WORKING GROUP ON ACOUSTIC AND EGG SURVEYS FOR SMALL PELAGIC FISH IN NORTHEAST ATLANTIC (WGACEGG; outputs from 2023 meeting)

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

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

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Editors

Guillermo Boyra • Paz Diaz

Authors

Jose Antonio Canseco • Guillermo Boyra • Pablo Carrera • Paz Díaz • Rosario Domínguez
Mathieu Doray • Erwan Duhamel • Martin Huret • Paz Jiménez • Anxo Lago • Maria Manuel Angélico
Ana Moreno • Ciaran Odonnell • Fernando Ramos • Silvia Rodríguez • María Santos • Beatriz Sobradillo
Jeroen Van Der Kooij

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Contents

i Executive summary

WGACEGG coordinates and provides quality control for acoustic and daily egg production (DEPM) surveys of several pelagic stocks in ICES areas 6-9.

During the 2023 meeting results from four DEPM surveys and nine acoustic surveys were presented and discussed jointly with members of the Working Group on Southern Horse Mackerel, Anchovy, and Sardine (WGHANSA). The provided abundance estimates were considered reliable. However, given the increase in the distance between transects in the JUVENA acoustic survey, its potential impact on the estimates was discussed. Anchovy stocks in areas 7 and 8 showed good conditions and continued evidence of northward migration. Sardine in area 9 was also in good condition due to last year’s recruitment, while horse mackerel and mackerel stocks were in generally poorer condition. Sprat biomass decreased in division 8 and increased in 7. Herring biomass in the western Channel is still under analysis, and boarfish stocks in divisions 6 and 7 are above average and increasing.

The group updated gridded maps and conducted space-time modeling of sardine distribution in the Bay of Biscay, showcasing the potential of common grid data.

The ICES TIMES report for DEPM surveys is under peer review. Preliminary discussion was held on future update of the ICES TIMES report for acoustics, improving the detail of the uncertainty estimates. Workshop sessions were held on both acoustic and DEPM databases.

Acoustic and egg-based biomass indices for anchovy and sardine available in area 8 were compared to evaluate their respective bias and precision. A workplan for investigating discrepancies between indices was proposed.

Methodological developments included a review of uncrewed vehicles for improved sampling, and improvements to surface school monitoring in acoustic surveys, based on lateral echosounders and multibeam sonars. Ongoing enhancements involved analyzing the ping interval's effect on acoustic abundance and a weakly supervised model for automatic classification of acoustic echotraces. A Bayesian approach to estimating egg production and mortality was introduced. Scientific studies covered evidence of anchovy's northward migration and a comparison of sardine genetics in Biscay and the English Channel.

WGACEGG members emphasized the importance of zooplankton monitoring, agreeing to host a Zooplankton Session in 2024 to address sampling and analysis methodologies for surface mesozooplankton communities.

ii Expert group information

Expert group name	Working Group on Acoustic and Egg Surveys for small pelagic fish in NE Atlantic (WGACEGG)
Expert group cycle	Multiannual
Year cycle started	2023
Reporting year in cycle	1/3
Chairs	Guillermo Boyra, Spain
	Paz Díaz, Spain
Meeting venue(s) and dates	13-19 November 2023, Pasaia, Spain (34 participants)

1 Terms of Reference

ToR	Description	Background	Science plan codes	Duration	Expected Deliverables
a	Evaluate and provide echo-integration and/or Daily Egg Production Method (DEPM) estimates for sardine, anchovy horse mackerel, boarfish, herring, and sprat, chub mackerel, blue whiting, in ICES sub-Areas 6, 7, 8 and 9	a) Data provide backbone of relevant stock assessments for key species at relevant WGs (Advisory Requirements) b) Requirements from other EGs	3.1	annually	Abundance and biomass estimates by age and/or length group. Fish spatial distribution will be provided to WGHANSA, WGWIDE, HAWG by the end of the WGACEGG meeting. Datasets will be published in the ICES repository when available.
b	Analyse sardine, anchovy (adults and eggs), and other SPF spatial and temporal distribution and their habitats in European waters	a) Surveys collect additional data on the wider ecosystem; interannual variation in sardine, anchovy biomass and other SPF distribution will be studied in relation to ecological processes. Science Requirements b) Requirements from other EGs	1.5	Year 2	Aim to publish results: Ecological processes driving: 1. seasonal, and 2. Longterm distributions in a peer reviewed paper in 2026; with decision to be made following review of results and progress in 2023.
c	Provide ecosystem data such as temperature, salinity, plankton diversity, top predators abundances, egg densities and backscattering for small pelagic fish for pelagic ecosystem monitoring (e.g. MSFD)	a) Combining the data from concurrent surveys (e.g. spring) provides improved insight into large scale features potentially affecting local survey observations and will ultimately help improve (understanding of both) the stock assessment and ecosystem dynamics. (Science Requirements) b) Requirements from other EGs	1.4, 1.5	annually	Gridded maps updated every year for temperature, salinity, egg densities and backscattering for small pelagic fish . Datasets will be published in the ICES repository when available
d	Assess developments in the technologies and data analyses for the application of both acoustics and the DEPM (on egg production or adult parameters).	a) Ensure best practise is applied. Science Requirements b) Advisory Requirements c) Requirements from other EGs	3.3	3 years	Report relevant new methodologies in annual WG report, available to the public one month after the meeting.
e	Improve and assess the suitability of CUFES data for anchovy and sardine egg production estimates in areas 8 and 9.	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	3.3	3 years	Report relevant new developments in annual WG report, available to the public one month after the meeting.

f	Develop and standardise data processing methods for DEPM and acoustics for surveys in Atlantic and Mediterranean waters	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	3.1, 3.2	3 years	Updated data processing protocols shared with the other relevant survey and data governance groups
G	Provide echo-integration estimates for other species (mainly blue whiting, mackerel, herring, sprat, horse mackerel, chub mackerel, pearlsideand boarfish) ICES sub-Areas 6, 7, 8 and 9	a) Surveys collect additional distribution, abundance and biological data on pelagic fish species, that are not currently used in stock assessment – make available for studies and possible future inclusion in assessment or ecological studies Advisory Requirements b) Requirements from other EGs	3.5	3 years	Biomass per age group when available otherwise per length classes and spatial density distribution. Datasets will be published in the ICES repository when available.
H	Coordinate surveys and develop and review the protocols for the WGACEGG surveys (DEPM: BIOMAN, SAREVA, PT-DEPM-PIL, BOCADEVA; Acoustic: PELAGO, PELACUS, PELGAS, ECOCADIZ, WESPAS, ECOCADIZ RECLUTAS, IBERAS-JUVESAR, JUVENA, PELTIC, CSHAS) in line with ICES QAprocedures	ICES aims to have a quality assurance process for data collections used in the provision of advice. One element of this is that all procedures describing the data collection are adequately described.	3.1	annually	Review acoustic and DEPMsurvey manuals, (TIMES) for the data collection, processing and deliverables and if required, submit new versions for publication.
I	Compare acoustic and DEPM biomass estimates of anchovy and sardine and evaluate their respective bias and precision with a view to providing improved data to stock assessment WGs	a) Currently, DEPM and acoustic derived indices for anchovy and sardine are presented separately to stock assessment working groups. Data from either methods may be used to validate the other method and improve information provided to assessment WGs. Science Requirements b) Advisory Requirements c) Requirements from other EGs	-	3 years	Report relevant developments in annual WG report,
J	Ongoing development on the use of image recognition techniques to characterise the distribution of mesozooplankton and possibly microplastics in areas 6, 7, 8 and 9, based on CUFES and/or plankton nets.	a) Science Requirements b) Requirements from other EGs	1.2	3 years	
	Use of emerging techniques (eg. genomics) to monitor the pelagic environment				Report annually on the progress

K	Collaborate with groups wishing to utilize available timeseries from WGACEGG coordinated surveys.	a) Science Requirements	3.2	Years 1-3	Facilitate collaborative activities with other groups, by contributing expertise and data to large scale studies on small pelagic fish.

Summary of Workplan

Year 1	**Annual meeting, including if convenient, a joint session with other shared interest groups:** • Evaluation of echo-integration and/or Daily Egg Production Method (DEPM) estimates for sardine, anchovy, horse mackerel, boarfish, herring, and sprat in ICES sub-Areas 6, 7, 8 and 9 • Update of gridded maps of ecosystem data derived from surveys, and assessment of feasibility of production of megafauna and mesozooplankton grid maps for ecosystem assessment • Session on historic data series consolidation and storage • Update of the WGACEGG DEPM and acoustic Survey Protocols (TIMES) if required • Session on acoustic data collection and analysis, including a topic on the analysis of acoustic data in presence of mixed mesopelagic and juvenile anchovies assemblages • Session on DEPM data collection and analysis • Session on comparison of acoustic and DEPM indices • Session on results of the analysis on time series of gridded maps of species-and ecosystem data • Session to analyse progress on sardine and anchovy egg production estimates from CUFES
Year 2	**Annual meeting, including if convenient, a joint session with other sahred interest groups:** • Evaluation of echo-integration and/or Daily Egg Production Method (DEPM) estimates for sardine, anchovy, horse mackerel, boarfish, herring, and sprat in ICES sub-Areas 6, 7, 8 and 9 • Update of gridded maps of ecosystem data derived from surveys, historic data series consolidation and storage • Session on historic data series dissemination and valorisation • Update of the WGACEGG DEPM and acoustic Survey Protocols (TIMES) if required • Session on acoustic data collection and analysis • Session on DEPM data collection and analysis • Session on comparison of acoustic and DEPM indices • Session to analyse progress on sardine and anchovy egg production estimates from CUFES • Session on the use of image recognition techniques to characterise the distribution of (surface) mesozooplankton communities

Year 3	**Annual meeting, including if convenient, a joint session with other shared interest groups:** • Evaluation of echo-integration and/or Daily Egg Production Method (DEPM) estimates for sardine, anchovy, horse mackerel, boarfish, herring, and sprat in ICES sub-Areas 6, 7, 8 and 9 • Update of gridded maps of ecosystem data derived from surveys, historic data series consolidation and storage • Update of the WGACEGG DEPM and acoustic Survey Protocols (TIMES) if required • Session on developments in acoustic data analysis • Session on developments in DEPM data analysis • Session on comparison of acoustic and DEPM indices • Session to analyse progress on sardine and anchovy egg production estimates from CUFES • Session on the use of image recognition techniques to characterise the distribution of (surface) mesozooplankton communities

2 Scientific highlights

2.1 Papers

Alvarez, P., Korta, M., Garcia, D. and **Boyra, G.** (2023). Life History Strategy of Maurolicus muelleri (Gmenlin, 1789) in the Bay of Biscay. Hydrobiology, 2, 289-313. https://doi.org/10.3390/hydrobiology2020019

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García-Barón, I., Granado, I., Astarloa, A., **Boyra, G.**, Rubio, A., Fernandes-Salvador, J. A., ... & Louzao, M. (2022). Ecological risk assessment of a pelagic seabird species in artisanal tuna fisheries. *ICES Journal of Marine Science*, fsac136.

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Virgili, A., Teillard, V., Dorémus, G., Dunn, T. E., Laran, S., Lewis, M., Louzao, M., Martínez-Cedeira, J., Pettex, E., Ruiz, L., Saavedra, C., **Santos, M.B.**, Van Canneyt, O., Vázquez, J.A., Ridoux, V. (2022). Deep ocean drivers better explain habitat preferences of sperm whales Physeter macrocephalus than beaked whales in the Bay of Biscay. *Scientific Reports*, *12*(1), 1-13.

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2.3 Presentations

Angélico M.M., Díaz P., Oliveira P. B., Tel E. and **Huret M**. Egg production estimation for Atlantic Iberian sardine using CUFES sampling. Implementation of a biophysical model to assess the egg vertical density distribution. Workshop 6 at Small Pelagic Fish Symposium. Lisbon, Nov. 2022.

Astarloa A., Citores L., Garcia-Barón I., Basterretxea M., Pedrajas A., **Boyra G., Santos M., Sobradillo B.**, Rubio A., Mugerza E, Louzao M. Cambios estacionales en la distribución espacial y captura incidental de delfín común en el golfo de Bizkaia. XIII Congreso de la Sociedad Española de Cetáceos, 27-30 octubre 2022.

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Doray M., Petitgas P., Huret M. and Hattab T. Comparison of the space-time dynamics of clupeiformes fish size-structured habitats in Atlantic (Bay of Biscay) and Mediterranean (Gulf of Lion) French shelf seas. Session 3 at Small Pelagic Fish Symposium. Lisbon, Nov. 2022.

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Doray M., Romagnan J-B., Petitgas P., Huret M. Combination of Continuous Underwater Fish Egg Sampler and acoustic data for estimating and mapping fish daily fecundity. Workshop 6 at Small Pelagic Fish Symposium. Lisbon, Nov. 2022.

Huret H., Doray M., Daurès F., Romagnan J-B., Alban F., **Duhamel** E., Hattab T., **Petitgas P.**, Travers-Trollet M. and Lehuta S. Fish quality impacts sardine fisheries through bottom-up and industry controls. Session 7 at Small Pelagic Fish Symposium. Lisbon, Nov. 2022.

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Uriarte A., **Santos M.** et al *Insights on F/W from "DEPM BIOMAN survey series in the Bay of Biscay: lessons learned after 35 years of tracking the anchovy population in its ecosystem".* Small Pelagic Fish Symposium. Lisbon, Nov. 2022.

van der Kooij J., **Campanella F.**, McKeown N., **Boyra G.**, **Doray M.**, **Santos M.**, **Huret M.** Northward range expansion of Bay of Biscay anchovy due to increased temperature
envelope and population increase. Session 3 at Small Pelagic Fish Symposium. Lisbon, Nov. 2022.

2.4 Posters

Angélico M.M., **Moreno A.**, **Nunes C.**, **Amorim P.**, Nogueira M., Nunes P., Brotas V., Tracana A. and Oliveira P.B. Adding value to regular fisheries surveys for pelagic ecosystem monitoring. Water quality assessment for MSFD requirements. Session 5 at Small Pelagic Fish Symposium. Lisbon, Nov. 2022.

Boyra, G., Martínez, U., Uranga, J., Moreno, G., and Peña, H. Correction of athwart distortion induced by beam overlap in multibeam sonars (2022). ICES Fisheries and Plankton Acoustic Symposium. Portland, Maine, USA. 27-30 March, 2023.

