virgin_billions	14.55	14.61	14.56	14.72
SR_LN(R0)	16.49	16.50	16.49	16.50
SR_BH_steep	0.71	0.71	0.71	0.71
L_at_Amax_Fem_GP_1	23.00	23.00	23.00	23.00
VonBert_K_Fem_GP_1	0.40	0.40	0.40	0.40
SSB_Virgin_thousand_mt	602.93	605.61	603.46	610.05
Bratio_2017	0.37	0.36	0.37	0.33
SPRratio_2016	0.33	0.33	0.32	0.32
2019 advice				
TOTAL_like	122.93	122.72	124.56	163.72
Survey_like	-23.59	-23.61	-23.07	-18.82
Age_comp_like	121.17	120.48	121.80	157.92
Parm_priors_like	0.00	0.00	0.00	0.00
Recr_Virgin_billions	14.62	14.53	14.50	14.87
SR_LN(R0)	16.50	16.49	16.49	16.51
SR_BH_steep	0.71	0.71	0.71	0.71
L_at_Amax_Fem_GP_1	23.00	23.00	23.00	23.00
VonBert_K_Fem_GP_1	0.40	0.40	0.40	0.40
SSB_Virgin_thousand_mt	605.84	602.21	601.09	616.05
Bratio_2017	0.35	0.37	0.38	0.43
SPRratio_2016	0.31	0.30	0.30	0.27
2020 advice				
TOTAL_like	135.14	124.49	138.57	163.72
Survey_like	-20.37	-24.60	-19.65	-18.82
Age_comp_like	131.36	122.75	134.33	157.92
Parm_priors_like	0.00	0.00	0.00	0.00
Recr_Virgin_billions	14.90	14.90	14.91	14.87
SR_LN(R0)	16.52	16.52	16.52	16.51
SR_BH_steep	0.71	0.71	0.71	0.71
L_at_Amax_Fem_GP_1	23.00	23.00	23.00	23.00
VonBert_K_Fem_GP_1	0.40	0.40	0.40	0.40
SSB_Virgin_thousand_mt	617.55	617.65	617.70	616.05
Bratio_2017	0.39	0.37	0.39	0.43
SPRratio_2016	0.30	0.31	0.30	0.27

Table 3.9.3.1. Catch (in tonnes), number of length samples and individuals measured in 2020 by subdivision.

Subdivision	Variable	Quarter				Total
		1	2	3	4	

8cE	Catch	135 (2.0%)	447 (6.6%)	152 (2.3%)	164 (2.4%)	896 (13.3%)
	Nº samples	16	6	0	18	40
	Nº ind	2297	442	0	1393	4132
8cW	Catch	1 (0.0%)	1361 (20.2%)	508 (7.5%)	56 (0.8%)	1925 (28.6%)
	Nº samples	0	0	0	1	1
	Nº ind	0	0	0	69	69
9aN	Catch	9 (0.1%)	1172 (17.4%)	671 (10.0%)	98 (1.5%)	1950 (29.0%)
	Nº samples	0	0	0	0	0
	Nº ind	0	0	0	0	0
9aCN	Catch	0	1170 (7.6%)	3657 (23.7%)	221 (1.4%)	5048 (32.3%)
	Nº samples	1	6	37	2	46
	Nº ind	10	316	2780	92	3198
9aCS	Catch	0	2197 (14.2%)	5071 (32.9%)	291 (1.9%)	7559 (49%)
	Nº samples	0	10	16	3	29
	Nº ind	0	738	970	167	1875
9aS-Alg	Catch	0	723 (4.7%)	1997 (12.9%)	107 (0.7%)	2827 (18.3%)
	Nº samples	0	3	5	1	9
	Nº ind	0	334	594	112	1040
9aS-Cadiz	Catch	23 (0.3%)	224 (3.3%)	947 (14.1%)	762 (11.3%)	1955 (29.1%)
	Nº samples	0	0	0	7	7
	Nº ind	0	0	0	770	770

Table 3.9.5.1 Catch (in tonnes), number of biological samples, number of individuals measured for age estimation and age readings in 2020 by subdivision.

Subdivision	Variable	Quarter				Total
		1	2	3	4	
8cE	Catch	135 (2.0%)	447 (6.6%)	152 (2.3%)	164 (2.4%)	896 (13.3%)
	Nº samples	2	2	1	0	5
	Nº ind	222	150	80	0	352
	Nº aged	222	150	80	0	352
8cW	Catch	1 (0.0%)	1361 (20.3%)	508 (7.6%)	56 (0.8%)	1925 (28.7%)
	Nº samples	0	1	2	1	3
	Nº ind	0	100	140	100	230
	Nº aged	0	100	140	100	230
9aN	Catch	9 (0.1%)	1172 (17.4%)	671 (10.0%)	98 (1.5%)	1950 (29.0%)
	Nº samples	0	2	3	0	4
	Nº ind	0	200	301	0	501
	Nº aged	0	200	301	0	501
9aCN	Catch	0	1170 (7.6%)	3657 (23.7%)	221 (1.4%)	5048 (32.3%)
	Nº samples	4	0	3	1	8
	Nº ind	207	0	158	39	404
	Nº aged	185	0	156	39	308
9aCS	Catch	0	2197 (14.2%)	5071 (32.9%)	291 (1.9%)	7559 (49%)
	Nº samples	0	0	0	0	0
	Nº ind	0	0	0	0	0
	Nº aged	0	0	0	0	0
9aSA	Catch	0	723 (4.7%)	1997 (12.9%)	107 (0.7%)	2827 (18.3%)
	Nº samples	0	2	3	1	6
	Nº ind	0	105	191	75	371
	Nº aged	0	103	191	74	368

9aSC	Catch	23 (0.3%)	224 (3.3%)	938 (14.0%)	762 (11.3%)	1947 (29.0%)
	Nº samples	0	0	2	1	3
	Nº ind	0	0	734	651	1385
	Nº aged	0	0	734	651	1385

Table 3.9.6.1. Number-at-age from the original subdivision (Original), based on the adjacent subdivision (Based-adj), difference (Dif), percentaje of the orignal (%original) age related to the total and percentage of the ages based on the adjacent subdivision (%adjacent) and difference in the proportion (dif. Prop) for year 2017.

2017	Original	Based_adj	Dif	%original	%adjacent	dif.prop
age0	35328.81	35981.40	1.85	0.08	0.09	-0.01
age1	198626.90	163713.20	-17.58	0.46	0.40	0.05
age2	126003.35	116088.23	-7.87	0.29	0.29	0.00
age3	39726.95	41744.26	5.08	0.09	0.10	-0.01
age4	15971.28	21905.51	37.16	0.04	0.05	-0.02
age5	8392.76	11323.65	34.92	0.02	0.03	-0.01
age6+	10852.82	15612.91	43.86	0.02	0.04	-0.01
total	434902.87	406369.16	-6.56			

Table 3.9.6.2. Number-at-age from the original subdivision (Original), based on the adjacent subdivision (Based-adj), difference (Dif), percentage of the original (%original) age related to the total and percentage of the ages based on the adjacent subdivision (%adjacent) and difference in the proportion (dif. Prop) for year 2018.

2018	Original	Based_adj	Dif	%original	%adjacent	dif.prop
age0	37222.17	38524.32	3.50	0.15	0.16	0.00
age1	49089.99	42256.29	-13.92	0.20	0.17	0.03
age2	87002.20	90391.13	3.90	0.36	0.37	-0.01
age3	33470.92	33513.31	0.13	0.14	0.14	0.00
age4	19049.78	21880.34	14.86	0.08	0.09	-0.01
age5	8942.98	10359.65	15.84	0.04	0.04	-0.01
age6+	9137.19	9503.01	4.00	0.04	0.04	0.00
total	243915.23	246428.05	1.03			

Table 3.9.6.3. Number-at-age from the original subdivision (Original), based on the adjacent subdivision (Based-adj), difference (Dif), percentage of the original (%original) age related to the total and percentage of the ages based on the adjacent subdivision (%adjacent) and difference in the proportion (dif. Prop) for year 2019.

2019	Original	Based_adj	Dif	%original	%adjacent	dif.prop
age0	53515.30	43475.16	-18.76	0.21	0.17	0.04
age1	80914.12	82929.33	2.49	0.32	0.33	-0.01

age2	43304.82	53756.28	24.13	0.17	0.22	-0.04
age3	48181.49	47008.57	-2.43	0.19	0.19	0.00
age4	15737.17	14146.50	-10.11	0.06	0.06	0.01
age5	3537.61	3701.12	4.62	0.01	0.01	0.00
age6+	4684.47	4714.34	0.64	0.02	0.02	0.00
total	249874.98	249731.30	-0.06			

Table 3.9.6.4. Assessment of 2020: Percentual differences between the runs MeanCatch, NoCatch and OtherCatch when compared to the 'real' assessment.

Run	Indicator	\`2017\`	\`2018\`	\`2019\`	\`2020\`
MeanCatch	Biomass	9.4	3.2	-4.7	-6.3
NoCatch		-7	-11.1	-18.1	42.6
OtherCatch		0.3	1.9	2.1	-3.2
MeanCatch	Fishing mortality	-7.7	-1.3	8.9	NA
NoCatch		6.9	12.8	-9.1	NA
OtherCatch		-0.8	-1.7	0.1	NA
MeanCatch	Recruitment	-21.8	-16	-6.2	NA
NoCatch		-22.7	-27.9	98.1	NA
OtherCatch		7.9	1.8	-8.1	NA

Table 3.9.6.5. Assessment of 2019: Percentual differences between the runs No Catch and OtherCatch when compared to the 'real' assessment.

Run	Indicator	\`2016\`	\`2017\`	\`2018\`	\`2019\`
MeanCatch	Biomass	14	2.6	-0.4	-4.5
NoCatch		1.9	2.7	-1.4	-0.9
OtherCatch		3.1	5.7	2.7	-5.6
MeanCatch	Fishing mortality	-11.4	-0.1	9.6	NA
NoCatch		-2.5	2.4	0.9	NA
OtherCatch		-4.7	-1.1	-0.2	NA
MeanCatch	Recruitment	-14.8	-7.6	-9.2	NA
NoCatch		3.1	-20.5	1.3	NA
OtherCatch		8.1	-13.5	-19.4	NA

Table 3.9.6.6. Assessment of 2018: Percentual differences between the runs No Catch and OtherCatch when compared to the 'real' assessment.

Run	Indicator	`2015`	`2016`	`2017`	`2018`
MeanCatch	Biomass	19.3	3.2	-11.4	-0.2
NoCatch		3.3	0.5	-4.4	-0.3
OtherCatch		2.9	1.8	-1.3	-1
MeanCatch	Fishing mortality	-10.4	-1.1	-1.6	NA
NoCatch		-1.6	1.1	3.3	NA
OtherCatch		-2.5	-1.2	0.6	NA
MeanCatch	Recruitment	-18.2	-28.1	55.8	NA
NoCatch		-3.2	-10.3	22.4	NA
OtherCatch		0.1	-5.5	2.1	NA

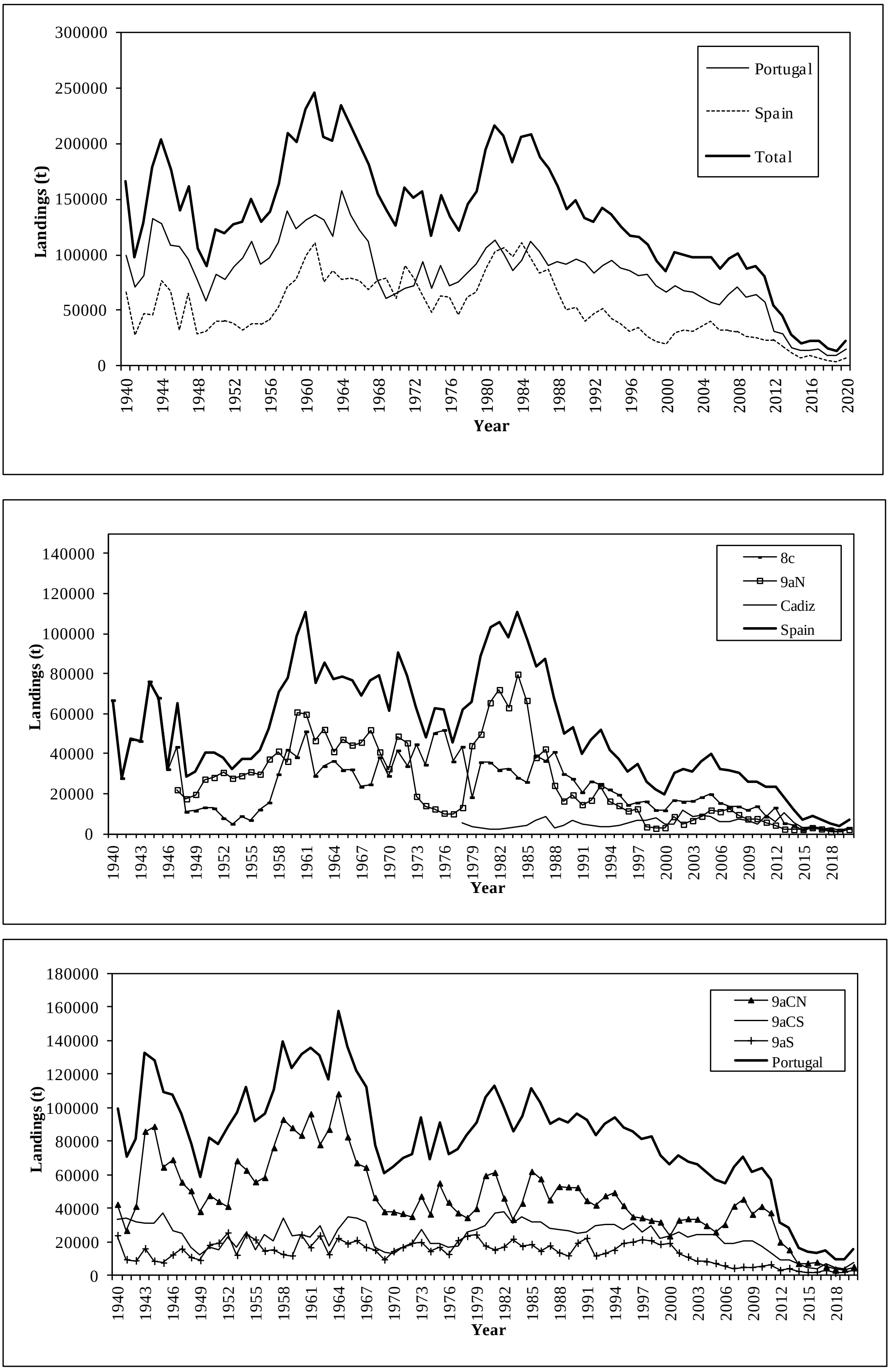


Figure 3.2.2.1. Sardine in 8c and 9a: WG estimates of annual landings of sardine, by country (upper panel) and by ICES subdivision and country.