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Landa J., **Domínguez-Petit R.**, Navarro M.R., **Nunes C**., Silva A.V., Tornero J., **Ramos F.**, Hernández C., Jurado-Ruzafa A.. Growth variability and demographic structure of Northeast Atlantic chub mackerel (*Scomber colias*) in Southern European Atlantic waters. VIII International Symposium on Marine Sciences. Las Palmas de Gran Canarias (Spain). Jul. 2022.

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3 List of Outcomes and Achievements of the WG in this delivery period

Table 3.1 Biomass and abundance indices derived from acoustic and DEPM surveys used as input for analytical assessment purposes. Note: in parentheses other indices and biological data used as supplementary information for assessment

Survey	Sardine	Anchovy	Horse-mackerel	Mackerel	Sprat	Herring	Boarfish	Blue whiting	Assessment
PT-DEPM23-PIL	9a S, W: SSBiomass (weight and length at age, maturity ogive)								WGHANSA
SAREVA 0423	9a N, 8c: SSBiomass (weight and length at age, maturity ogive)	9a N, 8c: Egg abundance	9a N, 8c: Egg abundance	9a N, 8c: Egg abundance					WGHANSA
PELAGO23	9a S, W:Tot Biomass, Numbers at age (weight and length at age)	9a S, W:Tot Biomass, Nbsatage (weight and length at age)							WGHANSA
PELACUS0423	9a N, 8c: Tot Biomass, Numbers at age, (weight and length at age, maturity ogive)	9a N, 8c: Tot Biomass, Numbers at age, (weight and length at age, maturity ogive)	9a N, 8c: distribu-tion, Numbers at age	9a N, 8c: distribution, Num-bers at age			9a N, 8c: distribution, Numbers at age	9a N, 8c: distribution, Numbers at age	WGHANSA WGWIDE
PELGAS23	8abd: Tot Biomass, Numbers at age, (weight and length at age)	Tot Biomass, Biomass at age 1 (Numbers, biomass, weight and length at age),							WGHANSA
BIOMAN23	8abcd: Egg abundance	8abcd: Tot Biomass, Biomass at age 1							WGHANSA

	8abd SSB (Numbers at age, biomass at age, W and L at age	(Numbers, biomass, weight and length at age)						
JUVENA23		8abcd: juvenal abundance index						WGHANSA
IBERAS0923	(9a W: juvenile abundance index)	(9a W: juvenile abundance index)						WGHANSA
BOCADEVA0723		(9a S: Spawning Stock Biomass)						WGHANSA
ECOCADIZ 2023-07	(9a S: Tot Biomass, Numbers and Biomass at age; weight and length at age)	9a S: Total Biomass, Numbers and Biomass at age; weight and length at age						WGHANSA
ECOCADIZ-RECLUTAS 2023-10	(9a S: Tot Biomass, Numbers and Biomass at age; weight and length at age)	(9a S: Total Biomass, Numbers and Biomass at age; weight and length at age)						WGHANSA
WESPAS23			7b-c, 7g, h, j and 6a: distribution, (biomass, abundance at age)			7aS, 7g-j: distribution, (biomass, abundance at age)	7b-c, 7g, h, j and 6a, distribution, biomass, abundance (at age)	WGWIDE HAWG
CSHSAS23						7aS, 7g-j Celtic Sea: Tot biomass, abundance at age		HAWG
PELTIC23	7e f: Tot Biomass, (weight and length at age)				7de: Tot biomass Numbers at age			WGHANSA, HAWG

Table 3.2 Other survey-derived products available

Survey	Sardine eggs	Anchovy eggs	Temperature	Salinity	Birds and mammals	Zooplankton
PT-DEPM23-PIL	Abundance by stage from CUFES	Abundance by stage from CUFES	Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	Biomass: Biovolumes
SAREVA0423	Abundance by stage from CUFES	Abundance by stage from CUFES	Surf TSG, CTD *profiles*	Surf TSG, CTD *profiles*		
PELAGO23	Abundance by stage from CUFES	Abundance by stage from CUFES	Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	Biomass: Biovolumes
PELACUS0423	Abundance by stage from CUFES	Abundance by stage from CUFES	Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	
PELGAS23	Abundance by stage from CUFES	Abundance by stage from CUFES	Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	Community abundances
BIOMAN23	Abundance by stage from CUFES	Abundance by stage from CUFES	Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	Community abundances
JUVENA23			Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	Community abundances
IBERAS0923			Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	Biomass: Biovolumes
BOCADEVA0723	Abundance from CUFES (not this year. PairoVET-based estimates instead)	Abundance by stage from CUFES (not this year. PairoVET-based estimates instead)	Surf TSG, CTD profiles (CTD not used this year. Multi-parameter sonde instead)	Surf TSG, CTD profiles (CTD not used this year. Multi-parameter sonde instead)		
ECOCADIZ 2023-07	Abundance from CUFES (not this year. PairoVET-based estimates from BOCADEVA0723 survey	Abundance by stage from CUFES (not this year. PairoVET-based estimates from BOCADEVA0723 survey	Surf TSG, CTD profiles	Surf TSG, CTD profiles	Not this year	

	instead)	instead)				
ECOCADIZ-RECLUTAS1023			Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	
WESPAS23			Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	Biomass: dry weight
CSHSAS23			Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	
PELTIC23	Abundance by stage from nets		Surf TSG, CTD profiles	Surf TSG, CTD profiles	abundance	Zooscan: abundance and size at higher taxonomic level

4 Progress report on ToRs and workplan

4.1 Indices for Stock Assessments of target species in ICES Divisions 6, 7, 8, 9 derived from Acoustic and DEPM Surveys

In total 14 surveys currently fall within the auspice of WGACEGG: ten acoustic (conducted in spring, summer, and autumn) and four DEPM surveys (Table 4.1).

Table 4.1 Overview of 2023 surveys under the auspice of WGACEGG

SURVEY	DATE	SURVEY TYPE	INSTITUTE/ COUNTRY	GEOGRAPHICAL AREA	TARGET SPECIES FOR ASSESMENT	OTHER SPECIES ESTIMATIONS
PT-DEPM23-PIL	10th-24th February	DEPM	IPMA, Portugal	27.9a, south and west	PIL	HOM eggs
SAREVA 0423	10th – 30th April	DEPM	IEO, Spain	27.9a north, 8c	PIL	ANE eggs, HOM eggs, MAC eggs, MAV eggs
PELAGO23	15th March-4th April	Acoustic	IPMA, Portugal	27.9a, south and west	PIL, ANE	VMA, HOM, MAC, JAA, BOG, HMM, etc
PELACUS0423	8th-30th April	Acoustic	IEO, Spain	27.9a north, 8c	PIL, ANE, WHB	VMA, HOM, MAC, JAA, BOG, HMM, SPR, etc
PELGAS23	29th April -30th May	Acoustic	IFREMER, France	27.8abd	27.8abd	VMA, HOM, MAC, JAA, BOG, HMM, SPR, etc
BIOMAN23	3rd -26th May	DEPM	AZTI, Spain	27.8abd	ANE, PIL	MAV eggs
WESPAS23	17th June -22th July	Acoustic	MI, Ireland	27.6 a, 7b,c	HER, BOC, HOM	
BOCADEVA0723	24th-28th July	DEPM	IEO, Spain	27.9a, south	ANE	
ECOCADIZ 2023-07	29th July-8th August	Acoustic	IEO, Spain	27.9a, south	ANE, PIL	VMA, HOM, MAC, JAA, BOG, HMM, SPR, etc
JUVENA23	15th August-28th September	Acoustic	AZTI/IEO Spain	27.8abcd	ANE, PIL	VMA, HOM, MAC, JAA, BOG, HMM, SPR, etc
IBERAS0923	12th-25th September	Acoustic	IEO/IPMA, Spain, Portugal	27.9. west	PIL, ANE	VMA, MAC, HOM
ECOCADIZ-RECLUTAS 2023-10	29th September-13th October	Acoustic	IEO, Spain	27.9a, south	ANE, PIL	VMA, HOM, MAC, JAA, BOG, HMM, SPR, etc

PELTIC23	28th September-31th October	Acoustic	CEFAS, United Kingdom	27.7 e, f, g	SPR, PIL	ANE, HOM, BOC, HER (no MAC this year)
CSHSAS23	9th – 29th October	Acoustic	MI, Ireland	27.7 j, g, a south	HER, SPR	PIL, ANE, HOM

Coverage of the 2023 spring acoustic surveys was restricted to the west coast of the Iberian Peninsula in the south and the shelf edge of the Celtic Sea and Irish and Scottish waters in the north (Figure 4.1)

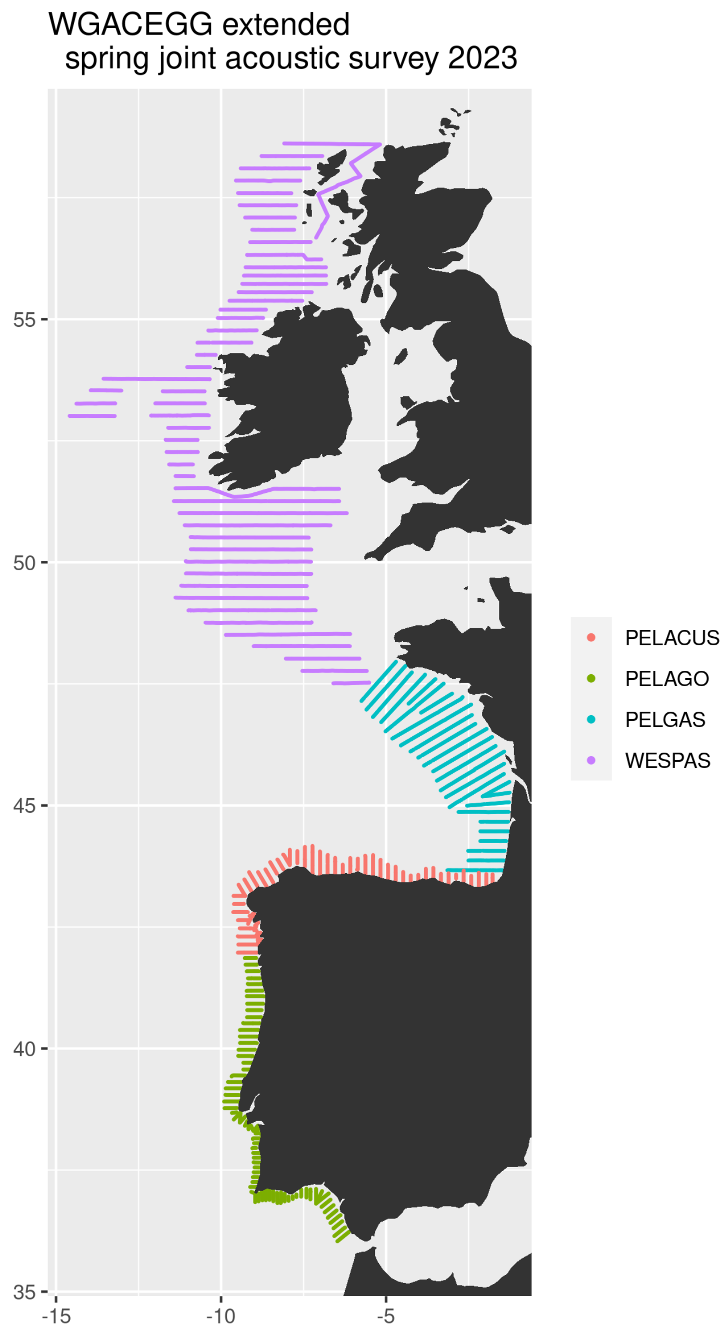


Figure 4.1 Sampling scheme of the spring acoustic surveys in ICES areas 6, 7, 8 and 9. PELAGO, PELACUS, PELGAS and WESPAS

The only dedicated summer survey, ECOCADIZ provides indices for both sardine and anchovy in ICES 9aS (Figure 4.2).

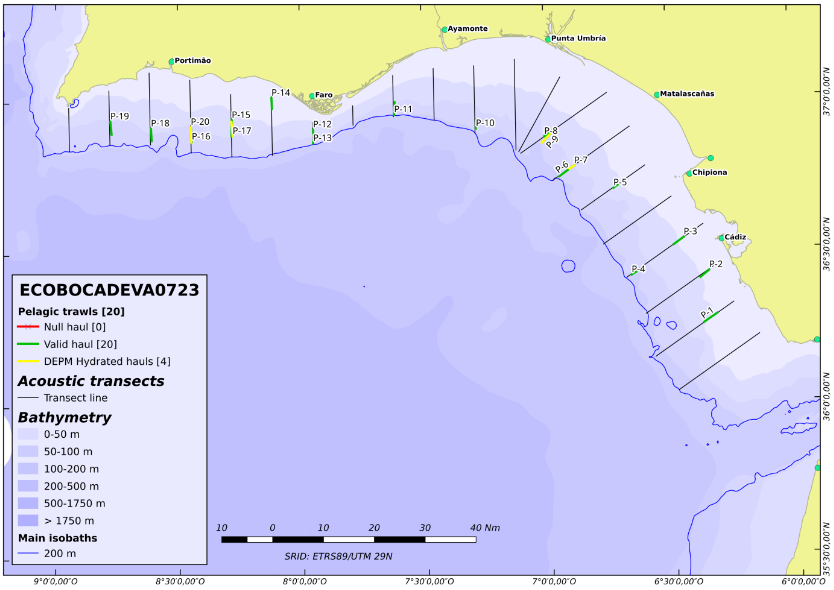


Figure 4.2 Sampling scheme of summer acoustic survey ECOCADIZ in 2023

All five autumn acoustics surveys were successfully completed in 2023, providing near-synoptic coverage of the shelf seas, from Gibraltar in the south to the south coast of Ireland in the north (Figure 4.3). In the south, ECOCADIZ-RECLUTAS provided the third acoustic survey coverage of ICES Subarea 9aS in the year. The IBERAS survey continued coverage northwards along the Portuguese coast to the northwest corner of the Iberian Peninsula. The JUVENA survey surveyed the Cantabrian coast, continuing northwards in the Bay of Biscay until 48° North. The PELTIC and CSHAS surveys completed the coverage, surveying the UK and Irish waters respectively of the English Channel and Celtic Sea. This year PELTIC extended its coverage further north into the southern Irish Sea.