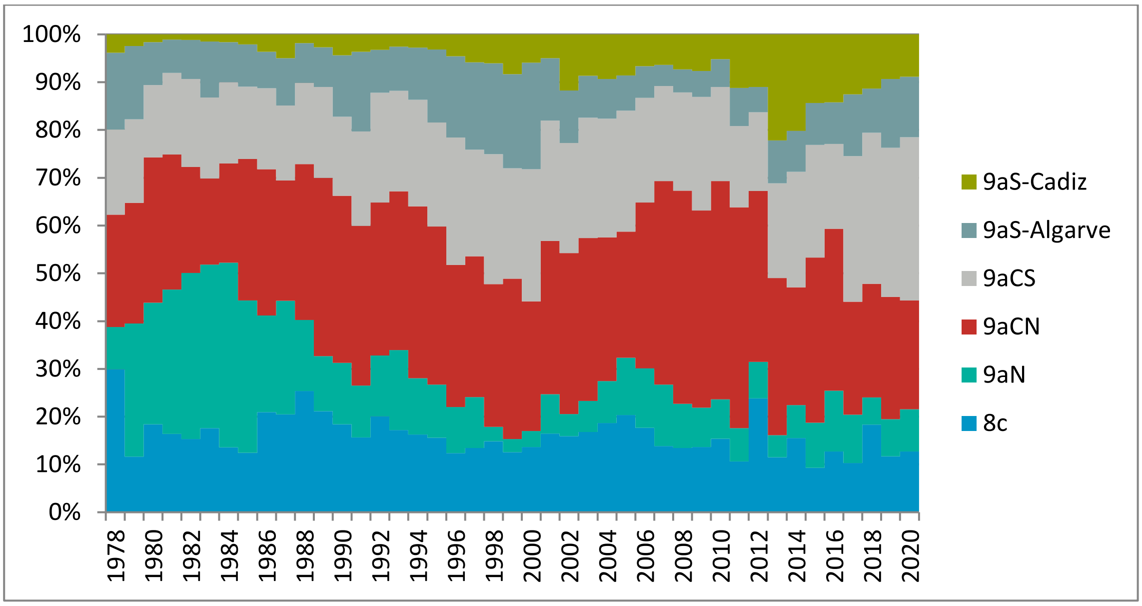


Figure 3.2.2.2. Sardine in 8c and 9a: Historical relative contribution of the different subdivisions to the total catches (1978–2020).

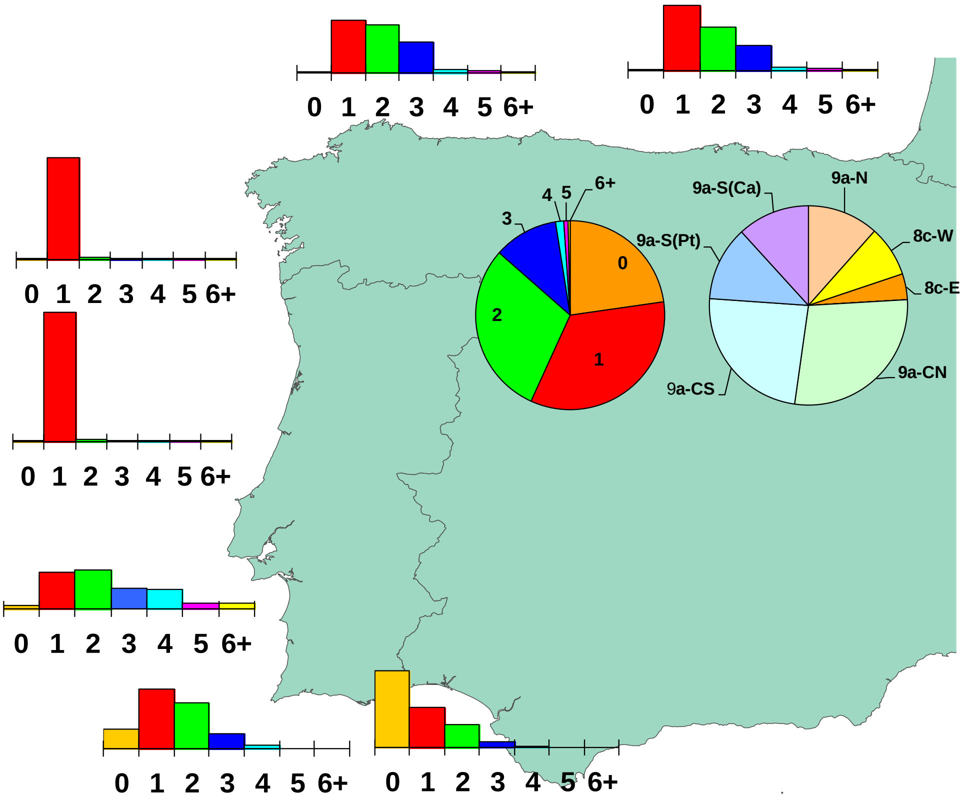


Figure 3.2.4.1. Sardine in 8c and 9a: Relative contribution of each age-class by subdivisions as well as their relative contribution to the 2020 catches (pie-chart).

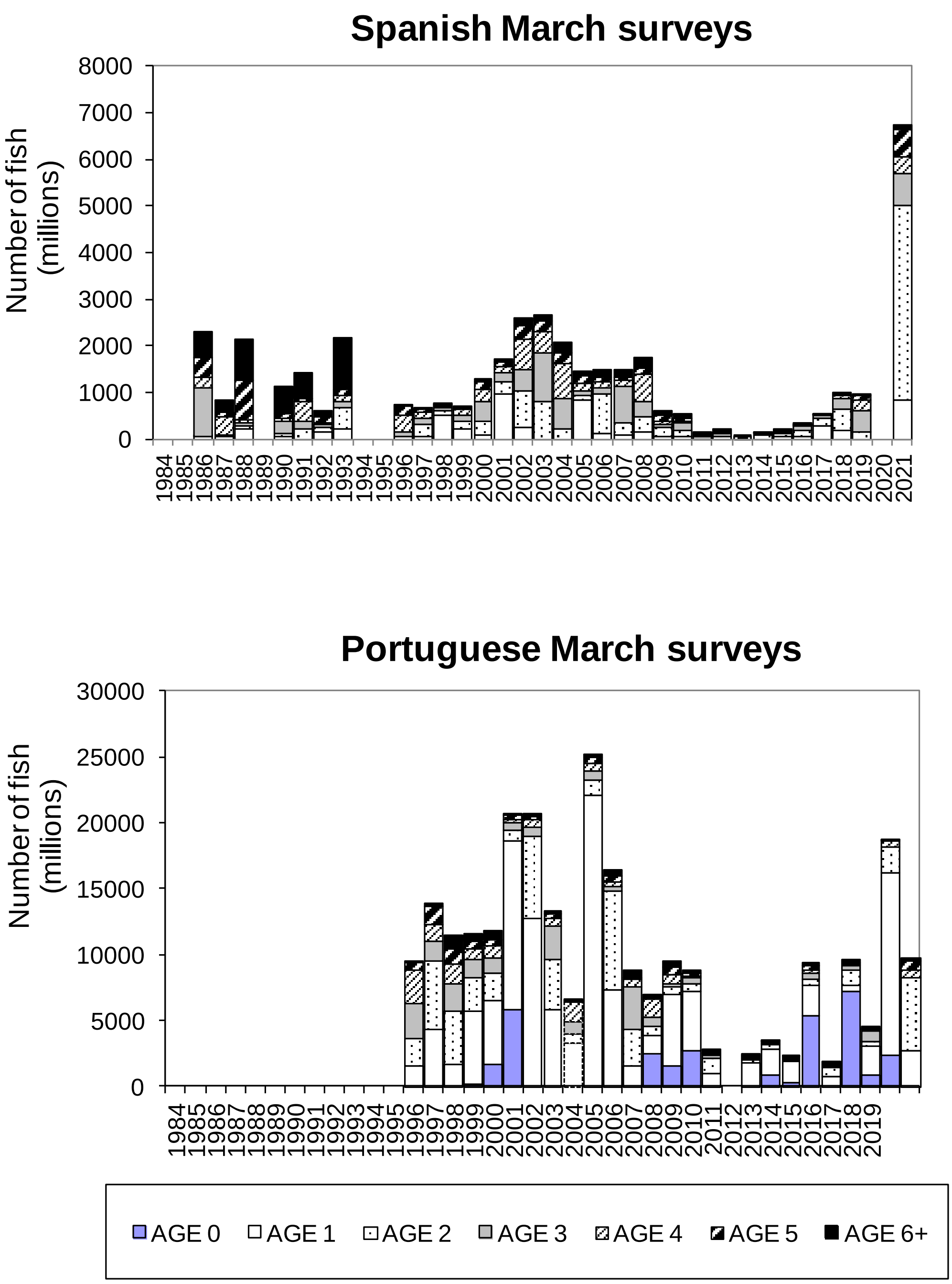


Figure 3.3.1. Sardine in 8c and 9a: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area 8c and 9a-N (top panel) and the Portuguese March surveys covers 9aCN, 9a-CS, 9aS-Algarve and 9aS-Cadiz subdivisions (bottom panel). 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 and for Spanish survey in 2020 (years without survey).

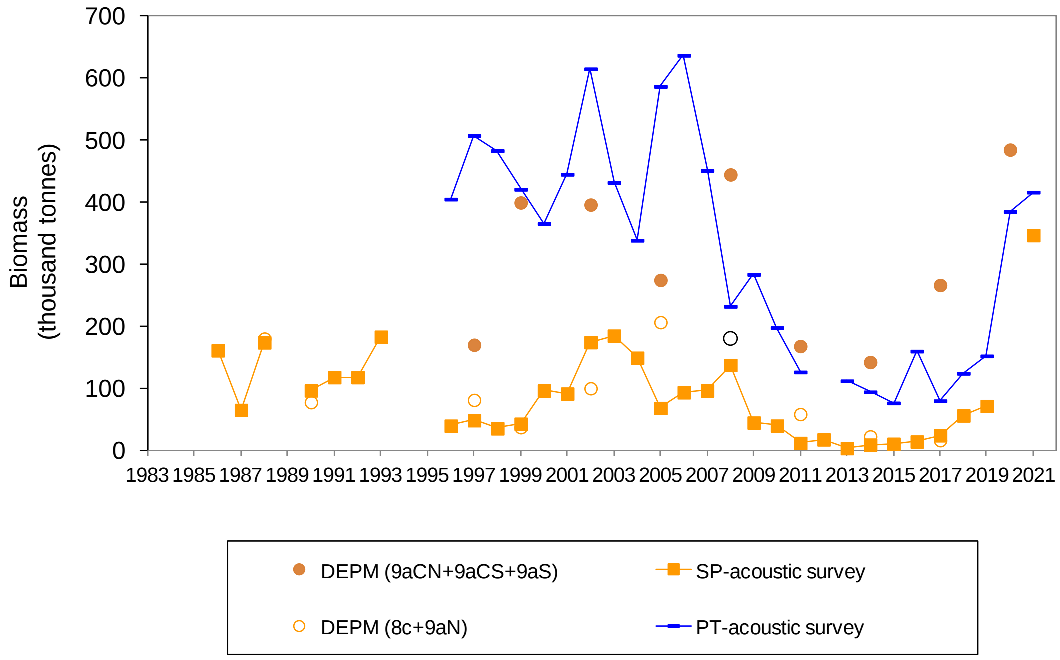


Figure 3.3.2. Sardine in 8c and 9a: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

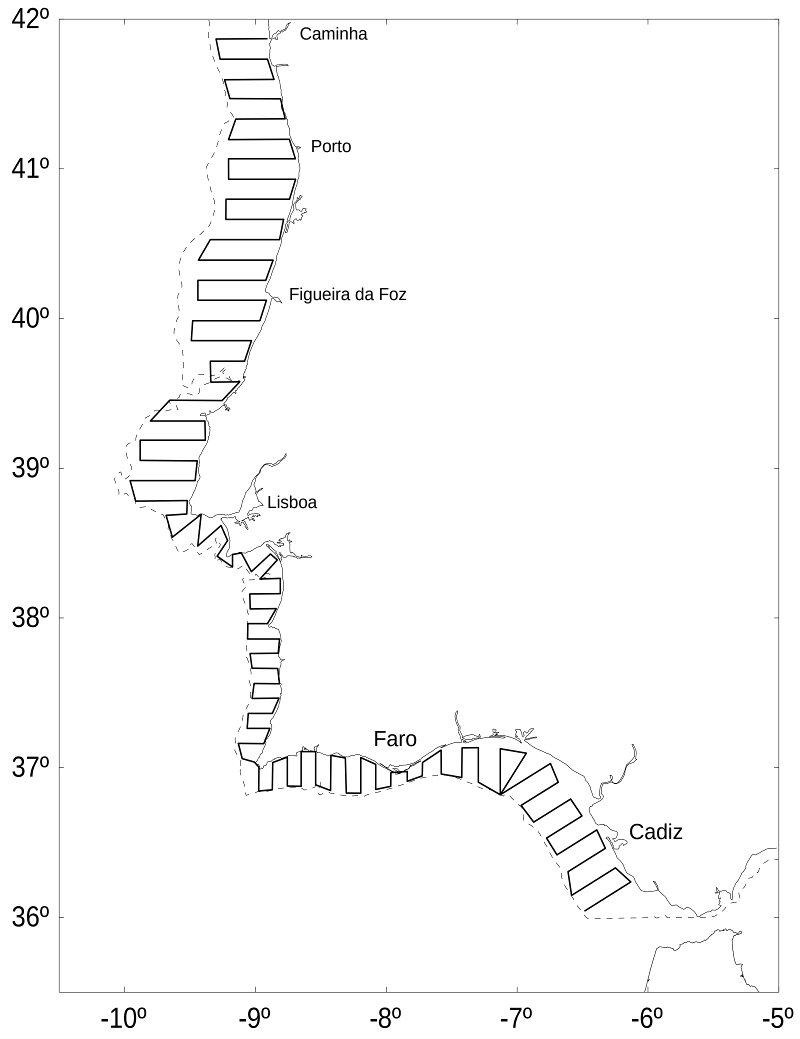


Figure 3.3.2.1.1. Sardine in 8c and 9a: acoustic transects during PELAGO 2021 survey.

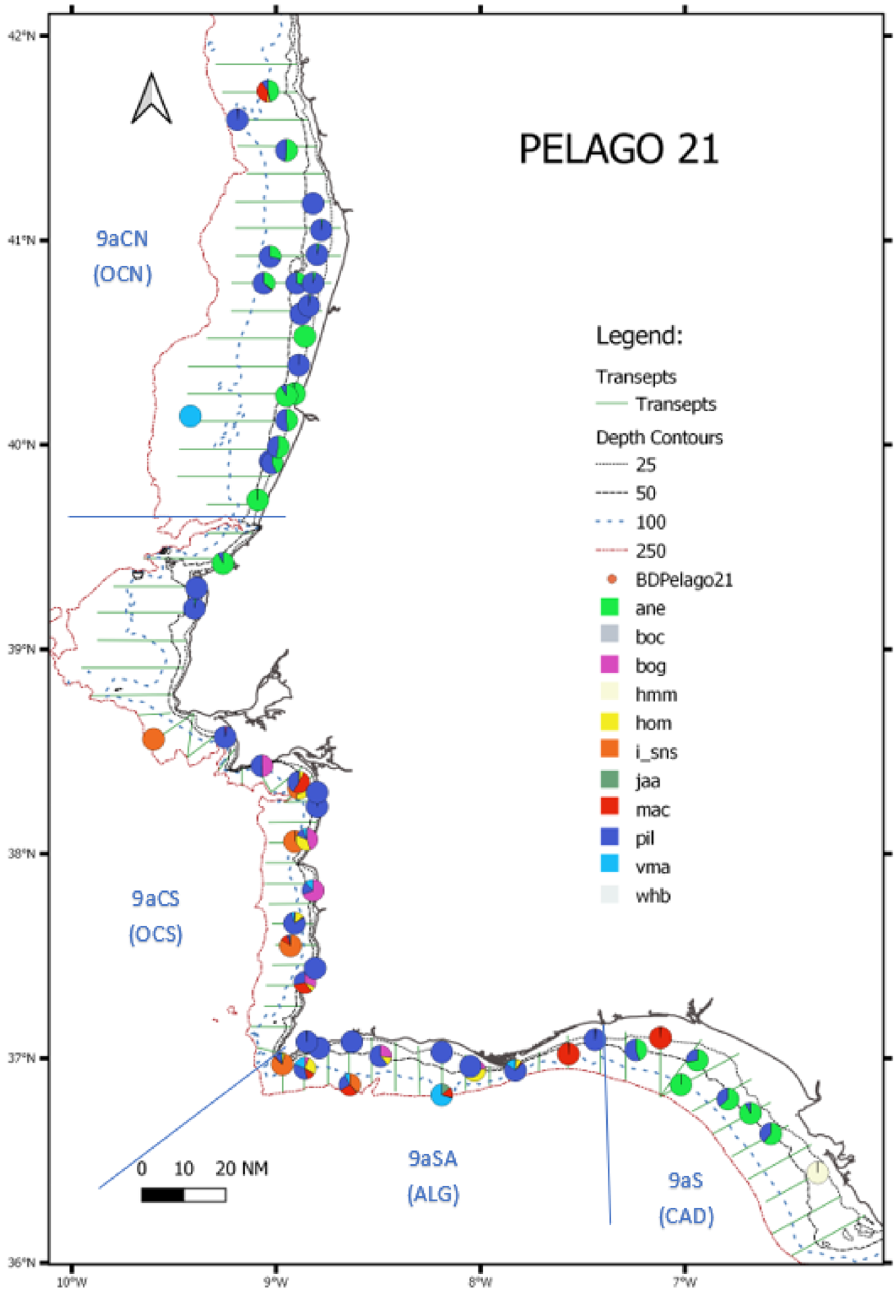


Figure 3.3.2.1.2. Sardine in 8c and 9a: Fishing haul operations during PELAGO 2021 survey.

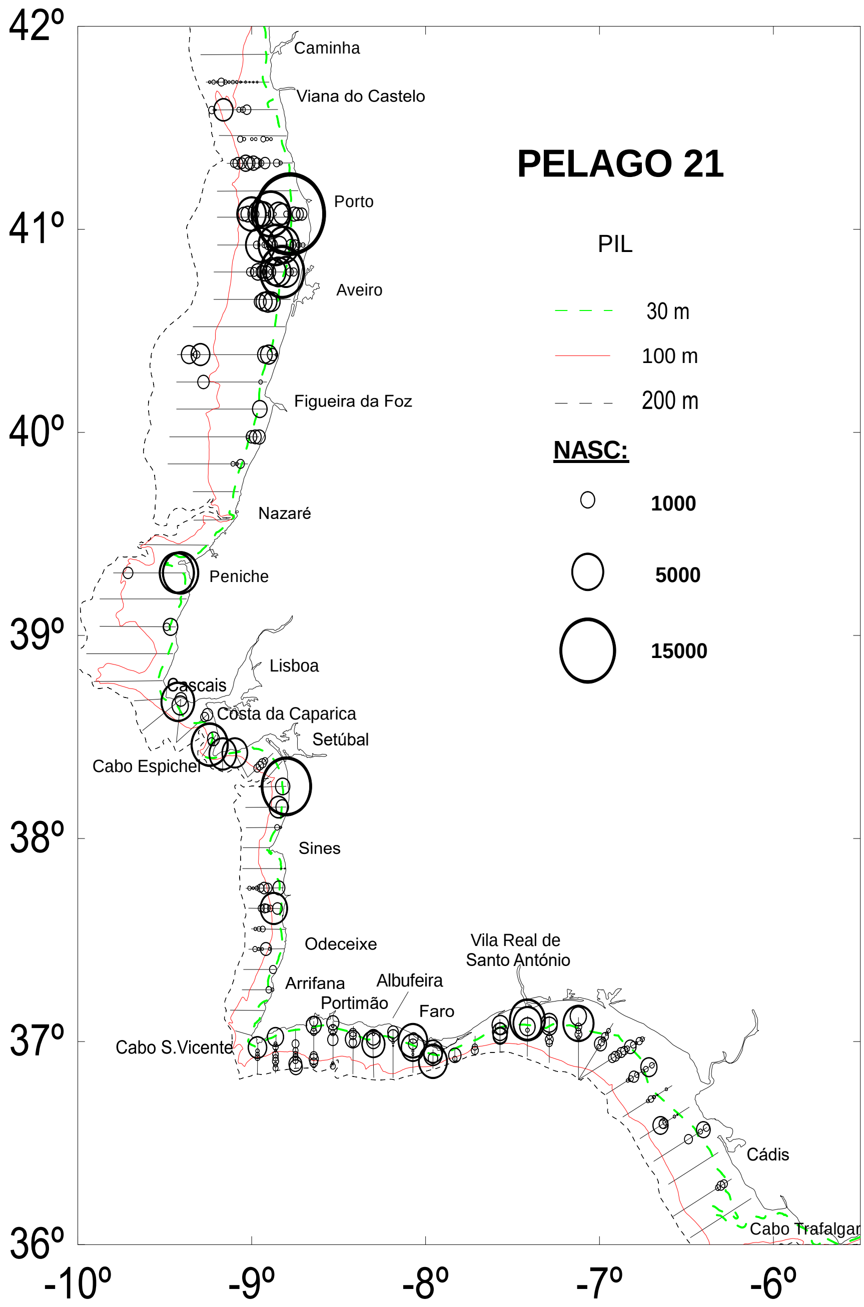


Figure 3.3.2.1.3. Sardine in 8c and 9a: Acoustic energy during PELAGO2021.

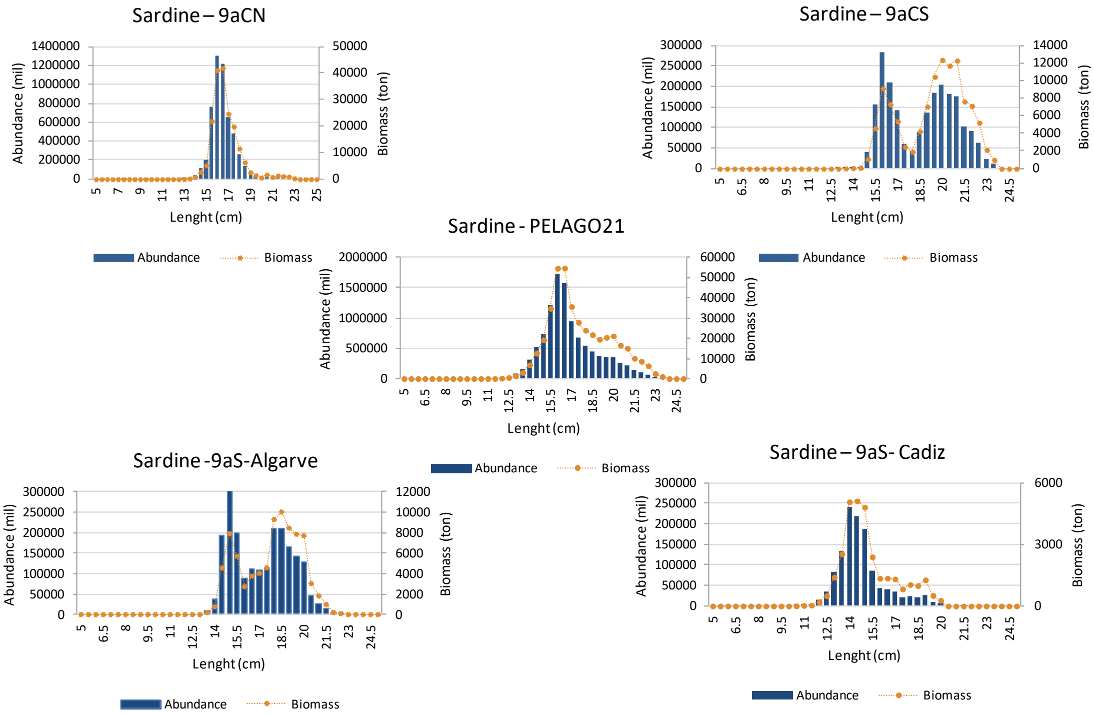


Figure 3.3.2.1.4. Sardine in 8c and 9a: Size composition during PELAGO2021.

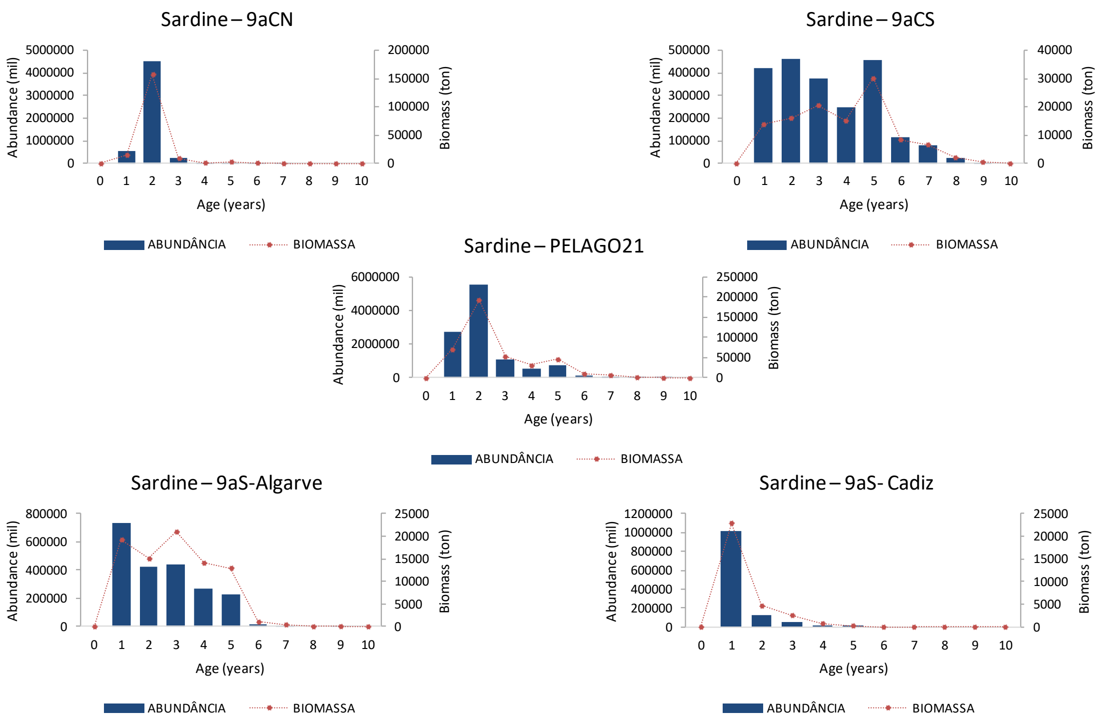


Figure 3.3.2.1.5. Sardine in 8c and 9a: Age composition during PELAGO2021.