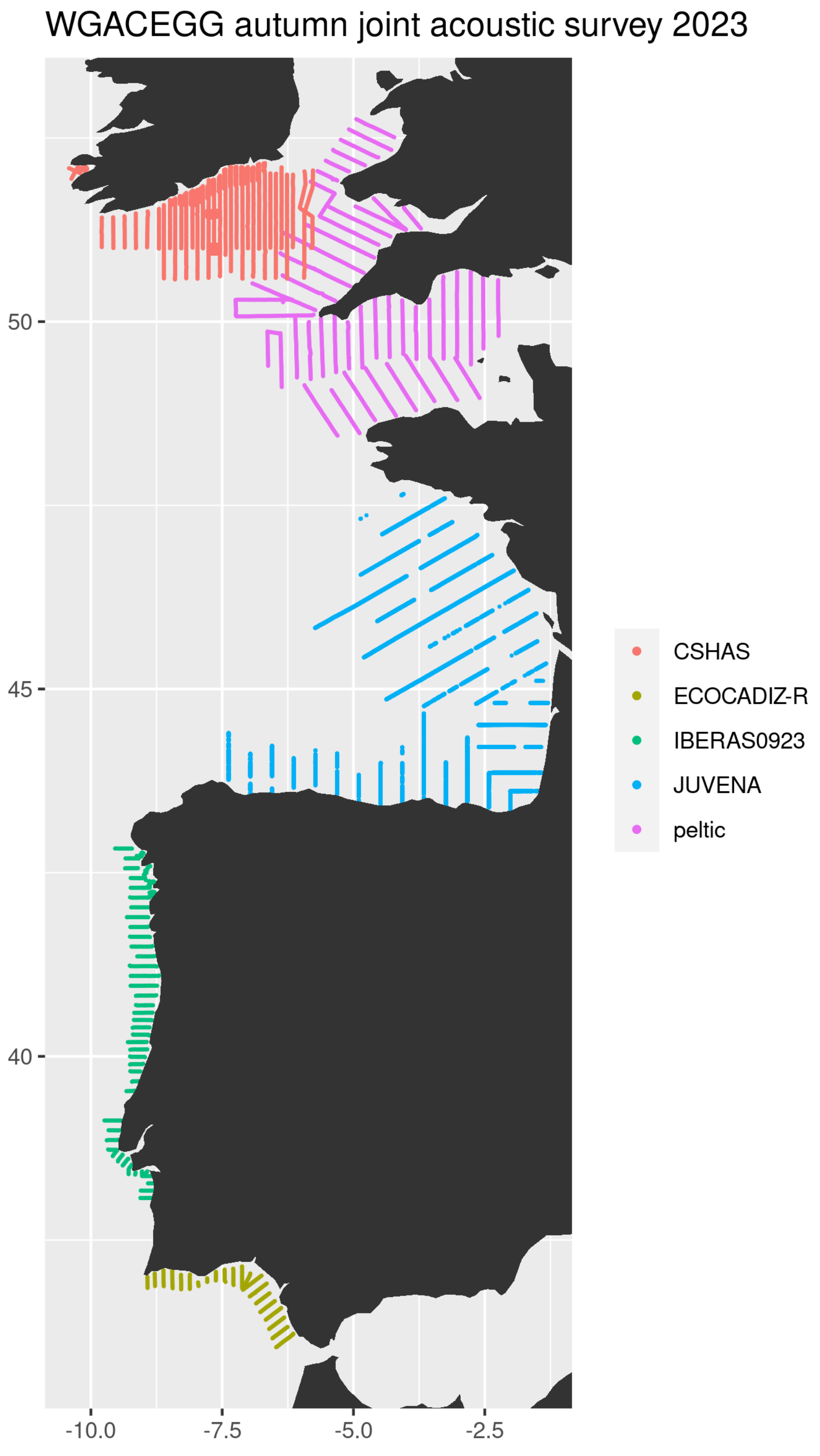


Figure 4.3 Sampling scheme of autumn acoustic surveys, covering ICES areas 7, 8 and 9. JUVENA, IBERAS, ECOCÁ-DIZ-R, PELTIC and CSHAS.

Daily Egg Production Method (DEPM) surveys within WGACEGG (Figure 4.4) focus exclusively on anchovy and sardine and are timed to coincide with the different spawning periods of both species around the Iberian Peninsula and in the Bay of Biscay. The late winter PT_DEPM_PIL survey provided coverage of 9aW and 9aS and the winter/spring SAREVA survey delivered 9a North and 8c. The BIOMAN survey provided data on both sardine and anchovy in the Bay of Biscay. The dedicated anchovy spawning survey, BOCADEVA, took place in summer, covering 9aS.

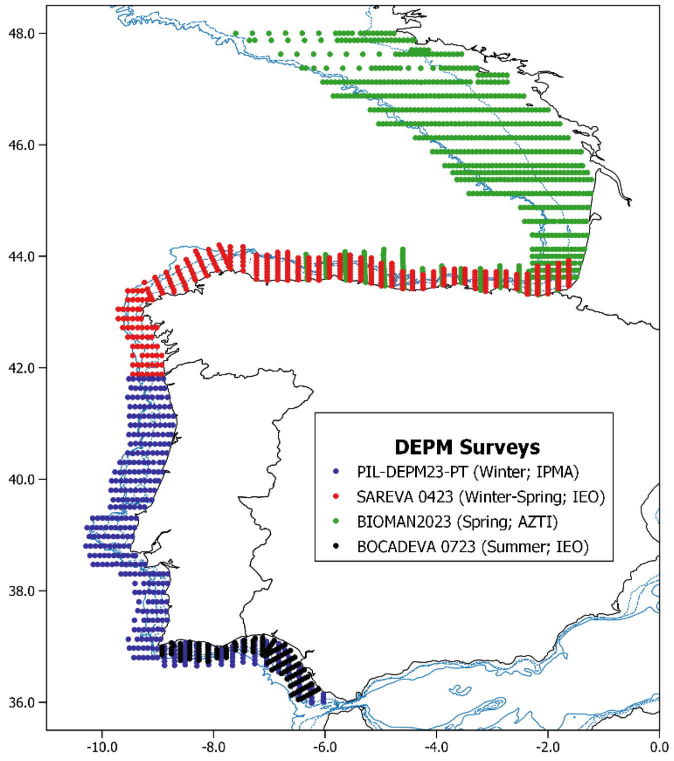


Figure 4.4 Sampling scheme of DEPM surveys. PIL-DEPM-PT, SAREVA, BIOMAN and BOCADEVA

4.1.1 Anchovy in Division 9a (South and West)

4.1.1.1 Spring acoustic survey (PELAGO): 9a South and West

Anchovy mean weight and length-at-age

Mean weights and length-at-age of anchovy were calculated from the biomass and abundance at age estimated for the PELAGO series in the division 9a, to evaluate annual trends at age and regional variations in trends. (Figure 4.5 and Figure 4.6) show the evolution of mean weight-at-age and mean length-at-age, respectively, for anchovy in the subdivisions 9aCN (northwest Portugal) and 9aSC (Cadiz). In subdivisions 9aCS and 9aSA no trends in mean weight and length-at-age are analysed as anchovy occurrence is occasional and restricted only to years of high abundance. We observe a general decreasing trend in mean weight and length of anchovy of ages 2 and 3 on the north western Portugal (9aCN) and of ages 1 and 2 in Cadiz (9aSC). In subdivision 9aCN, the long term trend of age 1 anchovy is upwards, in particular due to the persistent increase since 2018. Annual mean weight and length-at-age of the western component of the stock are significantly higher compared to the southern component. In 2023 due to inconsistencies in age readings no mean weight-at-age and mean length-at-age data is available.

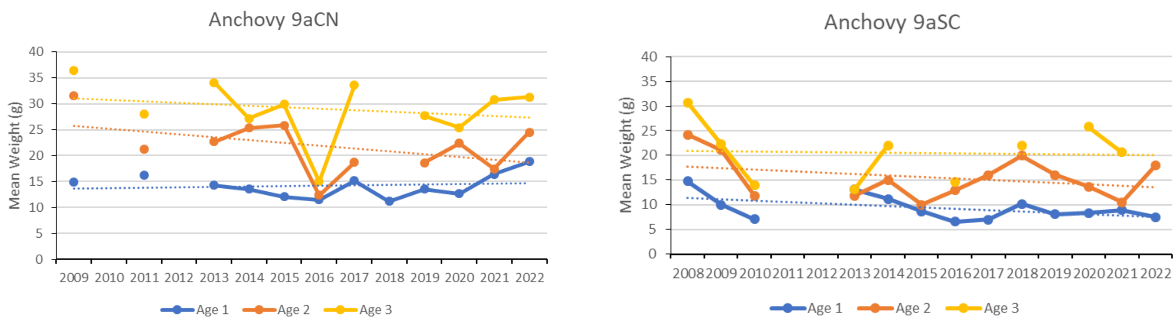


Figure 4.5 Evolution of mean weight-at-age of anchovy along PELAGO series – subdivisions in 9aCN and 9aSC

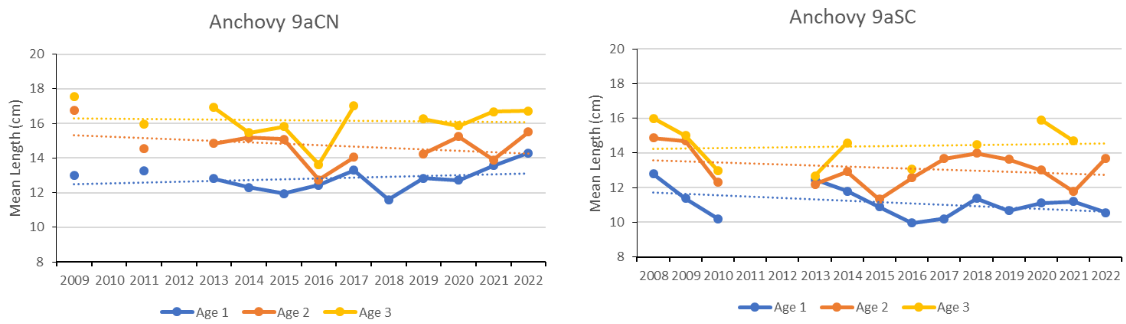


Figure 4.6 Evolution of mean length-at-age of anchovy along PELAGO series – subdivisions 9aCN and 9aSC

Anchovy biomass and abundance estimates in Division 9a

Anchovy abundance and biomass trends in PELAGO surveys is depicted in Figure 4.7 showing an important increase of both abundance and biomass in 2016. In 2023 abundance increased by 17%, but biomass decreased 20% reflecting the length structure composed mainly of small anchovies (mode = 11cm). Abundance and biomass trends for the western and southern components of the stock show important differences (Figure 4.8) in trends since 2005. In 2023 there was a decreased of 37% in both abundance and biomass of the western component, to 70 thousand tonnes. The southern component of the stock showed an important increase in 2023 to 27 thousand tonnes (increase of 150% in biomass and 131% in abundance). This component accounted for 89% of the whole area small anchovies (length < 12cm).

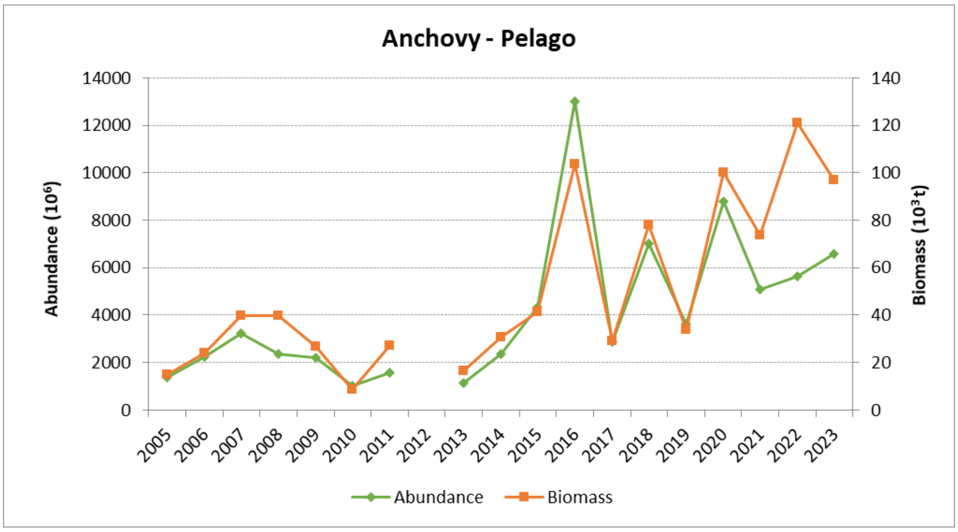


Figure 4.7 Anchovy biomass and abundance trends in during PELAGO surveys in division 9a

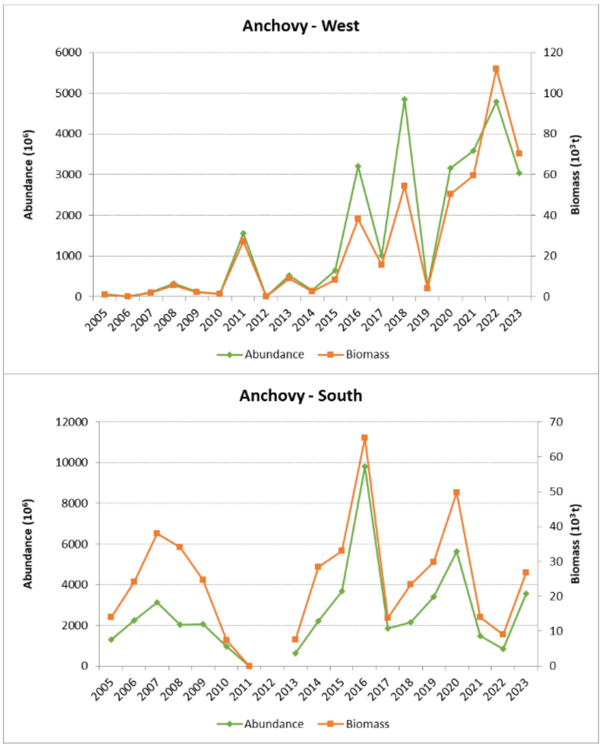


Figure 4.8 Anchovy biomass and abundance trends in PELAGO surveys in division 9a of the western and southern components of the stock.

4.1.1.2 Spring acoustic survey (PELACUS): 9a North

Anchovy mean weight and length-at-age

Mean weights and length-at-age of anchovy were calculated from the biomass and abundance at age estimated for the PELACUS survey series in the northern part of subdivision 9a. Figure 4.9 show the evolution of mean weight-at-age and mean length-at-age for anchovy in the area 9aN. Regarding the mean weight, oscillations were observed in all ages, with age 1 showing a decrease trend from 2019-2021 and then a slight recuperation since 2022. Age 2 behaved similarly in the anchovy mean weight, whereas age 3, showed an increase in 2018, then a plateau and since 2022 is showing a decreasing trend (Figure 4.9). Mean length was quite stable for all the time series and ages, only age 1 being the one oscillating a little bit more in the beginning of the time series.