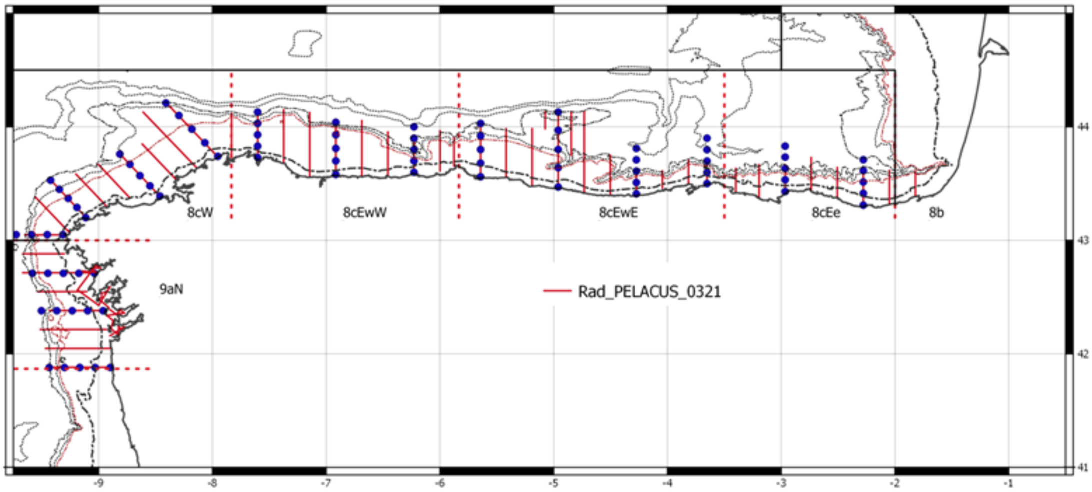


Figure 3.3.2.2.1. Sardine in 8c and 9a: Survey track of PELACUS0321 survey.

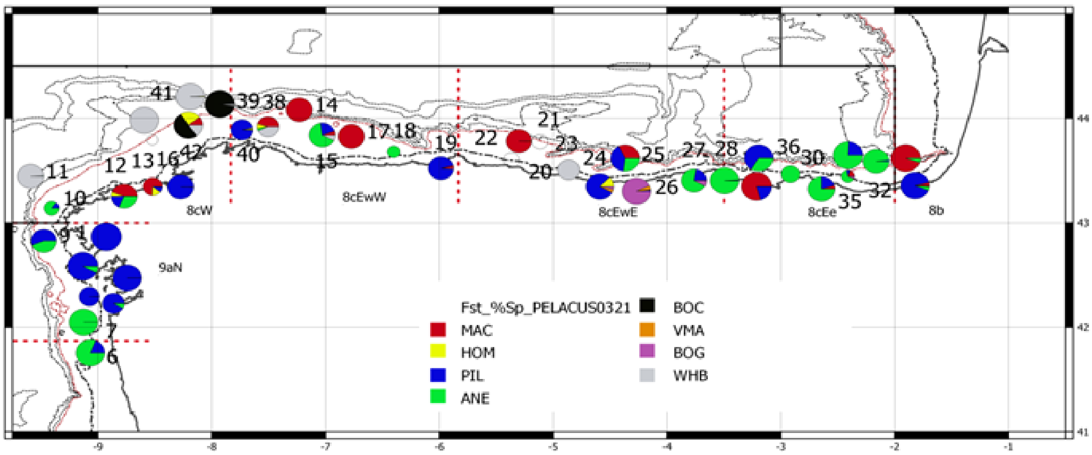


Figure 3.3.2.2.1. Sardine in 8c and 9a: Survey track of PELACUS0321 survey.

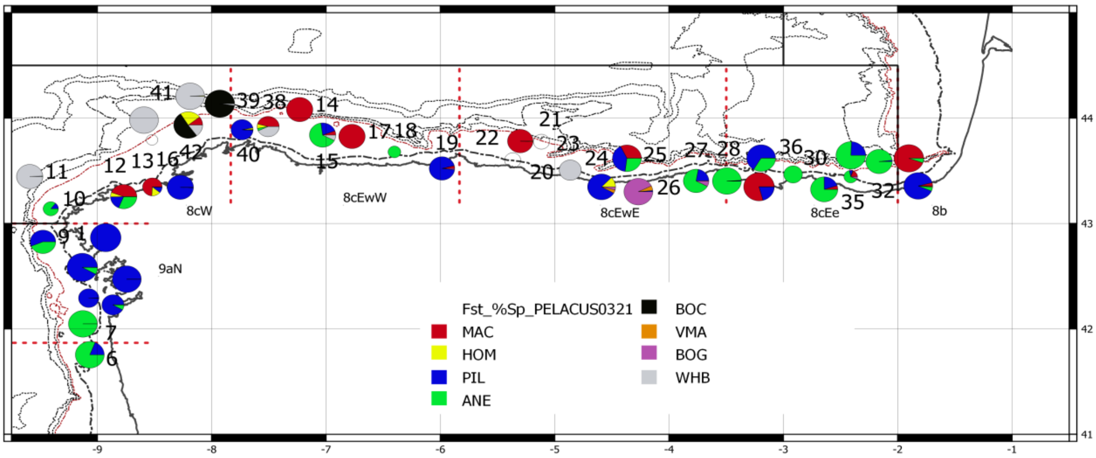


Figure 3.3.2.2.2. Sardine in 8c and 9a: Fishing stations and catch composition (% in number of fish caught). WHB-blue whiting; MAC-mackerel; HOM-horse mackerel; PIL-sardine; BOG-bogue; BOC-boarfish; MAV-Müller's pearlside; ANE-anchovy; VMA-chub mackerel; and HKE-hake.

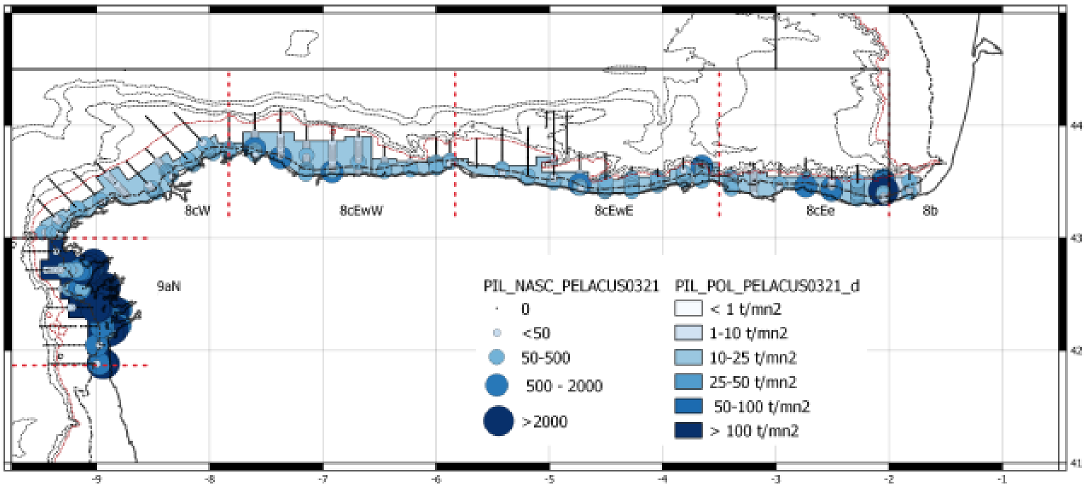


Figure 3.3.2.2.3. Sardine in 8c and 9a: Sardine spatial distribution in PELACUS0321 survey.

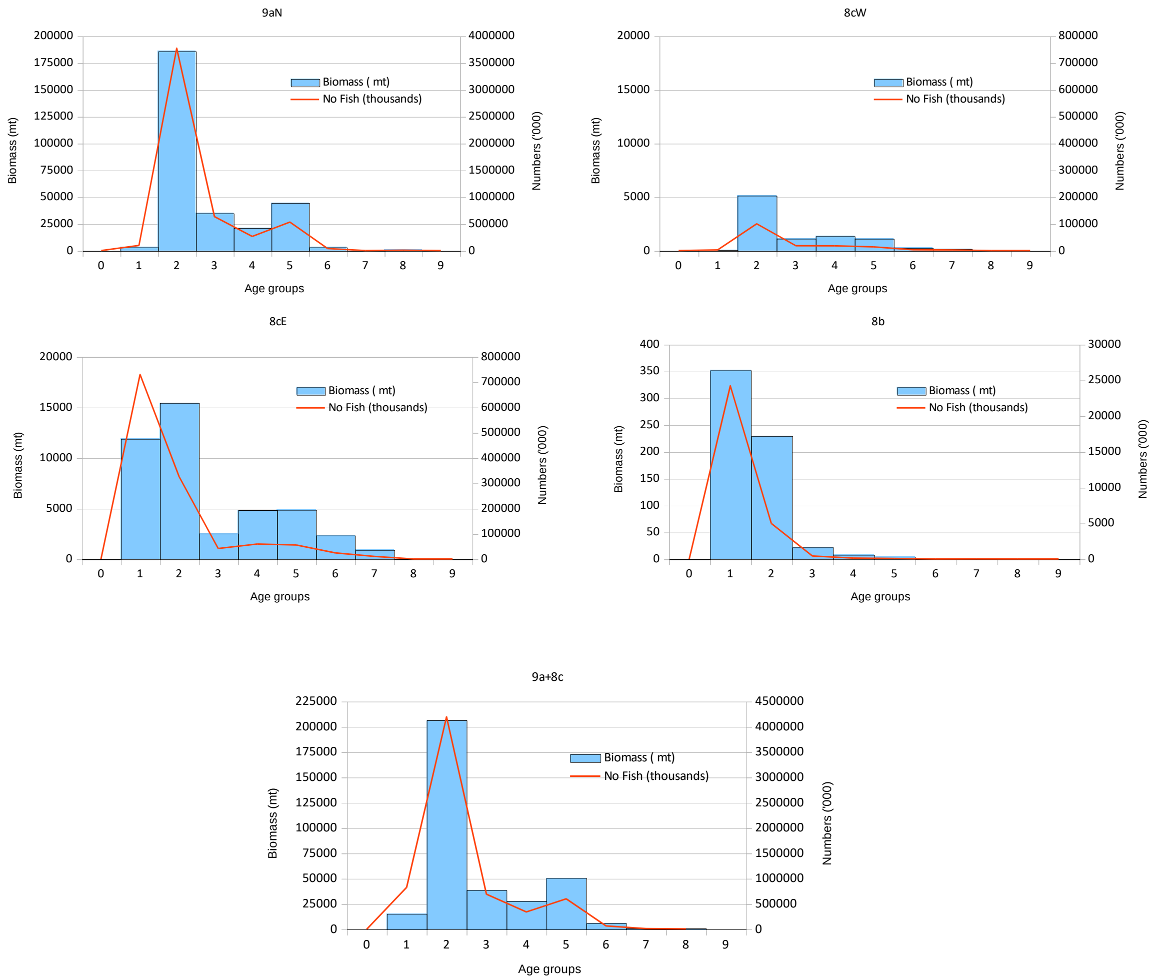


Figure 3.3.2.2.4. Sardine abundance by age group estimated in PELACUS 0321.

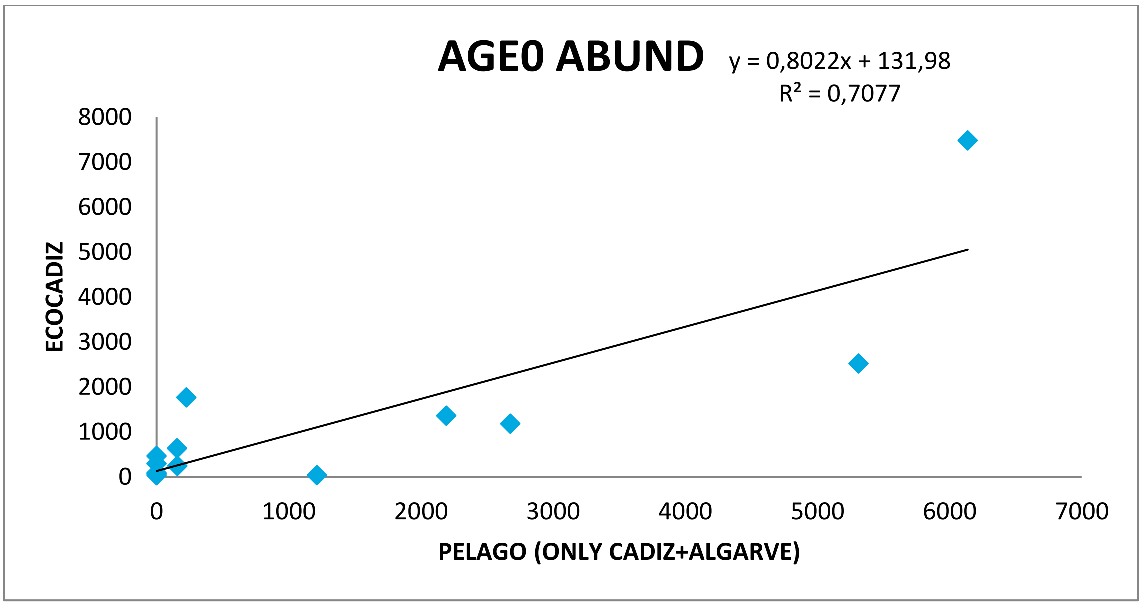


Figure 3.3.3.1. Sardine in 8c and 9a: Relationship between age-0 abundance in PELAGO survey and age-0 abundance in ECOCADIZ survey in the same year.