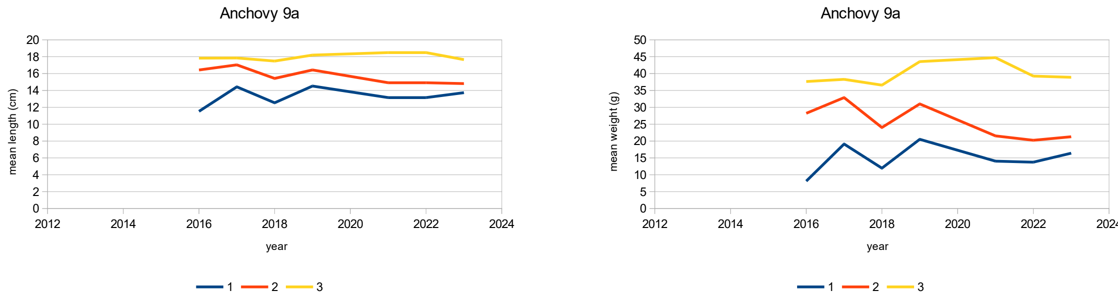


Figure 4.9 Evolution of mean weight-at-age (left) and length-at-age (right) of anchovy along PELACUS series in area 9a.

Anchovy biomass and abundance estimates in Division 9a

Anchovy biomass and abundance age 1 and total trends in PELACUS survey are depicted for subdivision 9a (Figure 4.10) and for the whole surveyed area (Figure 4.11). Last year (2022) there was very little amount of anchovy in division 9a (1.6 tonnes and 98 thousand individuals), and this year the stock recovered a bit in the area, reaching 3222 tonnes (167926 thousand individuals). The highest biomass was observed in 2021 ($62*10^9$ t and $4.7*10^9$ fish), mainly composed of age 1 anchovies (Figure 4.10). Since then a decreasing trend has been observed for anchovy in the whole surveyed area. 2020 appears blank as due to the Covid-19 pandemic it was not possible to run the survey.

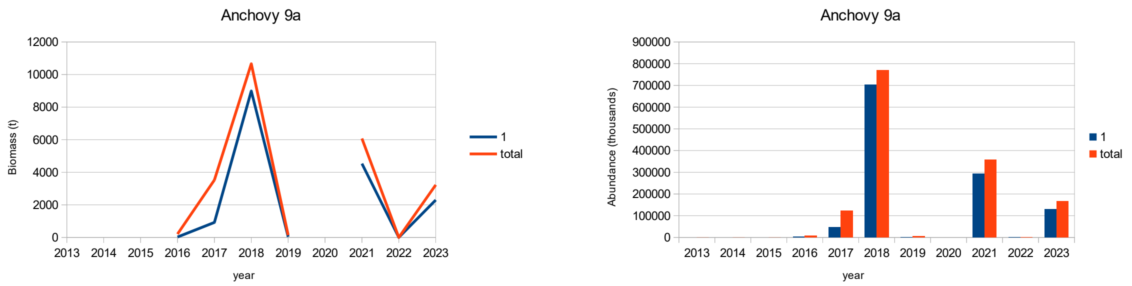


Figure 4.10 Anchovy biomass and abundance trends (age 1 and total) in PELACUS surveys series in 9a

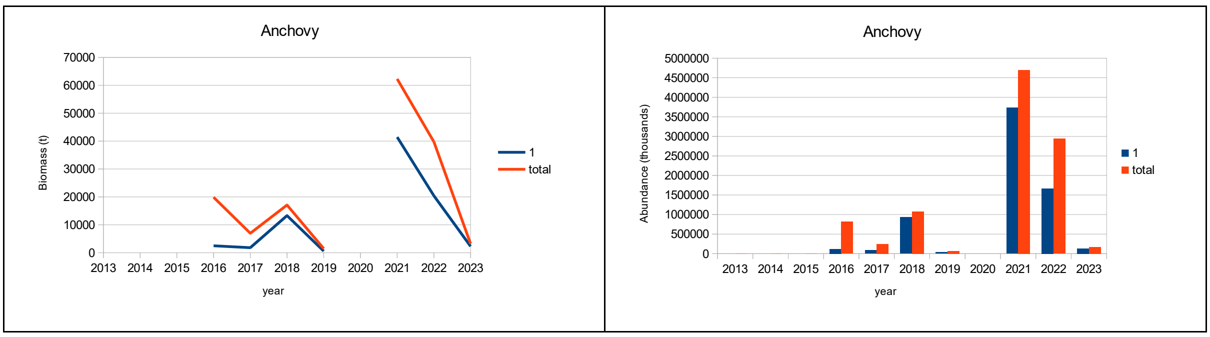


Figure 4.11 Anchovy biomass and abundance trends (age 1 and total) in PELACUS surveys (all surveyed areas)

4.1.1.3 Summer DEPM survey (BOCADEVA): 9a South

Gulf of Cadiz (GoC) anchovy daily egg production method (DEPM) surveys (*BOCADEVA* survey series), aimed to estimate the GoC anchovy spawning stock biomass (SSB) in the ICES Subdivision 9a south, are triennially conducted by Spain (Instituto Español de Oceanografía, IEO-CSIC) since 2005. Between 2014 and 2020, the egg sampling was carried out between late July-early August on board R/V *Ramón Margalef* (IEO-CSIC), whereas samples to estimate the DEPM adult parameters (sex ratio, female mean weight, batch fecundity and spawning fraction) were obtained in the corresponding annual acoustic-trawl *ECOCADIZ* surveys, carried out during the same period on board R/V *Miguel Oliver* (Spanish Fisheries General Secretariat). *ECOCADIZ* surveys were not conducted in 2021 and 2022, and it was not initially planned to be conducted in 2023. However, given the necessity of collecting DEPM adult samples for the 2023 DEPM survey, an *ad hoc* combined anchovy egg (*BOCADEVA* leg) and acoustic-trawl (*ECOCADIZ* leg) survey (*ECO/BOCADEVA_0723* survey) was planned by IEO to be conducted on board R/V *Ramón Margalef*, with the *BOCADEVA* leg (*BOCADEVA 0723*) being conducted first (24th – 28th July), and then the *ECOCADIZ* one (*ECOCADIZ 2023-07*; 29th July – 8th August).

Thus, *BOCADEVA 0723*, the seventh survey in the series, covered a surveyed area (13 261 km^2), which extended from the Strait of Gibraltar to Cape San Vicente (GoC Spanish and Portuguese waters). An adaptive sampling was carried out in the East - West direction using a PairoVET net in fixed stations as main sampler. Unfortunately, CUFES (*Continuous Underwater Fish Egg Sampler*) sampling was not possible during the survey due to logistical problems that prevented the CUFES from being shipped on board on time. A detailed description of the methods applied in this survey is given in Jiménez *et al*. (WD 2023).

A total of 139 PairoVET plankton samples were collected each 3 nm along a grid of 21 transects, perpendicular to the coast and 8 nm interspaced, for the spawning area delimitation and density estimation of the daily egg production. The survey objectives also included the characterization of the oceanographic and meteorological conditions in the study area. Hydrographical variables were collected with a multi-parameter sonde coupled to the PairoVET net. As quoted above, samples to estimate DEPM adult parameters were obtained in the *ECOCADIZ 2023-07* acoustic-trawl survey (see section 4.1.1.2 and Ramos *et al*., WD 2023a in this report). Table 4.2 summarizes a description of the methodology used to obtain egg and adult samples.

Table 4.2 *BOCADEVA 0723* & *ECOCADIZ 2023-07*. Sampling methods information

Eggs	*ECO/BOCADEVA 0723*: *BOCADEVA 0723* Anchovy DEPM survey
Survey area	36º13’-36º50’N –6º07’-–8º55’W
R/V	R/V *Ramón Margalef*
Date	24th to 28th July 2023
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 µm)	139
Sampling maximum depth (m)	100
Hydrographic sensor	EXO2 Multiparameter Sonde
Flowmeter	Yes
CUFES stations	No

Environmental data	Temperature, Salinity, Chl_a, Turbidity, Dissolved Oxygen, pH
Adults	*ECO/BOCADEVA 0723*: *ECOCADIZ 2023-07* acoustic-trawl survey
Survey area	36º11'-36º47'N –6º12'-–8º54'W
R/V	R/V *Ramón Margalef*
Date	29th July to 8th August 2023
Gears	Pelagic trawl *Gloria HOD-352* (*Bucareu-1*)
Number of hauls	20
Biological sampling:	On fresh material, on board the R/V
Sample size	At least 60 individuals randomly picked; up to 120 (adding batches of 10 randomly picked anchovies) if a minimum of 30 mature females were not found for spawning fraction estimation. A minimum of 150 hydrated females for batch fecundity estimation.
Fixation	4% Phosphate-buffered Formaldehyde
Preservation	4% Phosphate-buffered Formaldehyde

Egg sampling

The icthyoplankton sampling almost covered the whole 24 hours' day-time period. Temperature ranged between 14.90 and 23.48 °C (mean 19.05 °C), somewhat colder than in 2020. A total of 1736 anchovy eggs were caught in 65 positive stations (46.8%), showing a patched distribution along the area. Thus, in two stations were found more than 4000 eggs/m² (maximum density of 4260 eggs/m² close to the Guadalquivir river mouth, and 4023 eggs/m² in front of Portimão, in Portuguese waters); two stations with 1700-2500 eggs/m², and the rest of stations with less than 1000 eggs/m² (ranging between 0.8 and 943 egg/m²). The 54.6% and 45.4% of the eggs were caught to the East and West of Cape Sta. Maria, respectively. The station where the maximum egg abundance was recorded was located west Cape Sta. Maria at 50 m depth and temperature and salinity of 21.15 °C and 36.41 PSU, respectively. The highest estimates of maximum egg density by station and total egg density sampled by PairoVET were recorded during the 2020 survey. The total egg density in 2023 was 33% lower than in 2020 (Figure 4.12).

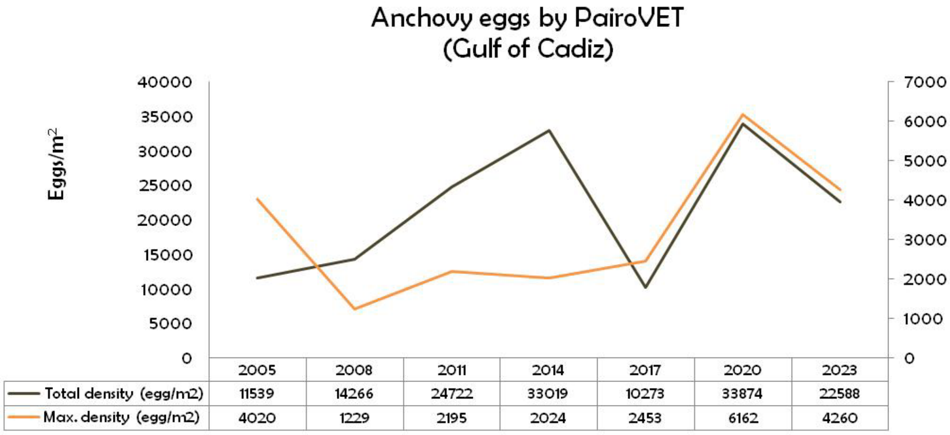


Figure 4.12 BOCADEVA 0723. Total Anchovy egg density and maximum number by PairoVet station

Adult sampling

The samples to estimate adult parameters (sex ratio, female mean weight, batch fecundity and spawning fraction) were obtained during the *ECOCADIZ 2023-07* acoustic-trawl survey (see section 4.1.1.2 and Ramos *et al*., WD 2023a in this report).

A total 16 fishing hauls which caught anchovies were performed, complemented by 4 hauls conducted by night aimed at the collection of anchovy females with hydrated egg. On the whole, 674 anchovies were sampled, 416 ovaries were collected and a total of 180 hydrated females were caught for batch fecundity estimation.

Egg and adult parameters and preliminary SSB estimation

The temperature at 5 m depth has been used for the estimates. Daily egg production (P0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of z converged. [depm.control (spawn.mu=22; how.complete=0.95; spawn.sig=2), initial z = 0.01].

The total weight of hydrated females was corrected for the increase of weight due to the hydration process by a linear regression model between individual data of gonad-free-weight (Wnov) and its corresponding total weight (Wt) from non-hydrated females. The expected female weight (Wexp) for all mature females was also estimated using this linear regression model. The expected batch fecundity for all mature females (Fexp) was estimated by modelling the observed individual batch fecundity (Fobs) in hydrated females in function of their gonad-free- weights (Wnov) by a GLM model. Since the histological process of the gonad samples is not complete yet, the mean value of Spawning fraction (S) of the historical series has been temporarily used to estimate the SSB for 2023. On the other hand, 30 gonads for batch fecundity (F) estimation has been used (the value can be considered as preliminary).

The total spawning area (A+) was: 5662 km^2 (43% of the total area).

The resulting estimates and their associated CVs for the egg and adult parameters, and the preliminary SSB estimate are summarized in Table 4.3. A total Spawning Stock Biomass of 15 138 tons (CV 0.62) has been estimated, well below the historical series and experiencing a strong decrease in relation to the 2020 estimate (Table 4.4). The 2023 DEPM estimate was at the same order of magnitude than its acoustic counterpart (9714 t in *ECOCADIZ 2023-07*), but somewhat lower than the 2023 spring estimate provided by *PELAGO* survey (26 785 t; Figure 4.13).

Table 4.3 Anchovy SSB in the Gulf of Cadiz by the DEPM in 2023. Summary of the results for egg and adult parameters and the preliminary SSB estimates (CVs in brackets). (*): mean value of the historical series.

Parameters	Gulf of Cádiz 2023
Eggs	
Po (eggs/m^2/day)	181.9 (0.54)
Z (day^{-1})	-0.1228 (0.45)
Ptot (eggs/day) (x10^{12})	1.03 X10^{12} (0.54)
Spawning area (Km^2)	5662
Adults	
Female Weight (g)	17.64 (0.25)
Batch Fecundity	9515 (0.14)
Sex Ratio	0.52 (0.02)
Spawning Fraction*	0.248*
SSB	
Spawning Stock Biomass 1 (tons) (CV)	15138 (0.62)

Table 4.4 Anchovy SSB in the Gulf of Cadiz by the DEPM. Historical series. (*): mean value of the historical series.