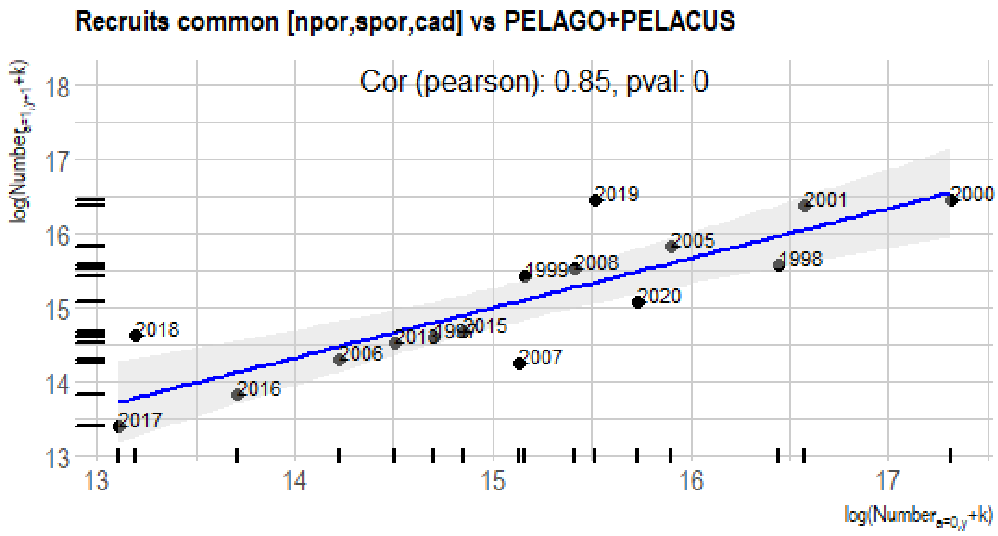


Figure 3.3.3.2. Sardine in 8c and 9a: Correlation between abundance of age-0 sardine in juvenile surveys (JUVESAR-IBE-RAS) and abundance of age-1 individuals in spring acoustic surveys of the next year.

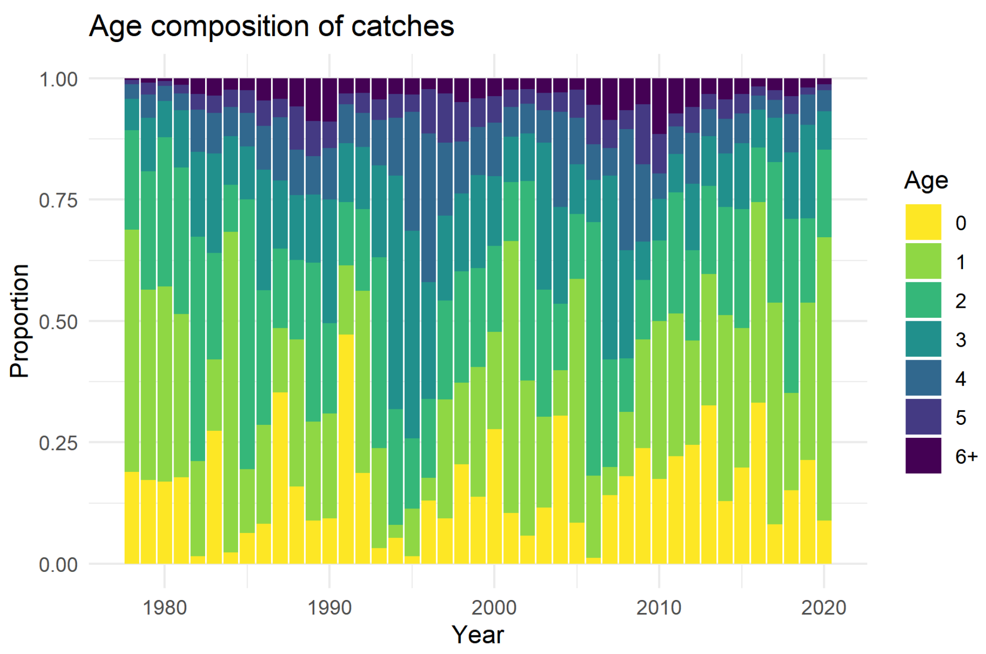


Figure 3.3.7.1. Sardine in 8c and 9a: Catches-at-age for 1978–2020.

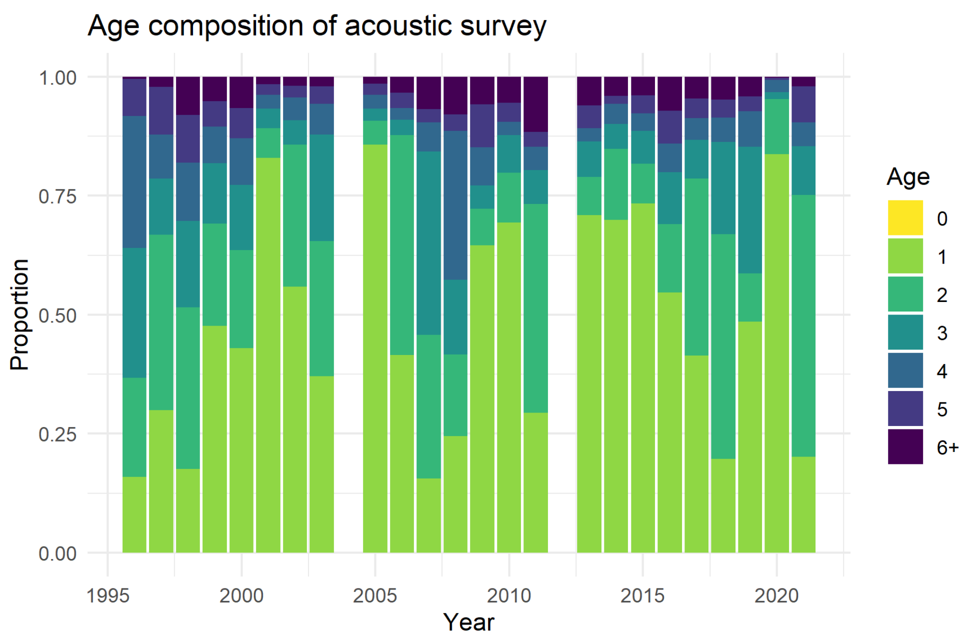


Figure 3.3.7.2. Sardine in 8c and 9a: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996–2021.

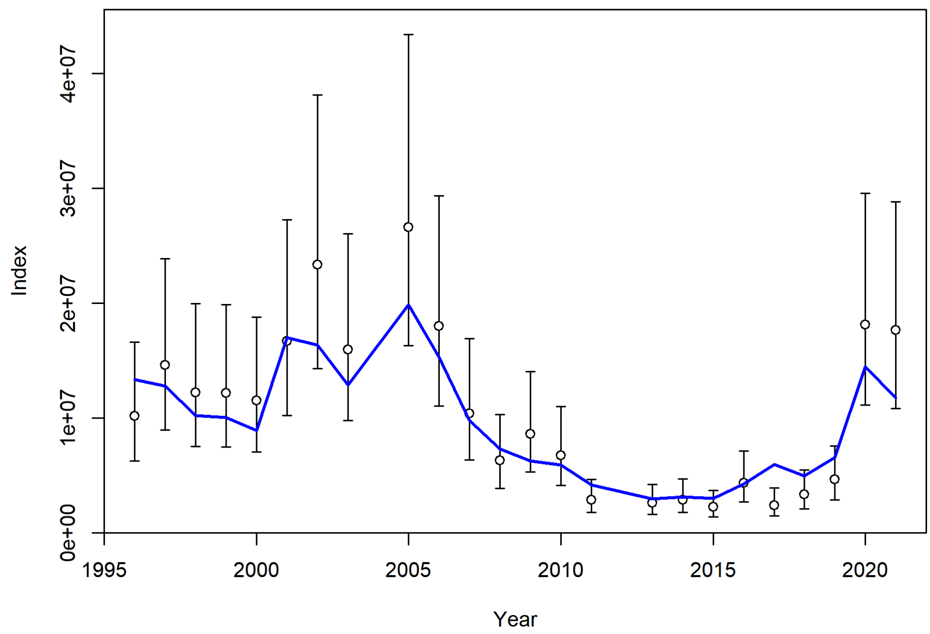


Figure 3.4.1.1. Sardine in 8c and 9a: Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Bars are standard errors re-transformed from the log scale.

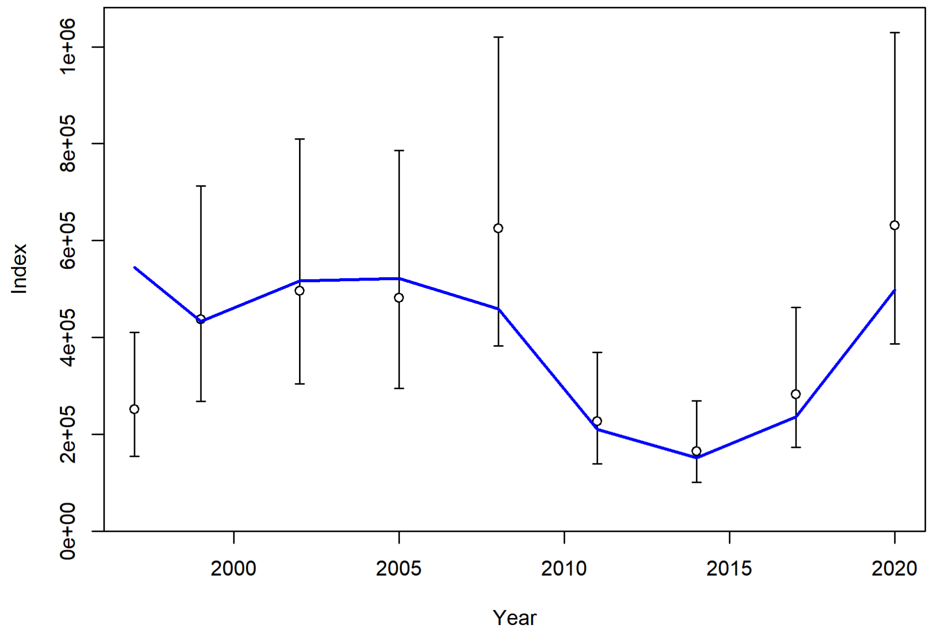
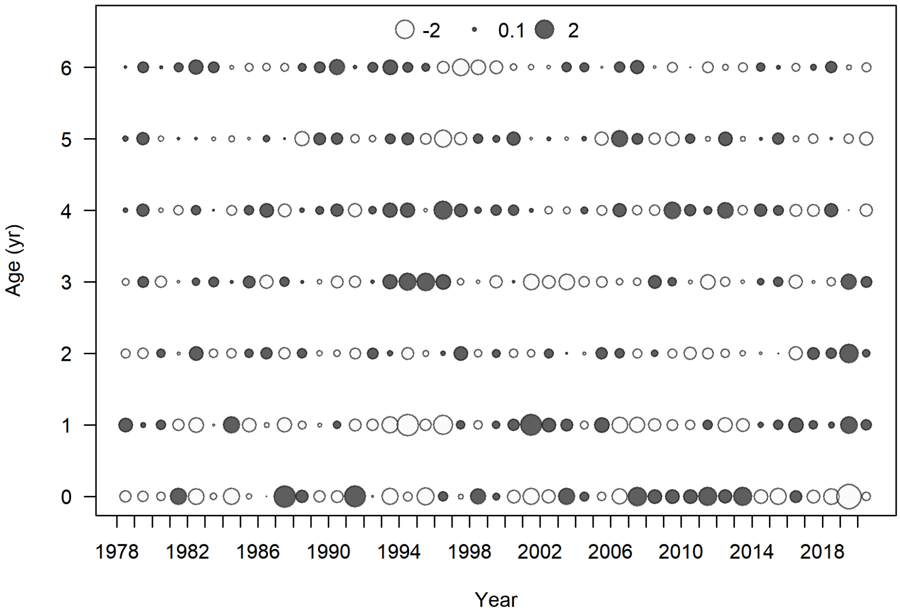


Figure 3.4.1.2. Sardine in 8c and 9a: Model fit to the DEPM survey series. The index is SSB (in thousand tonnes). Bars are standard errors re-transformed from the log scale.



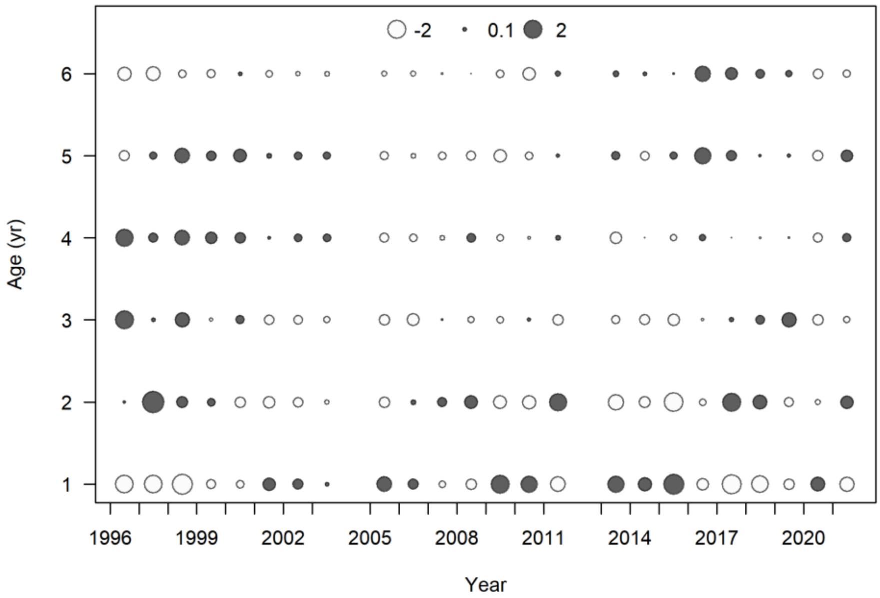


Figure 3.4.1.3. Sardine in 8c and 9a: Model residuals from the fit to the catch-at-age composition (top) and the acoustic survey age composition (bottom).

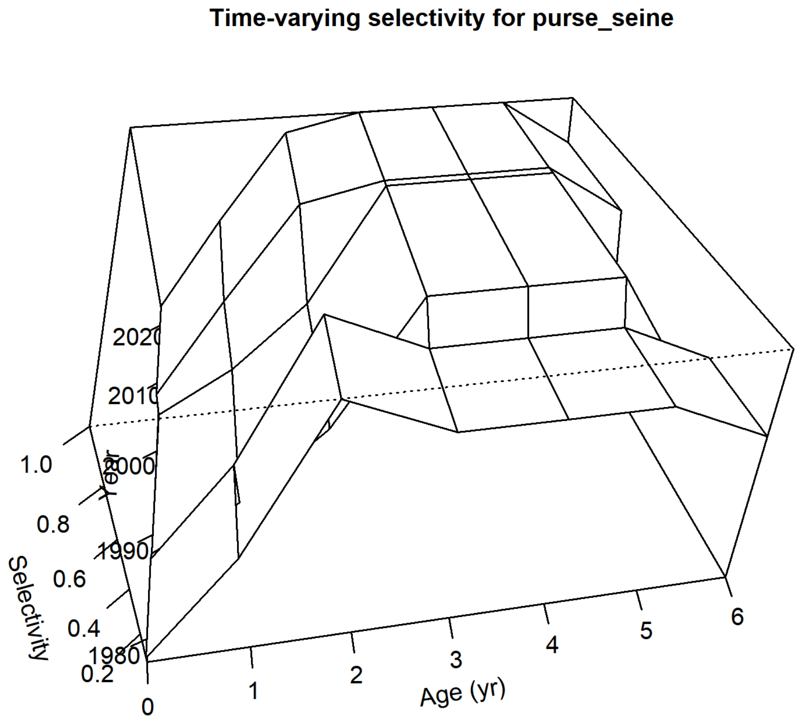


Figure 3.4.1.4. Sardine in 8c and 9a: Selectivity-at-age in the fishery showing the three blocks of fixed selectivity, 1978–1987, 1988–2005 and 2006–2020.

Figure 3.4.1.5. Sardine in 8c and 9a: Historical B1+ (top), $F_{bar(2–5)}$ (middle) and recruitment (bottom) trajectories in the period 1978–2020 (B1+ is estimated up to 2021). The WG 2020 assessment is shown for comparison (red line).

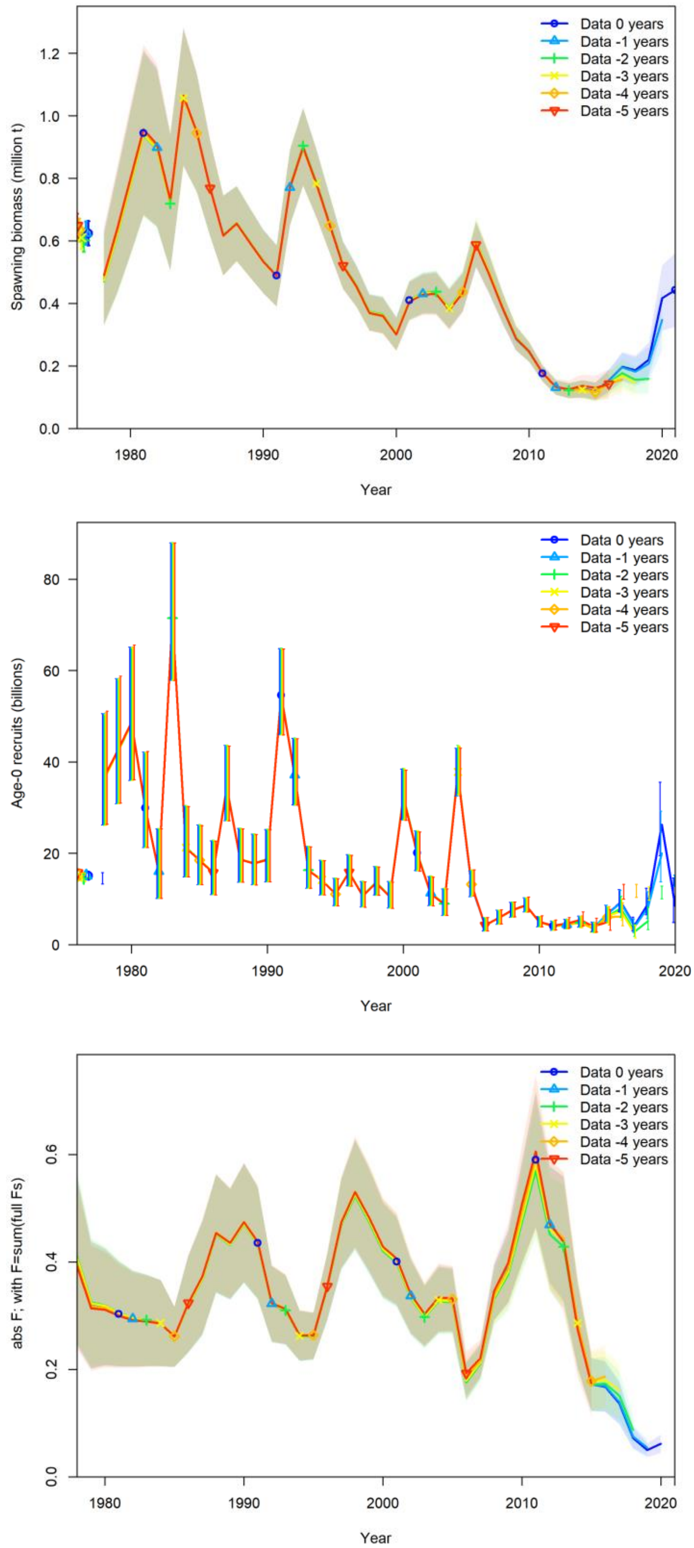


Figure 3.5.1. Sardine in 8c and 9a: Retrospective error for SSB (top), recruitment (middle) and absolute F (bottom) in the assessment (SSB is estimated up to 2021).

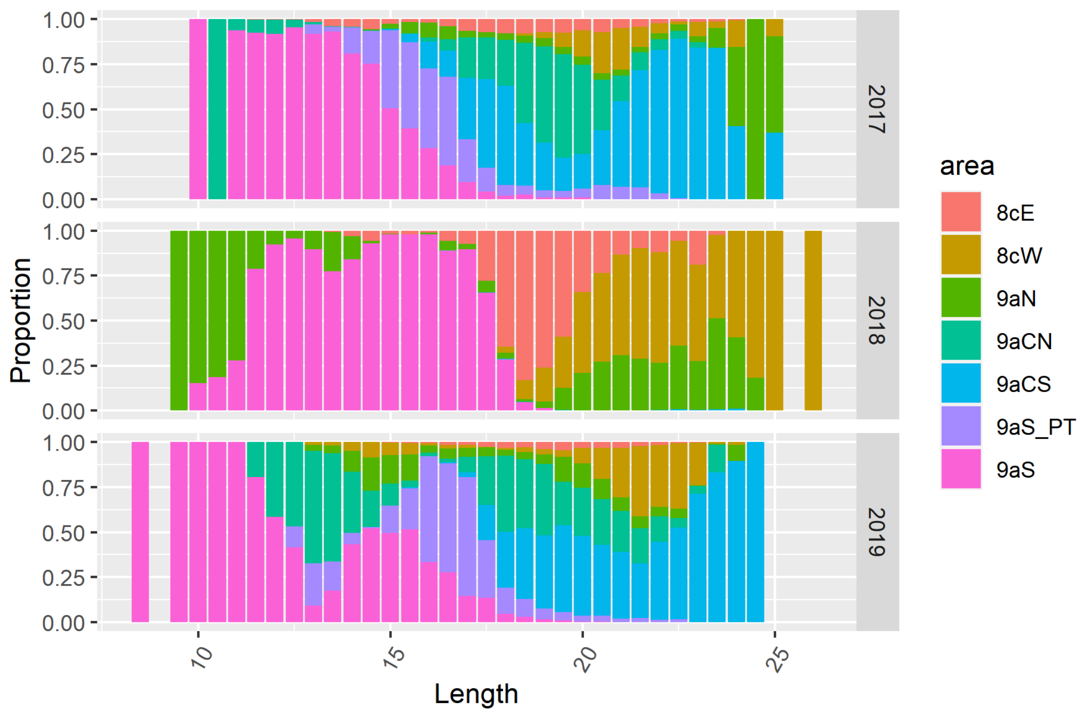


Figure 3.9.6.1. Proportion-at-length by subdivision (colours) and years (2017–2019).

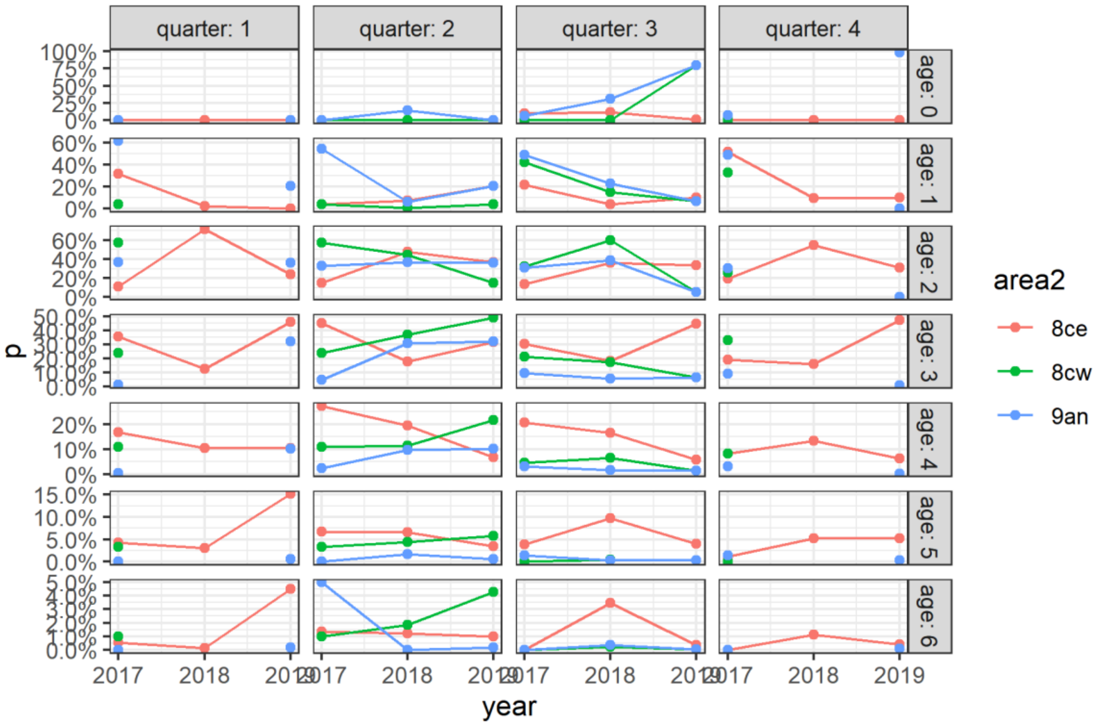


Figure 3.9.6.2. Proportion-at-age (rows) by quarter (columns) in years (2017–2019) in Subdivision 8cW and adjacent subdivisions 8cE and 9aN.

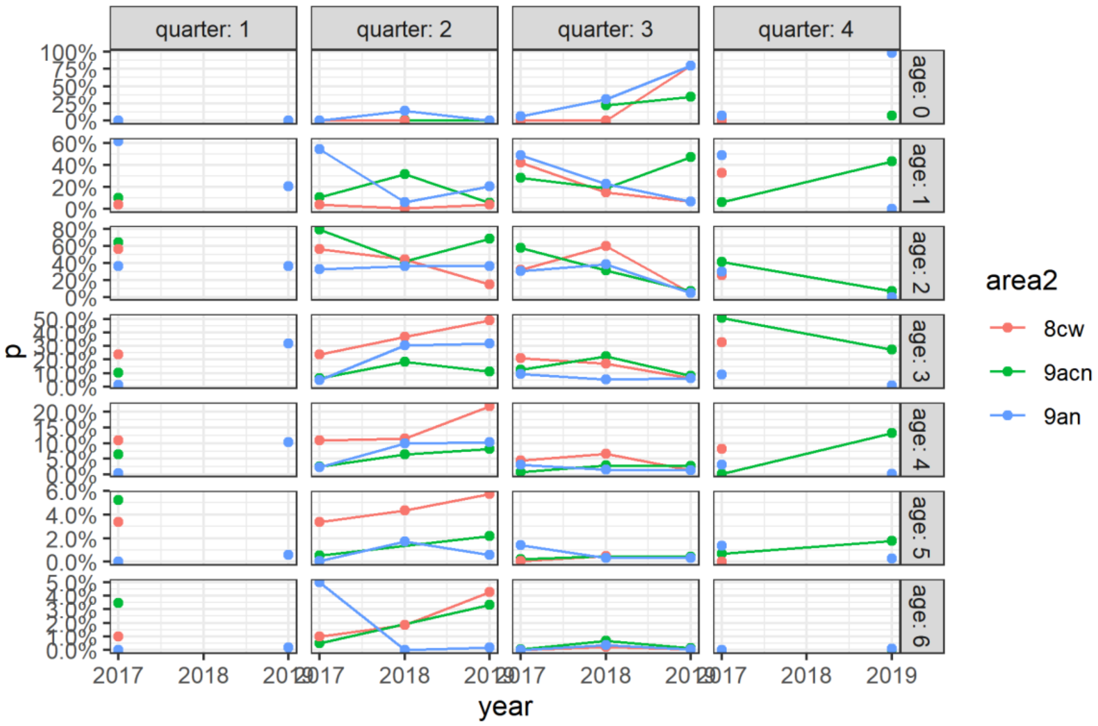


Figure 3.9.6.3. Proportion-at-age (rows) by quarter (columns) in years (2017–2019) in Subdivision 9aN and adjacent subdivisions 8cW and 9aCN.