Year	2005	2008	2011	2014	2017	2020	2023
Eggs							
P_0 (eggs/m^2/day) (CV)	50.8(0.80) / 224.5(0.69)	184(0.44) / 348(0.35)	276 (0.32)	313.5 (0.34)	145.8 (0.55)	523.4 (0.38)	181.9 (0.54)
Z (day^{-1}) (CV)	-0.039(0.75)	-1.43(0.29)	-0.29 (1.14)	-0.33 (1.19)	-0.16	-1.11 (0.44)	-0.1228 (0.45)
P_{total} (eggs/day) (x10^{12}) (CV)	0.07(0.76) / 1.06(0.65)	0.31(0.44) / 1.80(0.35)	1.87 (0.36)	1.95 (0.34)	0.74 (0.55)	5.26 (0.38)	1.03 (0.54)
Surveyed area (km^2)	11982	13029	13107	14595	15556	16223	13261
Positive area (km^2)	6139	6863	6770	6214	5080	10058	5662
Adults							
Female Weight (g) (CV)	25.2(0.03) / 16.7(0.04)	23.67 (0.06)	15.2 (0.11)	18.22 (0.08)	16.14 (0.17)	16.63 (0.13)	17.64 (0.25)
Batch Fecundity (CV)	13820(0.05) / 11160(0.05)	13.778 (0.07)	7486 (0.12)	7502 (0.08)	7507 (0.17)	8212 (0.14)	9515 (0.144)
Sex Ratio (CV)	0.53(0.01) / 0.54(0.01)	0.528 (0.005)	0.531 (0.007)	0.54 (0.008)	0.53 (0.009)	0.54 (0.009)	0.519 (0.02)
Spawning Fraction (CV)	0.26(0.07) / 0.21(0.07)	0.218 (0.065)	0.276 (0.036)	0.276(1)	0.234 (0.06)	0.241(2)	0.248(2)
SSB							
Spawning Biomass –tons (CV)	14673	31527(0.32)	32757 (0.40)	31569 (0.30)	12392 (0.61)	81466 (0.43)	15138 (0.62)

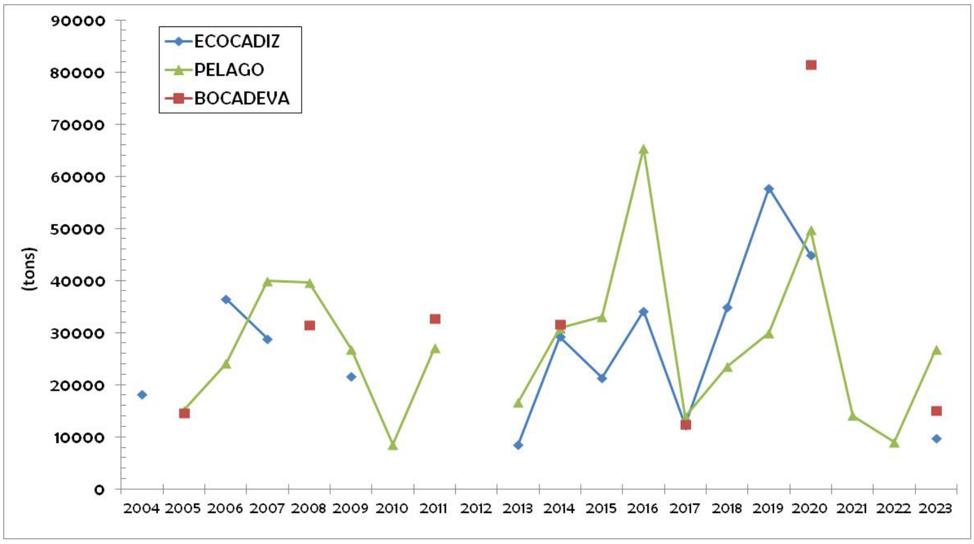


Figure 4.13 Time series of biomass estimates (in tonnes) by acoustic-trawl (spring PELAGO and summer ECOCADIZ series) and DEPM (summer BOCADEVA series) surveys.

4.1.1.4 Summer acoustic survey (ECOCÁDIZ): 9a South

The *ECOCADIZ 2023-07* Spanish (pelagic ecosystem-) acoustic-trawl survey was conducted by IEO between July 29th and August 8th 2023 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cádiz (GoC) onboard the R/V *Ramón Margalef*. Exceptionally in this year the survey was the acoustic component of a combined anchovy egg (*BOCADEVA*) and acoustic-trawl (*ECOCADIZ*) *ad hoc* survey (*ECO/BOCADEVA_0723 survey*), which were performed one after the other, the egg survey first. This year's acoustic-trawl survey was marked by a reduction of 3-4 days to the usual survey length (ca. 14 days at sea), due to the R/V tight schedule. The survey's main objective is the acoustic assessment and mapping of the main pelagic resources and the biological and oceanographic conditions of the GoC continental shelf.

Age-structure of the 2023 acoustic estimates was not available to the WG. The information provided in the following sections only corresponds to a review of the time-series, with special reference to the last available data in 2023.

Anchovy mean weight and length-at-age

Figure 4.14 shows the mean length- and weight at age along the time-series. The 2023 summer estimates of mean size and weight for the whole population (10.3 cm, 6.6 g) were the lowest in their respective time-series and well below their historical averages (12.2 cm, 12.3 g). As it has been occurring in the last years, a relatively high contribution of the small fish (e.g. ca. 40 % of the total population in 2020 was composed by fish ≤10 cm; ca. 74% of age 0 fish in numbers) during the survey season might be the cause of the low value of such estimates previously recorded. Age 1 and notably age 2 fish have showed an increase in mean size and weight since 2018, but no information is available for these variables since 2021 on.

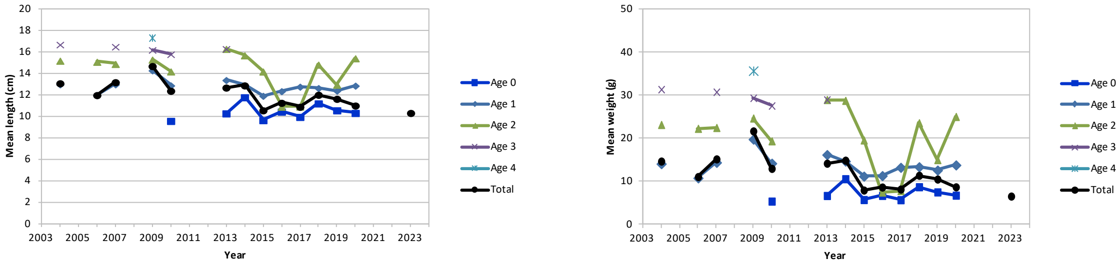


Figure 4.14 Anchovy mean length and weight at-age throughout the ECOCADIZ Gulf of Cadiz summer acoustic surveys series (gaps mean no survey). This series was temporarily suspended in 2021 and 2022. Age-structured estimates from the 2023 survey are not yet available

Anchovy biomass and abundance estimates

GoC anchovy was widely distributed in the surveyed area, although it showed very low acoustic densities in the easternmost and westernmost waters. High densities were mainly recorded between Ayamonte and the Bay of Cadiz. GoC anchovy acoustic estimates in summer 2023 were of 1479 million fish and 9714 tonnes, accounting for 71% and 78% decreases in abundance and biomass, respectively, as compared to 2020 estimates (5153 million, 44 886 t) and they are well below their time-series averages (2626 million, 28 925 t; Figure 4.15). By geographical strata, the Spanish waters yielded 82% (1216 million) and 81% (7 933 t) of the total estimated abundance and biomass in the Gulf, highlighting the importance of these waters in the species' distribution, but also the noticeable regional decrease experienced by the species in the Spanish waters. The estimates for the Portuguese waters were 263 million and 1781 t.

The recent decreasing trend for the whole population seems to have stopped and abundances and biomass seem to be increasing in 2023, as evidenced, at least, by the spring Portuguese *PELAGO* survey series. However, such a recovery does not seem to be evidenced by the summer and autumn surveys' estimates that suggest a more alarming scenario. Such recent fluctuations should therefore be conveniently monitored.

The size class range of the assessed anchovy population in summer 2023 varied between the 2.0 and 19.0 cm size classes. The size distribution showed a mixed composition, with one main mode at 13.0 cm, and with a small proportion of individuals being observed at 2.0 cm. It is noticeable the occurrence of this last modal size during summer, as it is a consequence of the record of very tiny juveniles in the coastal waters located in front of Faro, Portugal. 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, although individuals belonging to the smallest size classes were also observed in western waters. No information on the age structure of the estimated population in 2023 is available to the WG.

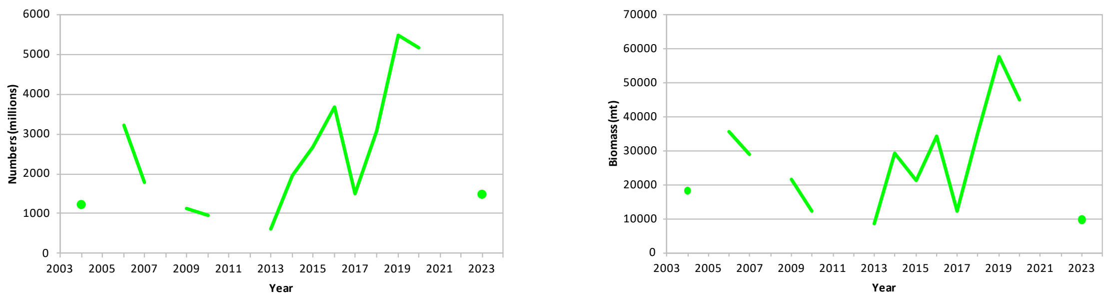


Figure 4.15 Anchovy abundance (million fish) (left) and biomass (t) (right) estimates through the ECOCADIZ Gulf of Cadiz summer acoustic surveys series (gaps mean no survey). This series was temporarily been suspended in 2021 and 2022.

4.1.1.5 Autumn acoustic survey (ECOCÁDIZ-RECLUTAS): 9a South

The *ECOCADIZ-RECLUTAS 2023-10* survey was carried out between 29th September and 13th October 2023 onboard the R/V *Ramón Margalef* covering the Spanish and Portuguese waters of the Gulf of Cadiz, from Strait of Gibraltar to Cape San Vicente, between the 20 m and 200 m isobaths. The main objectives of this survey were the acoustic assessment and mapping of neritic fish resources and oceanographic and biological conditions off the Gulf, with special reference to anchovy, sardine, and chub mackerel juveniles (age 0).

This survey series has experienced a successive reduction in ship-time (from 18-20 days to 15-16 days in 2022-2023). Besides this shortening of the survey time, the starting day was forwarded ca. 10 days in relation to the usual schedule. Half working day had also to be invested in picking up a spare fishing gear at land after the gear breaking suffered during the first haul. The coincidence of the survey dates with NATO naval manoeuvres in the GoC Spanish waters entailed a shift in the start and direction of the acoustic sampling, which was carried out following a W-E direction instead of the usual E-W one. The duration of these naval manoeuvres caused a shortening of the available time to sample the Spanish waters, which was additionally reduced by a 1-day anticipated survey ending because logistic issues. These time constraints entailed a significant reduction in the available time for acoustic-trawl and CTD-LADCP samplings.

Age-structure of the 2023 acoustic estimates was not available to the WG. The information provided in the following sections corresponds to an update (*i.e* age-structured estimates) of the 2022 data not showed in the last year's report and the last available size-based data provided by the 2023 survey. A detailed description of the survey's methods and results is given by Ramos *et al*. (WD 2023b).

Anchovy mean weight and length-at-age

Figure 4.16 shows the mean length- and weight at age along the time-series. The autumn 2022 estimates of mean size and weight for the whole population (10.3 cm, 6.5 g) were between the lowest ones in their respective time-series and well below their last year's historical averages (11.3 cm, 9.5 g). As it has been occurring in the last years, a relatively high contribution of the small fish (93% of age 0 fish in numbers in the autumn 2022 population) during the survey season might be the cause of the low value of such estimates previously recorded. Population in autumn 2022 was composed by age 0, age 1 and age 2 fish, with all these age groups showing a decrease in mean size and weight. This situation seems to be reversed in 2023, at least for the whole population, with mean size and weight estimated at 11.3 cm and 10.2 g, respectively, estimates slightly higher than their updated time-series averages (11.2 cm, 9.1 g).

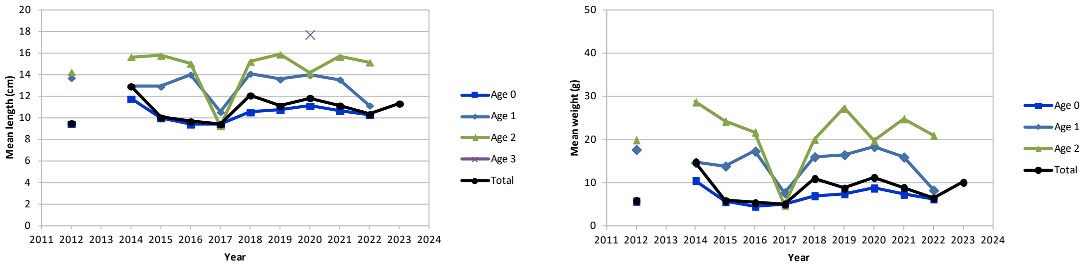


Figure 4.16 Anchovy mean length and weight at-age throughout the ECOCADIZ-RECLUTAS Gulf of Cadiz autumn acoustic surveys series (gaps mean no survey). The 2012 estimates correspond to the Spanish waters only. The 2017 estimates correspond to a part of the Spanish w

Anchovy biomass and abundance estimates

No acoustic estimates were available to the last year's WG from the 2022 autumn survey because the closeness of its ending dates to the starting dates of the meeting. Such estimates will be presented in this section together with those ones from the 2023 survey. In this last case, age-based acoustic estimates are not yet available and, therefore, neither the corresponding age 0-based recruitment index.

Regarding the autumn 2022 estimates, overall anchovy acoustic estimates were of 1837 million fish and 11 912 tonnes (Figure 4.17), accounting for 5% and 31% decreases in abundance and biomass, respectively, as compared to the 2021 estimates (1973 million, 17 512 t), and with values also than the time-series average as estimated the last year (i.e. 2851 million; 21 399 t). By geographical strata, the Spanish waters yielded 99% (1825 million) and 98% (11 719 t) of the total estimated abundance and biomass in the Gulf, highlighting the importance of these waters in the species' distribution. The estimates for the Portuguese waters were 11 million and 193 t.

The population in autumn 2022 was composed by fishes not older than 2 years. Age 0 fish accounted for 93% (1705 million) and 91% (10 797 t) of the total estimated abundance and biomass, respectively (Figure 4.17). Spanish waters concentrated the bulk (99.8%) of this juvenile fraction. The estimates of age-0 fish experienced a similar trend than the one showed by the whole population in relation to the historical peak recorded in 2019 and the values recorded in 2020. Age-0 fish in autumn 2022 showed 5% increase in number and 11% decrease in weight in relation to the estimates recorded in 2021. The recent strong decreasing trends for the whole population and juveniles seem to have slowed down in 2022, with the 2022 estimates being well below their time-series averages. Age 1 fish represented 7% and 9% of the total abundance and biomass, while Age 2 fish accounted for <1% of the total abundance and biomass.

Overall anchovy acoustic estimates in autumn 2023 were of 816 million fish and 8 300 tonnes (Figure 4.17), accounting for 55% and 30% decreases in abundance and biomass, respectively, as compared to 2022 estimates. Current overall estimates are also noticeably lower than the time-series average (i.e. 2920 million; 22 898 t), and this year's abundance estimate is the lowest of the time series. Although no age structure of the population in autumn 2023 is still available, a similar trend is also expected to be shown by the Age-0 juveniles in 2023. By geographical strata, the Spanish waters yielded 88% (716 million) and 73% (6 073 t) of the total estimated abundance and biomass in the Gulf, highlighting the importance of these waters in the species' distribution. The estimates for the Portuguese waters were 100 million and 2 227 t. These current population levels indicate the persistence of a strong reduction in the whole GoC, more markedly in Spanish waters. The size distribution of the estimated population (range between 5.5 and 17.5 cm size classes) showed a mixed composition, with one main mode at 9.5 cm, a secondary mode at 13.0 cm, and with a small proportion of individuals being observed at 7.5 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.

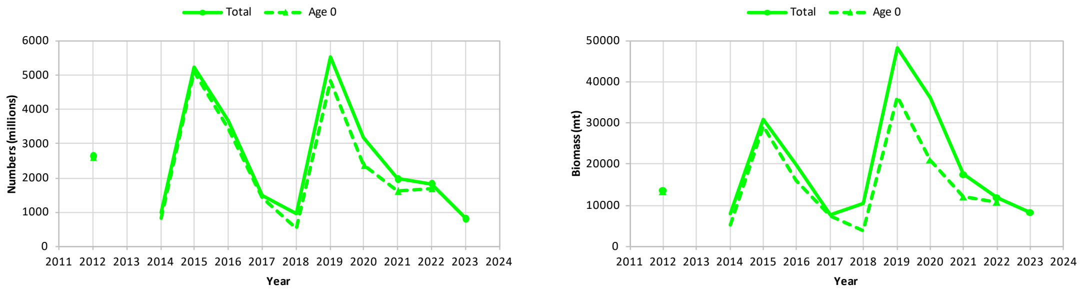


Figure 4.17 Anchovy abundance (million fish) (left) and biomass (t) (right) estimates for the whole population and Age-0 fish through the ECOCADIZ-RECLUTAS Gulf of Cadiz autumn surveys series (gaps mean no survey). The 2012 estimates correspond to the Spanish water.

4.1.1.6 Autumn acoustic survey (IBERAS): 9a West

Anchovy mean weight and length-at-age

Mean weights and length-at-age of anchovy were calculated from the biomass and abundance at age estimated for the JUVESAR and IBERAS survey series in the western part of subdivision 9a. Figure 4.18 show the evolution of mean weight-at-age and mean length-at-age for anchovy in the area 9aCN. In areas 9aN and 9aCS no trends in mean weight and length-at-age are analysed as anchovy occurrence is occasional and restricted only to years of high abundance. We observe a general increasing trend in mean weight and length of anchovy of all ages. But since 2020, mean weight and length-at-age of age 0 anchovies decreased significantly. Surveys were conducted in November-December between 2015 and 2018 and anticipated to September since 2019, but no consistent effect of this change is detected in mean weight and length-at-age. On the other hand, 2019 seems to have been a distinct year, which affected the age 1 and 2 anchovies mean weight and mean length (large decrease). This was not observed in the new cohort (age 0). In 2023, a large recruitment of very small anchovies enhanced the decrease in mean weight and length to the lowest values in the time series.

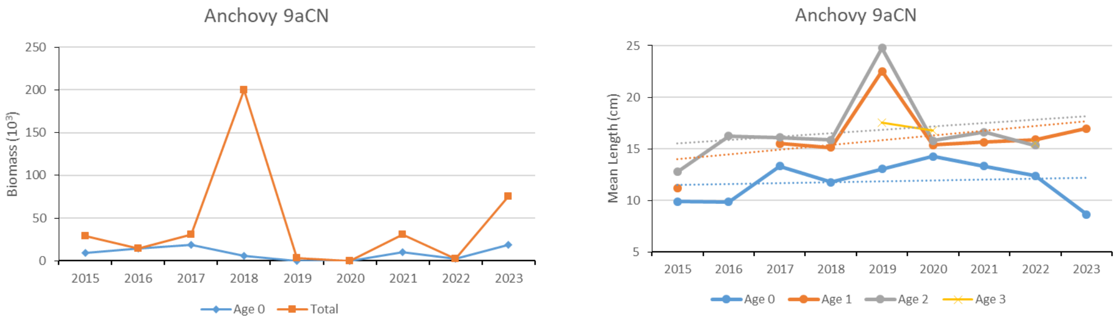


Figure 4.18 Evolution of mean weight-at-age (left) and length-at-age (right) of anchovy along JUVESAR-IBERAS series in area 9aCN

Anchovy biomass and abundance estimates in Division 9a West

Anchovy biomass and abundance age 0 and total trends in JUVESAR and IBERAS surveys are depicted for subdivision 9aCN, generally the main distribution area in 9a west (Figure 4.19) and for the whole survey (Figure 4.20). The highest biomass was observed in 2018, mainly composed of age 1 anchovies in the area 9aCN. Biomass and abundance were very low in 2019 and 2020. In 2020 the highest abundance was recorded in area 9aN, north of the main distribution area. Total biomass decreased from 31236 t in 2021 to 5166 t in 2022. The abundance of the age 0 group decreased from 664 in 2021 to 204 billion individuals in 2022, nevertheless in 2022 the age 0 anchovies was the most abundant age group. The abundance of the age 0 group in the total surveyed area increased sharply in 2023 from 204 to 5334 billion individuals. The larger amount of were located in subdivision 9aCS, south of the main distribution area are total biomass increased from 5166 t in 2022 to 144843 t in 2023.

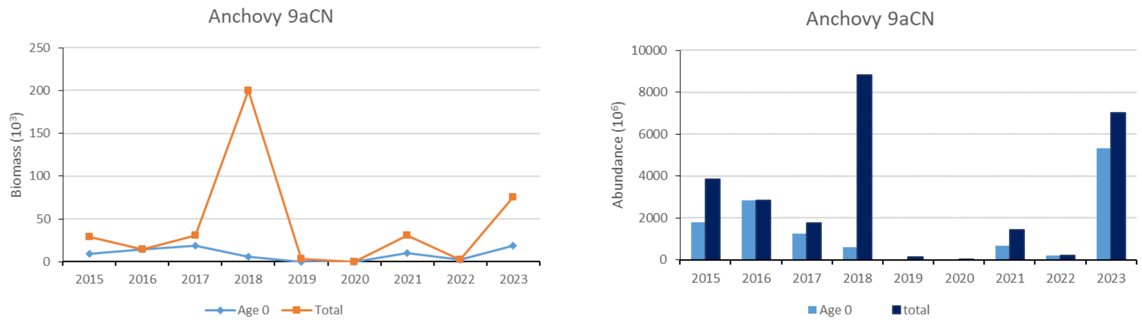


Figure 4.19 Anchovy biomass and abundance trends (age 0 and total) in JUVESAR and IBERAS surveys series in 9aCN.

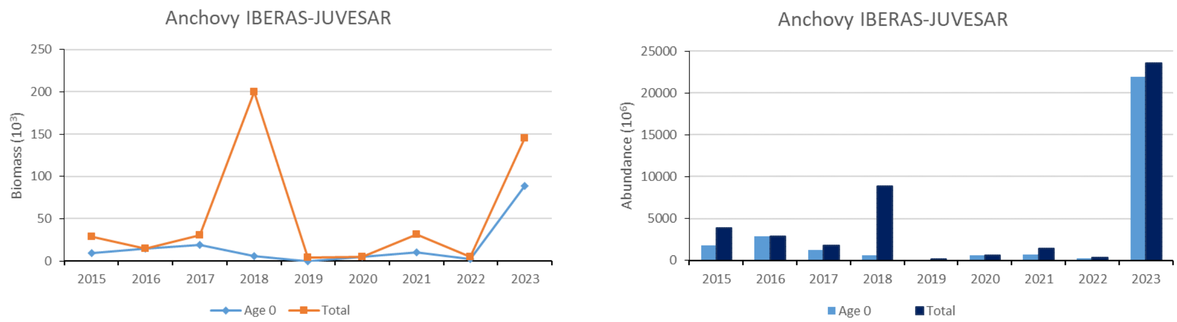


Figure 4.20 Anchovy biomass and abundance trends (age 0 and total) in JUVESAR and IBERAS surveys series (all surveyed area).

4.1.2 Anchovy in division 8abcd

4.1.2.1 Spring acoustic survey (PELGAS): 8ab

Anchovy biomass and abundance estimates

Anchovy biomass and abundance in ICES area 8ab have been calculated since 2000, based on acoustic and trawl data from PELGAS survey (cf. details in Doray et al. 2021) (Figure 4.21 & Figure 4.22).

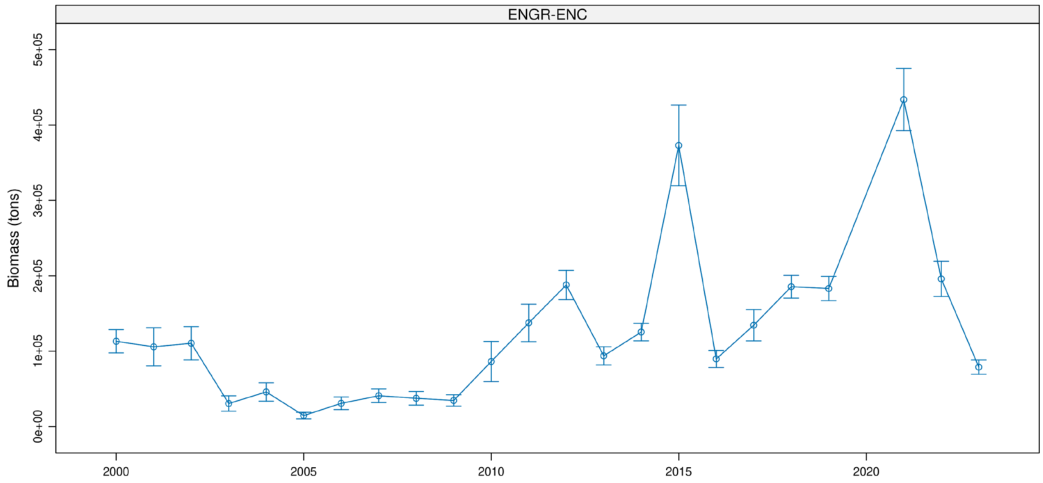


Figure 4.21 Time series of biomass estimates and CVs for spring anchovy in ICES area 8ab, derived from PELGAS survey data.

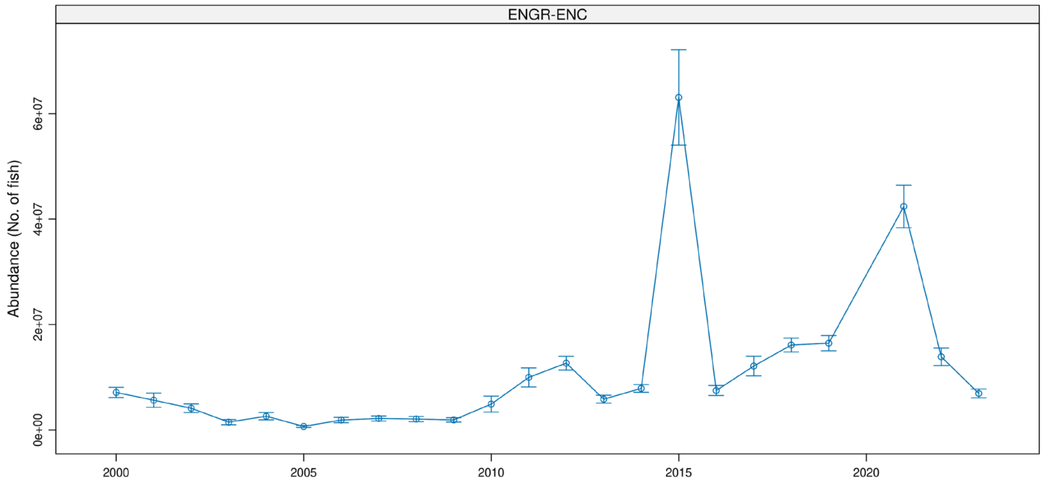


Figure 4.22 Time series of abundance estimates and CVs for spring anchovy in ICES area 8ab, derived from PELGAS survey data.

Anchovy acoustic abundance and biomass estimates in areas 8ab were high from 2000 to 2003. They have collapsed in 2004 due to low recruitments and excessive fishing pressure. Following a fishery closure from 2005 to 2010, biomass and abundance have recovered and remained at high or very high levels since 2010, with peaks in 2015 and 2021.

Anchovy mean weight and length-at-age

Anchovy mean weights and lengths-at-age in ICES area 8ab were calculated based on abundance-at-length, length-age and length-weight keys from PELGAS survey (cf. details in Doray et al. 2021). Time series of anchovy mean weights and lengths-at-age are presented in Figure 4.23 and Figure 4.24.