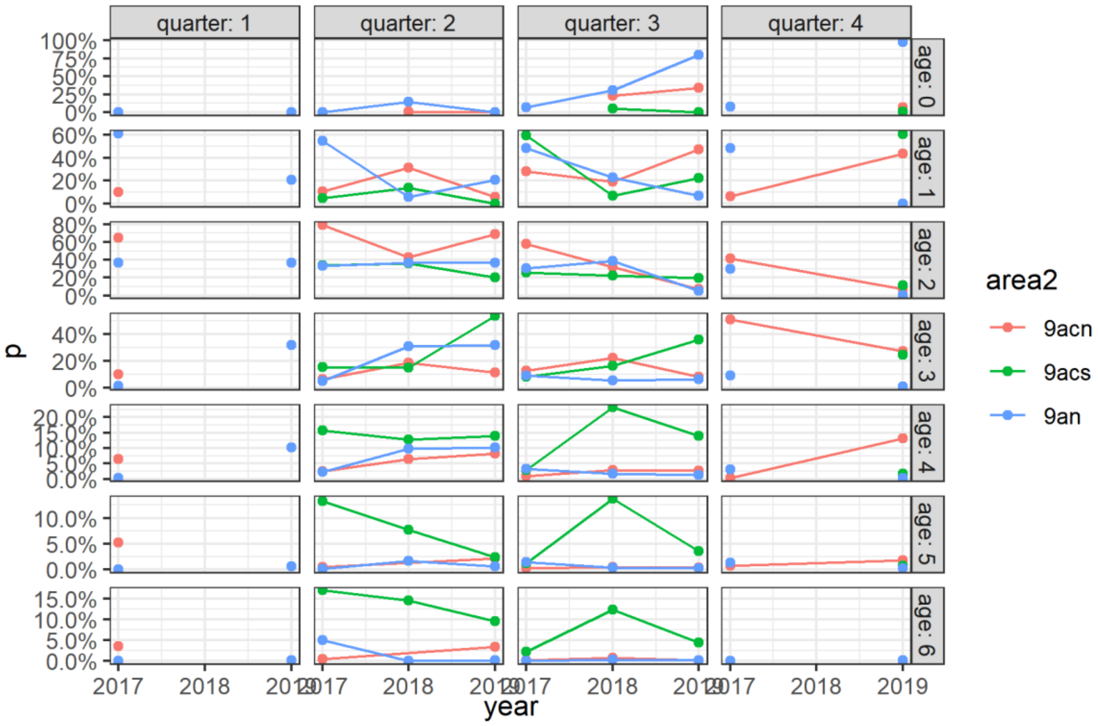


Figure 3.9.6.4. Proportion-at-age (rows) by quarter (columns) in years (2017–2019) in Subdivision 9aCN and adjacent subdivisions 9aN and 9aCS.

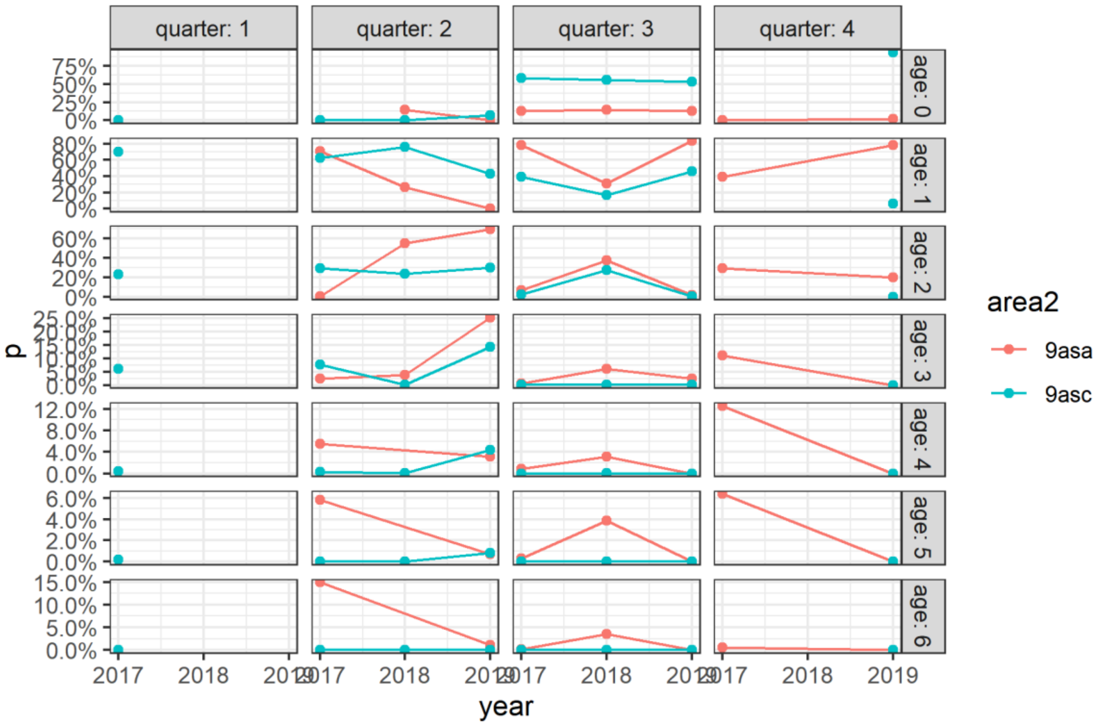


Figure 3.9.6.5. Proportion-at-age (rows) by quarter (columns) in years (2017–2019) in Subdivision 9aS-Cádiz and adjacent subdivision 9aS-Algarve.

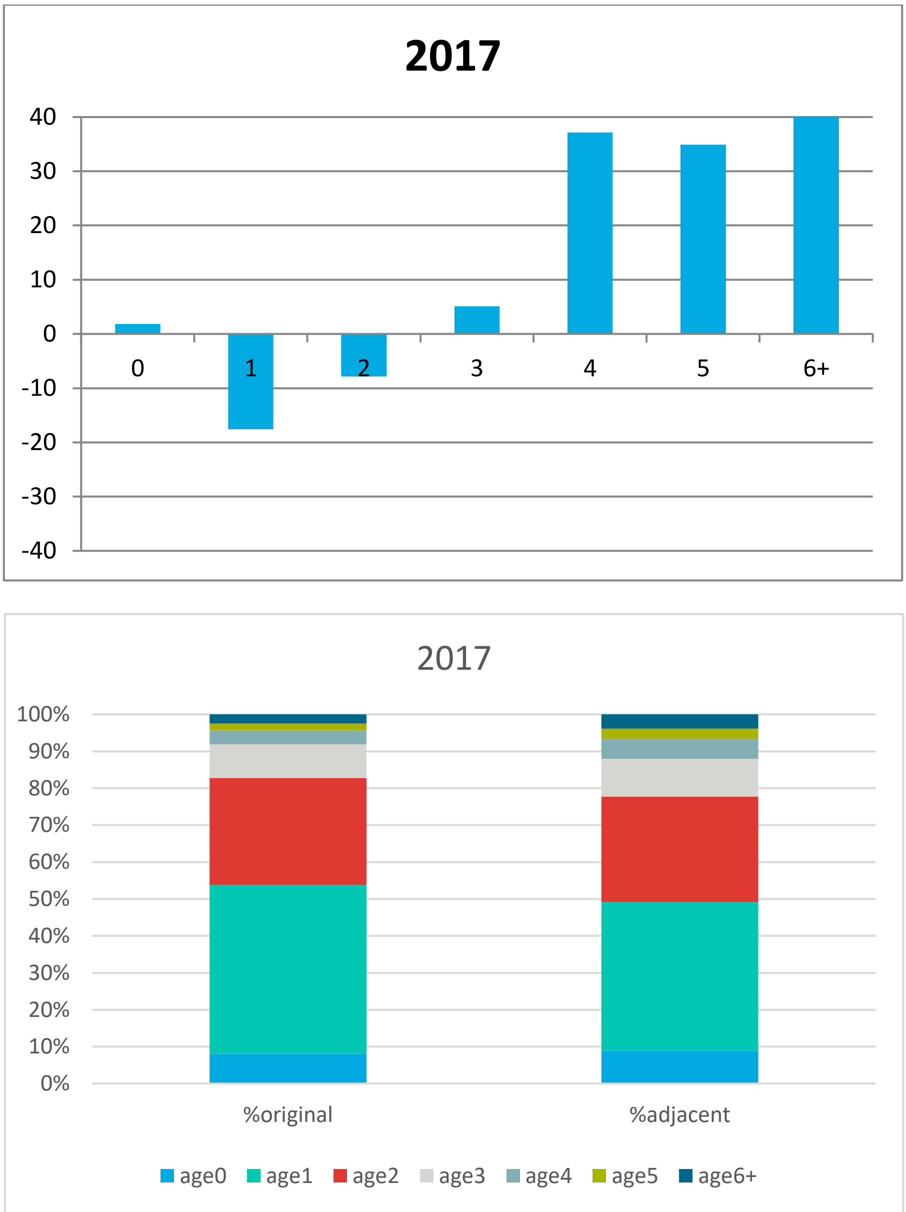


Figure 3.9.6.6. Difference at-age for year 2017 (top panel in numbers, bottom panel in proportions).

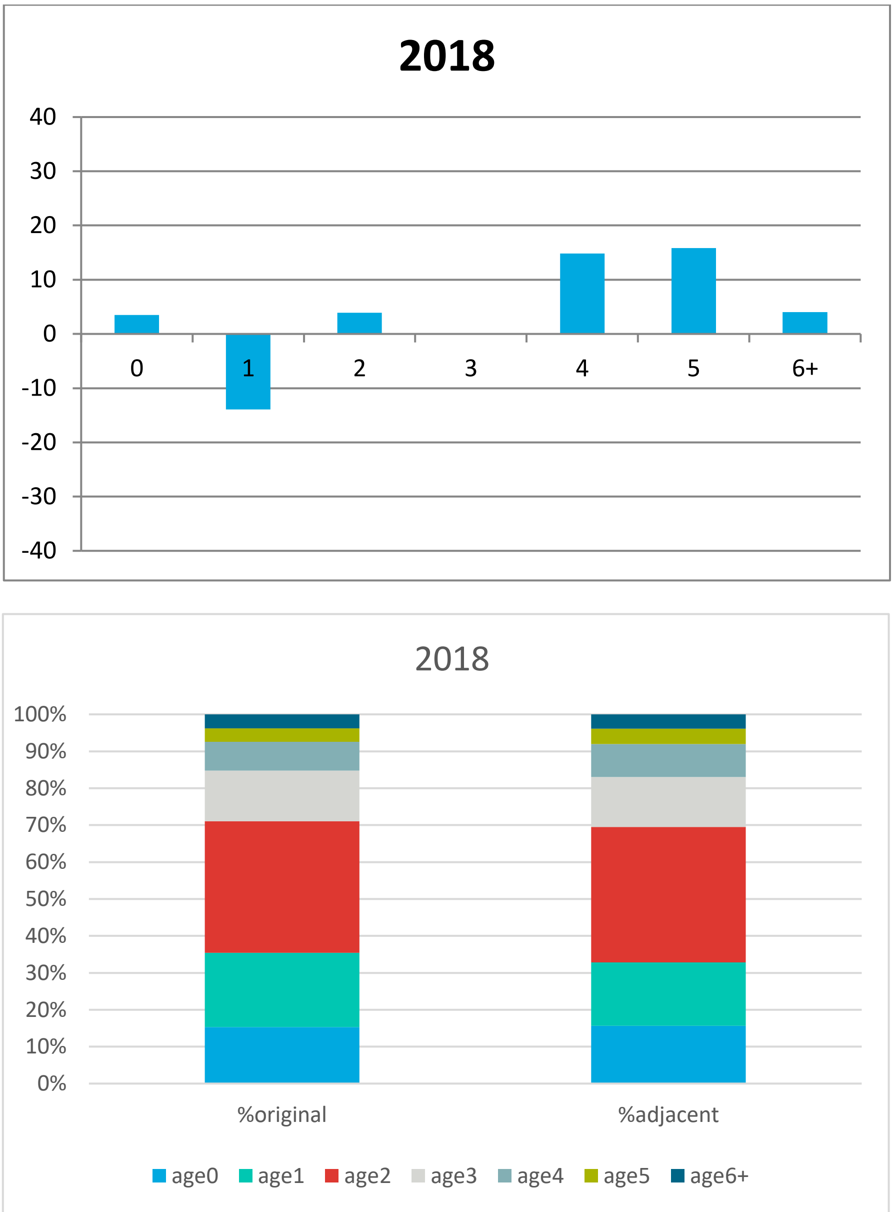


Figure 3.9.6.7. Difference at-age for year 2018 (top panel in numbers, bottom panel in proportions).