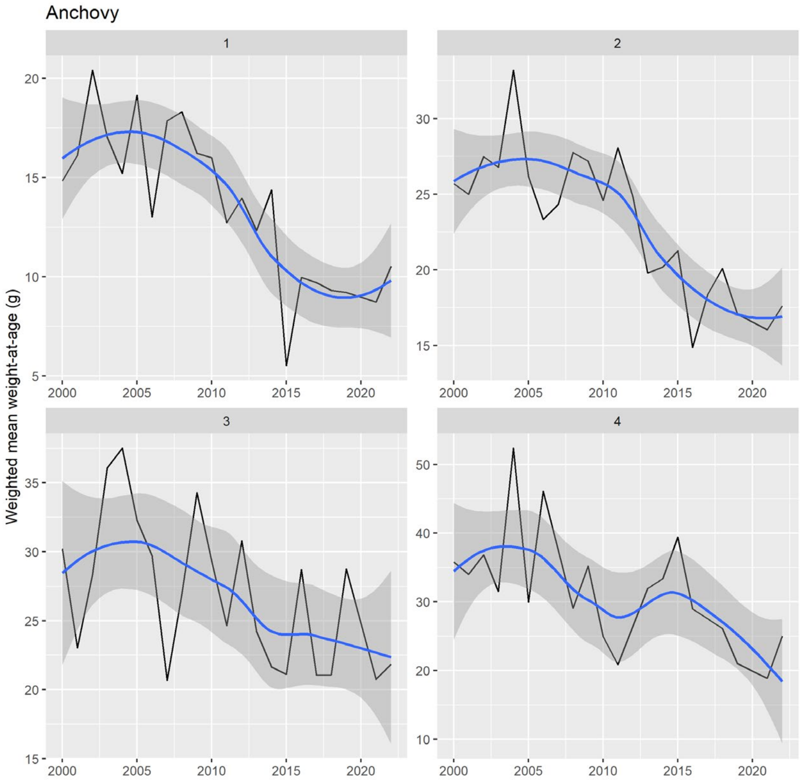


Figure 4.23 8ab Anchovy mean weight at-age, PELGAS survey

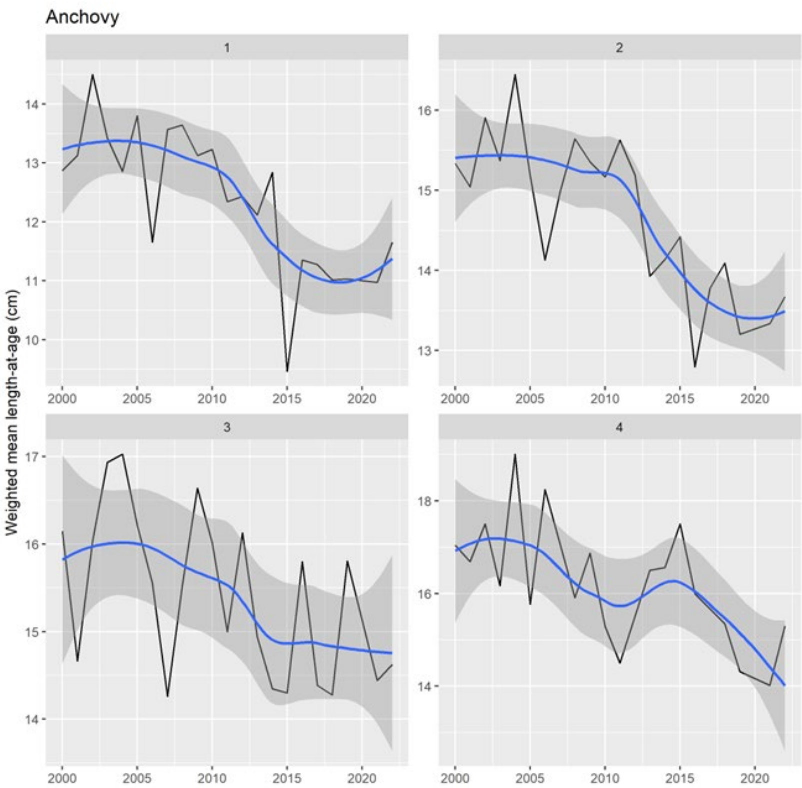


Figure 4.24 8ab Anchovy mean length at-age, PELGAS survey.

Anchovy mean weights and lengths-at-age in ICES area 8ab have decreased since 2000, with a sharp drop around 2010 (Figure 4.23 and Figure 4.24). Anchovy mean weights-at-age have decreased by 5 (age 1) to 10 g (age 2+) within 15 years, while mean lengths-at-age have decreased by about 2 cm.

4.1.2.2 Spring acoustic survey (PELACUS): 8c

Anchovy mean weight and length-at-age

Mean weights and length-at-age of anchovy were calculated from the biomass and abundance at age estimated for the PELACUS survey series in the subdivision 8c. Figure 4.25 show the evolution of mean weight-at-age and mean length-at-age for anchovy in the area 8c. A decrease in the mean length was observed for all ages, being more pronounced in age 1. Regarding the weight at age, it showed an increasing trend until 2016 (for ages 1 and 2) and 2018 (for age 3), and then a clear decreasing trend, reaching in 2023 the lowest value of the time.

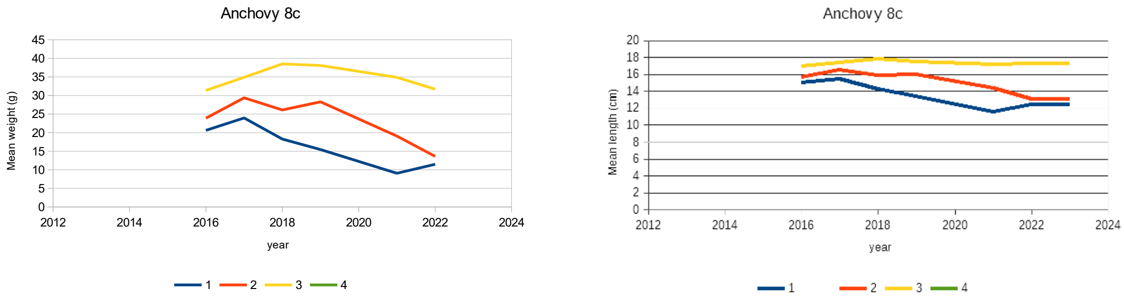


Figure 4.25 Evolution of mean weight at age (left) and length at age (right) of anchovy along PELACUS series in area 8c.

Anchovy biomass and abundance estimates in Division 8c

Anchovy biomass and abundance at age 1 and total trends in PELACUS surveys are illustrated for subdivision 8c (Figure 4.26) and for the whole survey (Figure 4.27). The highest biomass was observed in 2021 with 56218 t, mainly composed of age 1 anchovies in the area 8c. No assessment for ages was done in 2023 in 8c subdivision due to the scare quantity of anchovy found. 2020 appears blank as due to the Covid-19 pandemic it was not possible to run the survey.

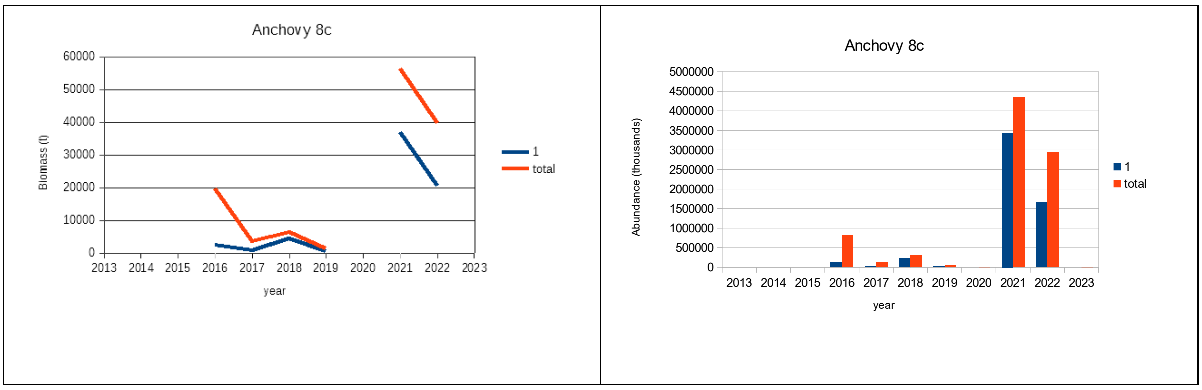


Figure 4.26 Anchovy biomass and abundance trends (age 1 and total) in PELACUS surveys series in 8c.

Total biomass decreased from 62293 t (4.7*10⁶ individuals) in 2021 to 3223 t (0.16*10⁶ individuals) in 2023. The abundance of the age 1 group also decreased from 41448 t (3.7*10⁶ individuals) in 2021 to 2296 t (0.12*10⁶ individuals) in 2023.

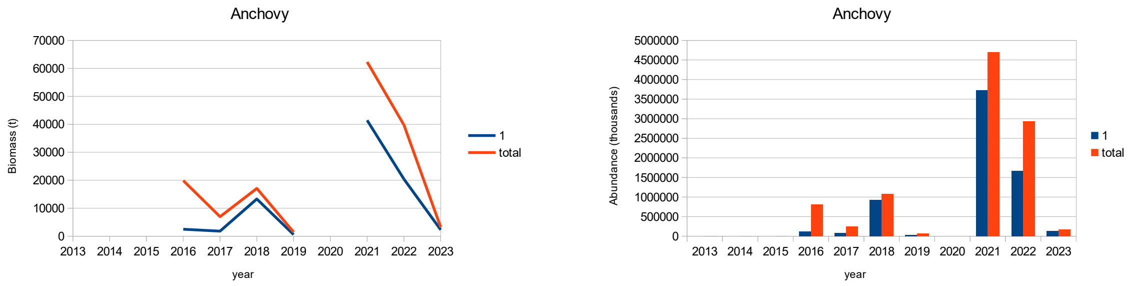


Figure 4.27 Anchovy biomass and abundance trends (age 1 and total) in PELACUS surveys series (all surveyed area).

4.1.2.3 Spring DEPM survey (BIOMAN): 8abcd

The biomass at age 1, total biomass and its CV derived from this survey are used as inputs for the assessment of anchovy in area ICES 27.8

The survey took place in the Bay of Biscay from the 3rd to the 26th of May, covering the whole spawning area of the species. All the methodology concerning the survey and the estimates performance, are described in detail in the stock annex - Bay of Biscay Anchovy (area ICES 27.8). https://doi.org/10.17895/ices.pub.18621968. A detailed report of the survey and results 2023 are in the link to the working document (Santos Mocoroa M. *et al*. BIOMAN 2023). doi:10.13140/RG.2.2.10327.24485

Two research vessels were used at the same time and place: the RV Vizconde de Eza to collect plankton and adult samples and the RV Emma Bardán to collect adult samples. Some specifications of the sampling are given in the survey summary sheet in annex 2.

Total number of PairoVET samples (vertical sampling) obtained was 778. From those, 584 had anchovy eggs (75%) with an average of 314 eggs m^2 per station in the positive stations, and a maximum of 4,350 eggs m^2 in a station. A total of 18,039 anchovy eggs were encountered and classified. The number of CUFES samples (horizontal sampling) obtained was 1,824. Frome those 778 (63%) stations had anchovy eggs with an average of 30 eggs m^3 per station and a maximum of 845 eggs m^3 in a station in the positive stations.

This year 19% of the anchovy eggs abundance was found in the Cantabrian Sea, the eggs were distributed all over the area and beyond 200m depth isoline, the area surveyed limit was at 6º20'W. In the French platform there were eggs all over the platform and passed the 200 m depth isoline almost in all the area up to the limit of area ICES 8 (48ºN), except for the west part of the platform from 47º30 to 48ºN that arrived until 180m approximately. The total area covered was 113,814Km2 and the spawning area for anchovy was 77,312Km2, 68% of the total.

Egg parameters estimate

The DEPM BIOMAN survey has produced egg parameter estimates for anchovy in 2023 in ICES areas 8abcd (**table 4-5**). Those are part of the parameters for the application of the DEPM. Time series of each parameter are showed in Figure 4.28. Spatial distribution of plankton stations, egg distribution and abundance, and adult hauls for 2023 are showed in **Santos *et al* 2023** working document doi:[10.13140/RG.2.2.10327.24485](https://doi.org/10.13140/RG.2.2.10327.24485)

In 2023 daily egg production(P_0) 130.6 egg/m²/day CV 0.0949 was lower than the last 5 years but well above the historical mean (101.69 egg/m²/day). The spawning area was 77,312 Km². The daily mortality rate (z) 0.276 CV 0.2026 was lower than last years but at historical mean level (0.25); the z value of this year means that 76% of the eggs were dying per day. Total daily egg production (P_{tot}) 1.01E+13eggs CV 0.0949 as the product between the spawning area and the daily egg production (P_0), was lower than the last 5 years but well above the historical mean (5.8 E+12 eggs). Figure 4.28 shows the historical series of P_0, z, spawning area and P_{tot} and the values for 2023 are in Table 4.5**.**

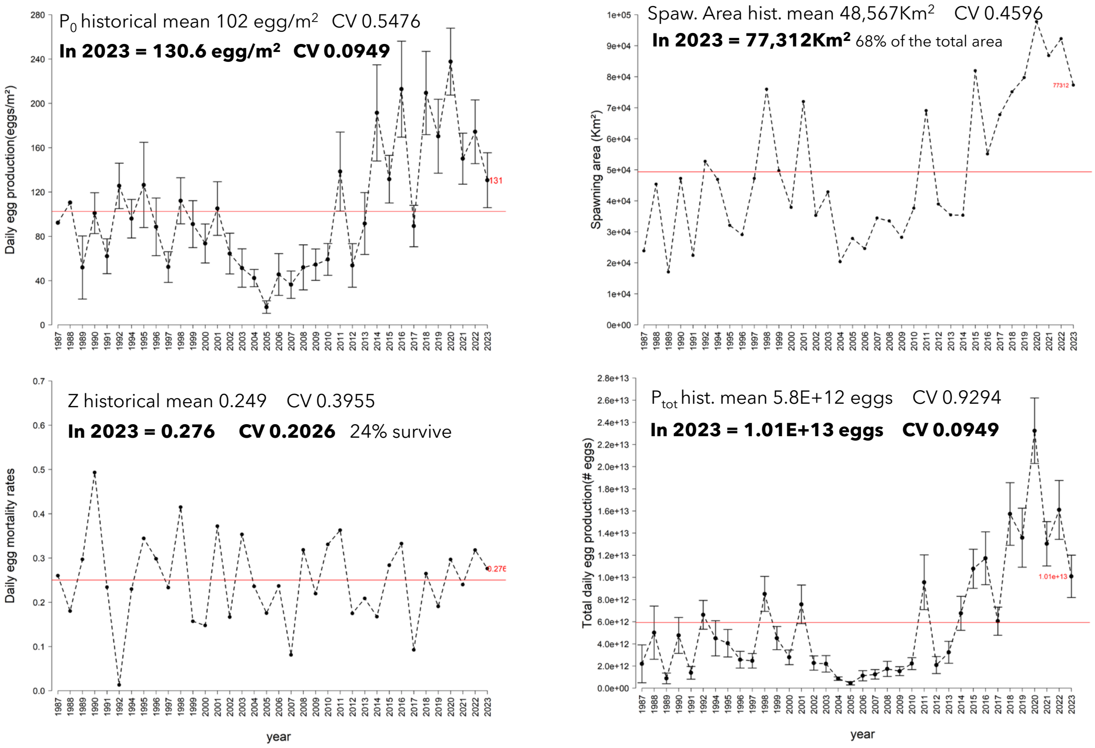


Figure 4.28 Historical series including 2023 estimates and its CV (in bold) for daily egg production (P0) (egg/m2/day), spawning area (Spawning area) (Km2), daily mortality rates (z) and total daily egg production (Ptot)(eggs/day) for anchovy in the Bay of Biscay (ICES 8abcd). The red line is the historical mean.