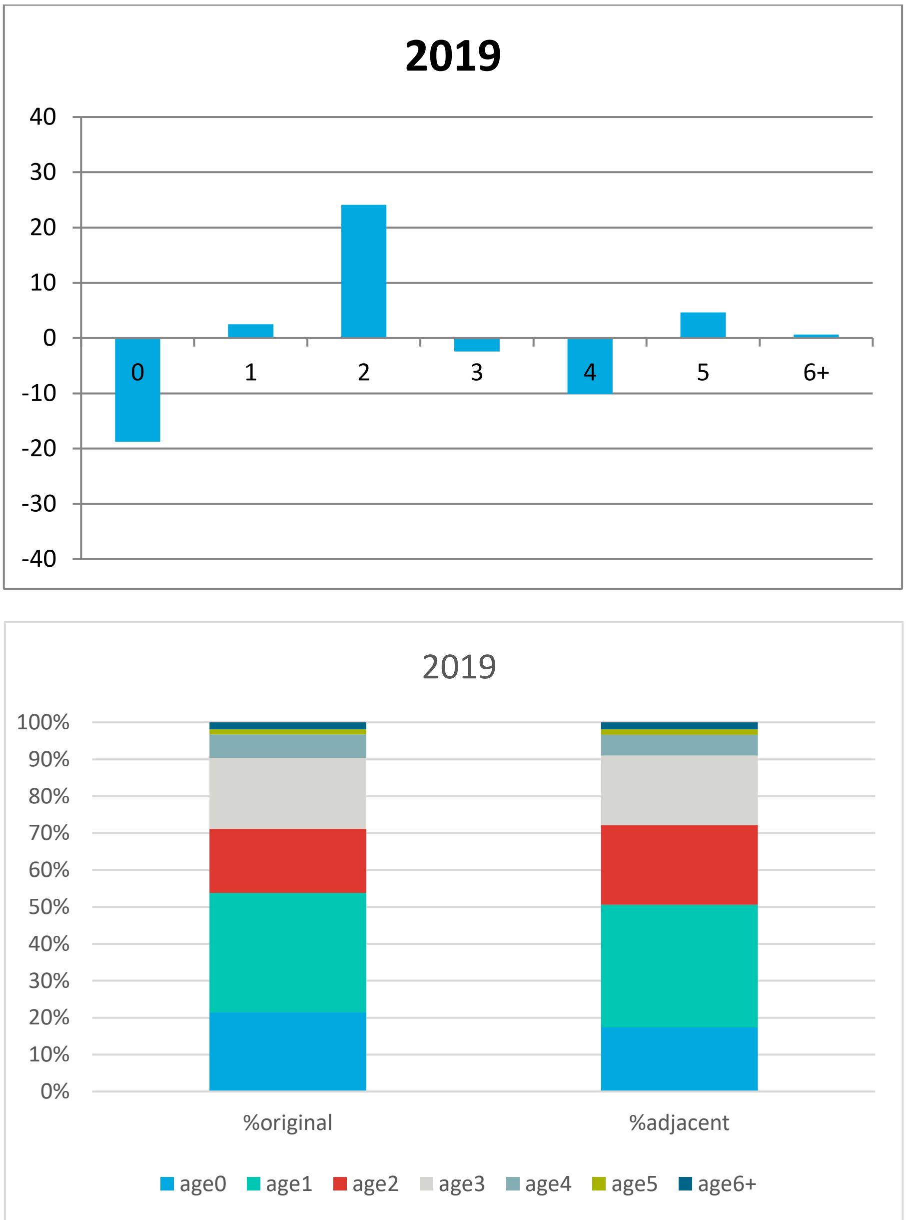


Figure 3.9.6.8. Difference at-age for year 2019 (top panel in numbers, bottom panel in proportions).

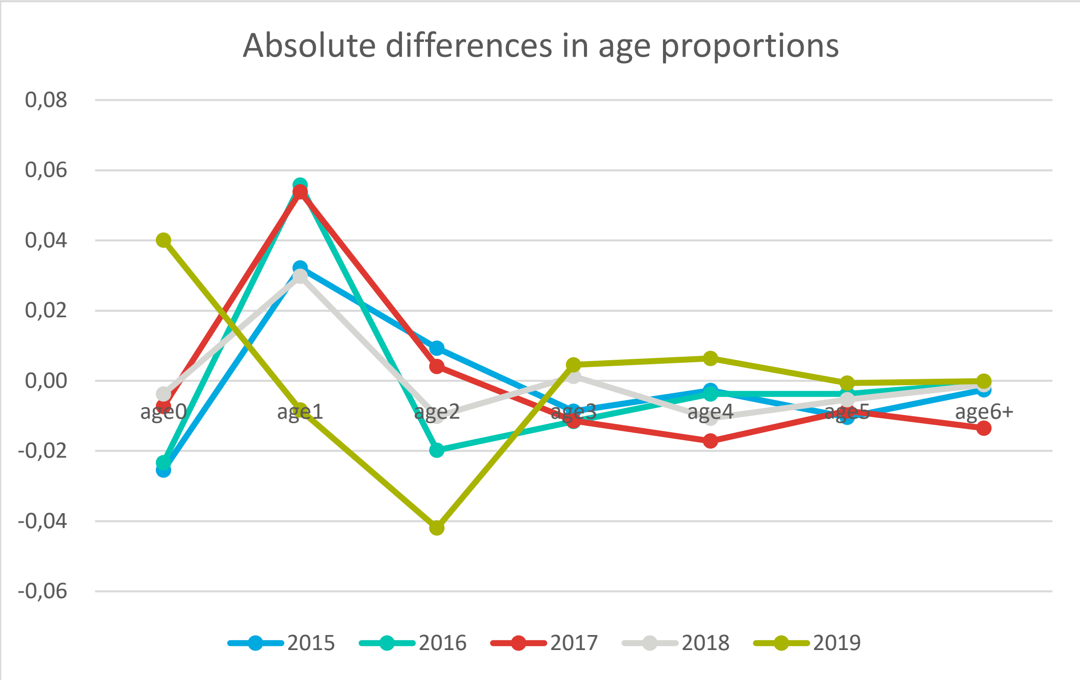


Figure 3.9.6.9. **Absolute differences in age proportions.**

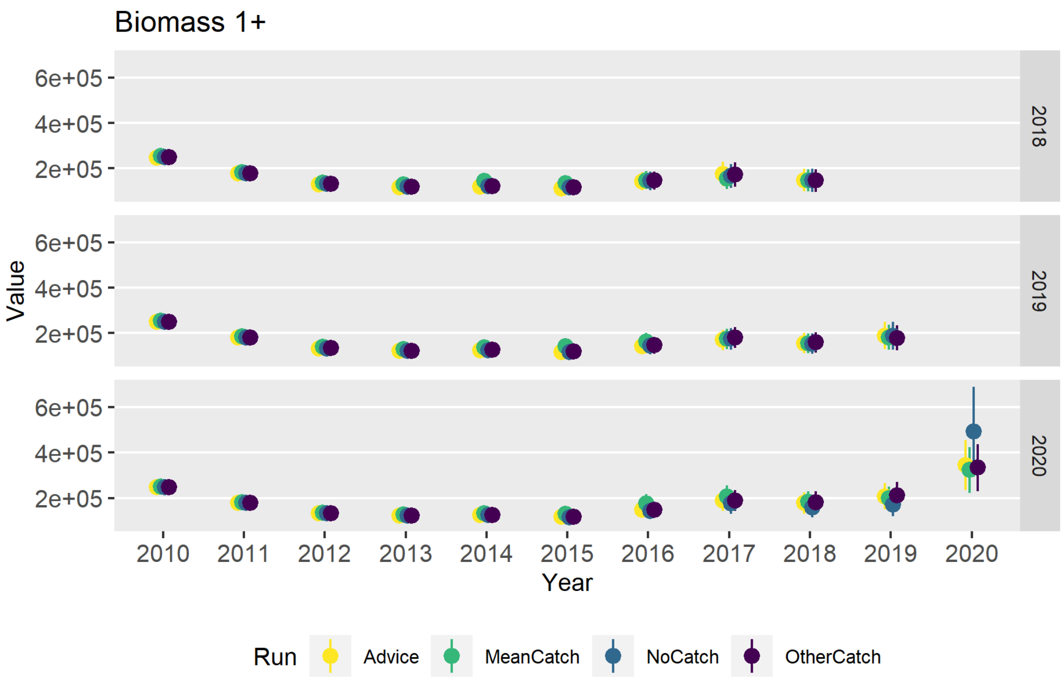


Figure 3.9.6.10. Point estimates and 95% confidence intervals of Biomass of age 1 and older for 4 runs (Advice, Mean-Catch, NoCatch and OtherCatch) for three different assessments (2018, 2019, 2020).

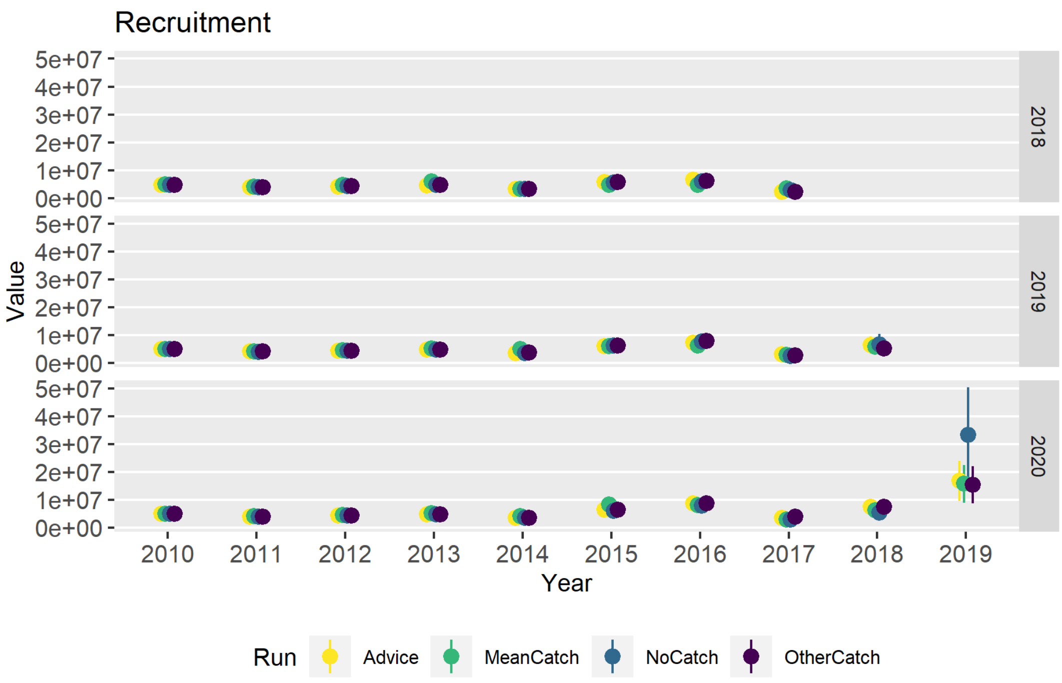


Figure 3.9.6.11. Point estimates and 95% confidence intervals of Recruitment and older for 4 runs (Advice, MeanCatch, NoCatch and OtherCatch) for three different assessments (2018, 2019, 2020).

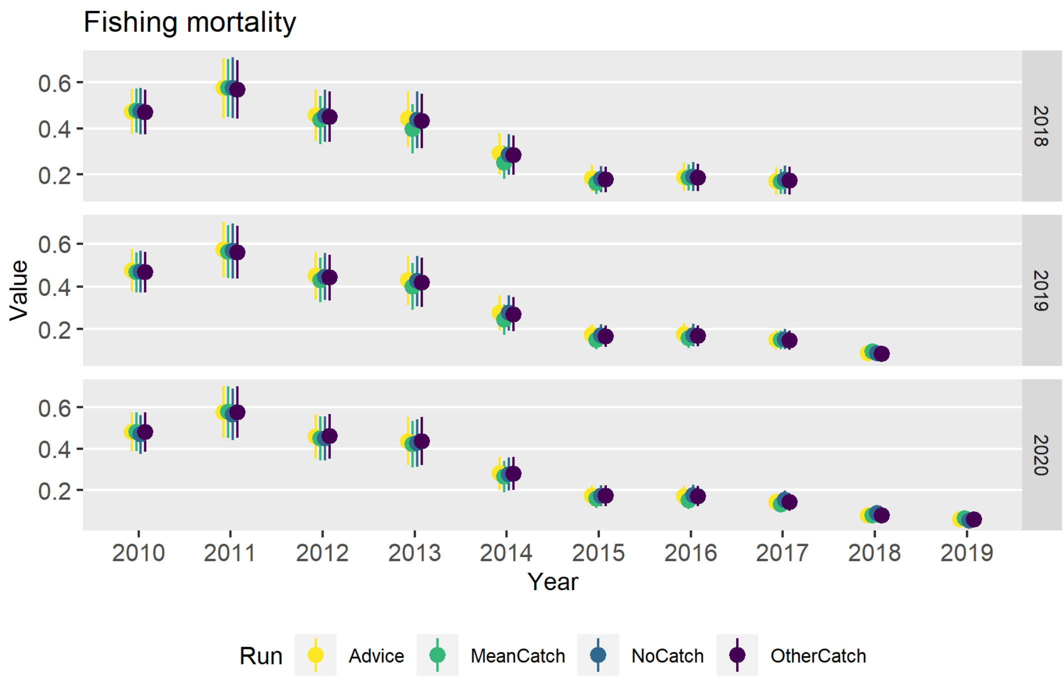


Figure 3.9.6.12. Point estimates and 95% confidence intervals of Fishing mortality and older for 4 runs (Advice, Mean-Catch, NoCatch and OtherCatch) for three different assessments (2018, 2019, 2020).