Table 4.5 Bay of Biscay anchovy 2023 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	130.59	12.39	0.0949
z	0.28	0.056	0.2026
Ptot	1.01.E+13	9.6.E+11	0.0949

Anchovy adult parameters and total anchovy biomass estimates, in the Bay of Biscay

All the adult parameters needed to apply the DEPM to obtain the total biomass were estimated for anchovy 2023 in the Bay of Biscay, based on 42 hauls. The spawning stock biomass (SSB) is estimate dividing total daily egg production (*P_{tot}*) by the daily fecundity (*DF*) estimates. In the case of anchovy, *SSB* is equal to the total biomass (*B*), since at the survey time, which is at the spawning peak, the whole population is spawning. Time series and 2023 estimates of the adult parameters and total biomass are shown in Figure 4.29and Table 4.6.

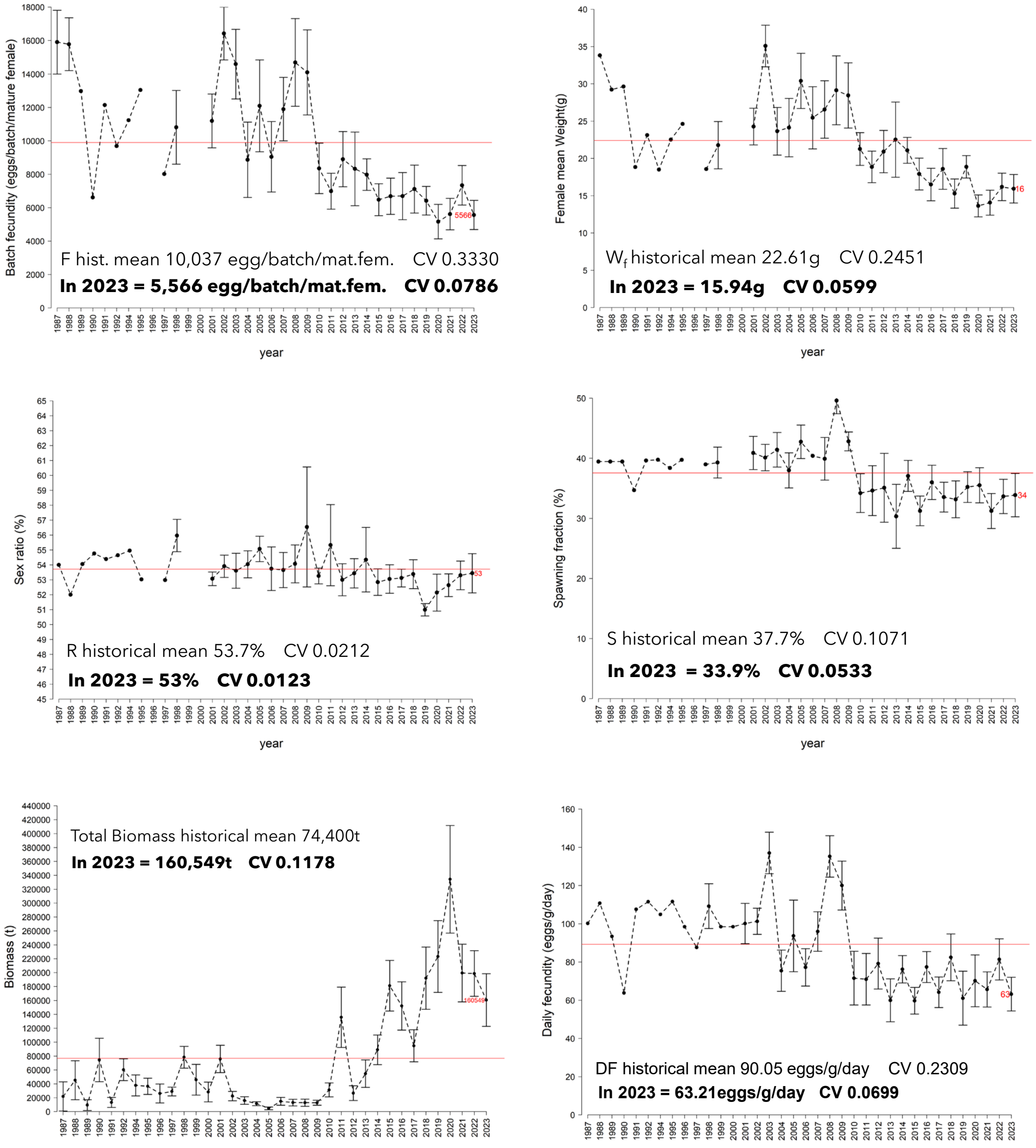


Figure 4.29 Historical series including 2023 estimates of the adult parameters for anchovy in the Bay of Biscay (ICES 8abcd): batch fecundity (F) (eggs/batch/mature female), female mean weight Wf(g), sex ratio (R) (% of females), spawning fraction (S) (% of females spawning per day), daily fecundity (DF) (eggs/g/day) for the application of the DEPM and the total biomass (B)(tons). The red line is the historical mean.

Table 4.6 Bay of Biscay (ICES 8abcd) anchovy 2023 estimates of adult parameters: 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 (D

Parameter	estimate	S.e.	CV
R'	0.53	0.0066	0.0123
S	0.34	0.0181	0.0533
F	5,566	437	0.0786
Wf	15.94	0.96	0.0599
DF	63.21	4.42	0.0699
BIOMASS (Tons)	**160,549**	18,914	0.1178

The batch fecundity in 2023 was the second lowest of the series, and the general tendency over time is downwards. The female mean weight was at levels of last year, well below the historical mean (22.6g). The general tendency in the historical series is downward, especially after 2010 it was down drastically, when the fishery was reopened. The sex ratio was at levels of the historical mean (53.7%) and did not change much in the time-series. The spawning fraction was at levels of last year; since 2010 was maintained at levels of 34 %, lower than the tendency before the reopen of the fishery in 2010. The daily fecundity was 63.21 eggs/g/day. Since 2010 was going up and down but maintained at levels of 70 eggs/g/day, although the historical mean is 90 eggs/g/day. Since the reopen of the fishery in 2010 the adult parameters F, W_f, S and DF are in another regimen below the respectively historical means. Finally, the total biomass in 2023 was lower than the last 5 years but well above the historical mean. (Figure 4.29and Table 4.6).

Anchovy weight, length, numbers, percentage, and biomass-at-age estimates in the Bay of Biscay

Mean weight and length-at-age for anchovy were estimated for 2023 and the historical series from BIOMAN surveys is showed in Figure 4.30.and Table 4.7. A notable decrease since the beginning of this century in the weight is observed specially since 2010, when the fishery was reopened after 5 years of closure.

Between 1987 and 2010 included, the anchovy biomass estimates derived from the DEPM were below the mean (≈77,000t) (Figure 4.29). During this period, the biomass was changing up and down from one year to the other. From 2002 to 2009 DEPM biomass estimates were below 20 000 t. Within this period the fishery had difficulties to get normal levels of catches. In 2003 there was a deep crisis of the Spanish fishery (STECF 2003) and later in 2005 and 2006 the Spanish fishery crashed and was unable to get any significant catch. This led to the repeated closure of the fishery first in June 2005 and next in June 2006 which last until January 2010. The DEPM estimated a recovery of the population in 2010 and peaked in 2020 with the historical maximum 334,283 CV 0.1158. In 2010 and 2011 the recovery was due to a strong recruitment, as reflected in the high percentage of 1-year old anchovies, above 85% Figure 4.31and Table 4.8 The one-year-old percentage, in numbers, in 2020 was the highest recruitment of the historical series. In 2023 was higher than last year but lower than that maximum (Table 4.8 **and** Figure 4.32). More information is showed in the WD Santos Mocoroa *et al* 2023 doi:10.13140/RG.2.2.10327.24485

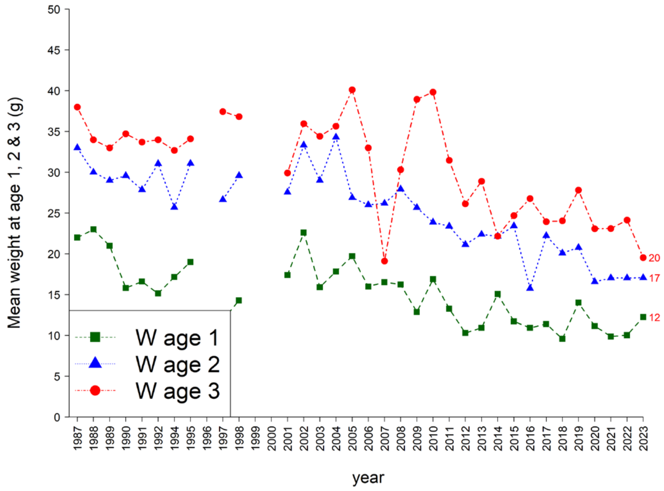


Figure 4.30 Historical series of anchovy mean weight (grams) at age in the Bay of Biscay observed during BIOMAN sur-veys. W at age 1(green), W at age 2(blue) and W at age 3 (red).

Table 4.7 Estimates of weight at age (grams) and Length at age (mm) for anchovy in the Bay of Biscay (ICES 8abcd) for 2023

2023	estimate	S.e.	CV
Weight at age 1 (g)	12.3	0.64	0.0523
Weight at age 2 (g)	17.1	0.80	0.0467
Weight at age 3 (g)	19.6	1.12	0.0574
Lenght at age 1 (mm)	126.5	1.88	0.0148
Lenght at age 2 (mm)	141.0	1.82	0.0129
Length at age 3 (mm)	148.0	2.12	0.0143

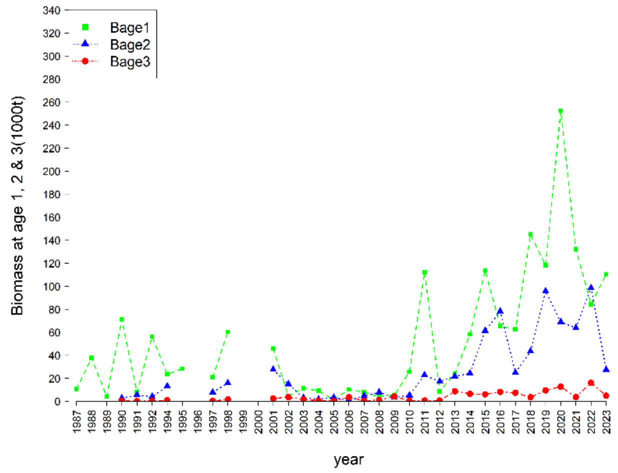


Figure 4.31 Historical series of biomass (tones) at age 1 (green), age 2 (blue) and age 3 (red) for anchovy in the Bay of Biscay observed during BIOMAN surveys.

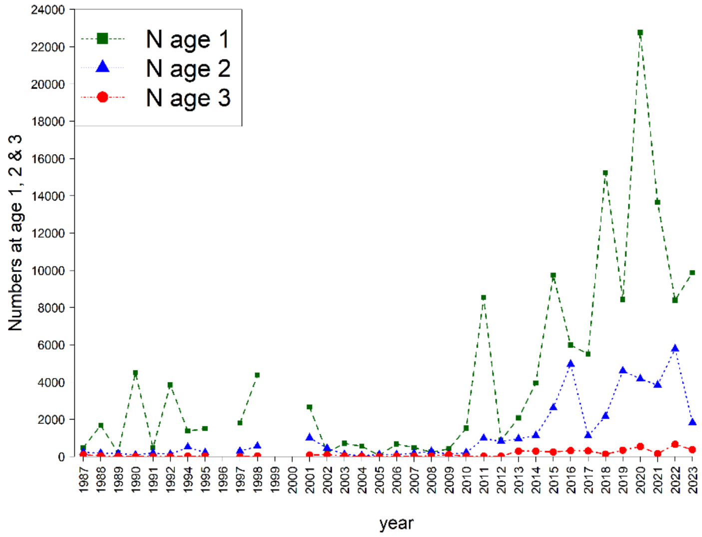


Figure 4.32 Historical series of numbers at age 1(green), age 2 (blue) and age 3 (red) for anchovy in the Bay of Biscay observed during BIOMAN surveys.

Table 4.8 2023 estimates of adult parameters for anchovy in the Bay of Biscay (ICES 8abcd): total biomass (Tons), total mean weight(grams), percentage at age in numbers (%), numbers at age, percentage at age in mass (%) and biomass at age (tons), with their Stand

Parameter	estimate	S.e.	CV
BIOMASS (Tons)	**160,549**	18,914	0.1178
total mean Weight	13.32	0.73	0.0550
Population (millions)	12,071	1657	0.1373
Percentage at age 1	**0.82**	0.021	0.0257
Percentage at age 2	**0.15**	0.016	0.1047
Percentage at age 3+	**0.03**	0.008	0.2412
Numbers at age 1	9,866	1,485.4	0.1506
Numbers at age 2	1,828	232.5	0.1272
Numbers at age 3+	377	93.0	0.2470
Percent. at age 1 in mass	**0.76**	0.024	0.0316
Percent. at age 2 in mass	**0.20**	0.018	0.0920
Percent. at age 3+ in mass	**0.05**	0.010	0.2042
Biomass at age 1 (Tons)	121,532	15,359	0.1264
Biomass at age 2 (Tons)	31,538	4,321	0.1370
Biomass at age 3+ (Tons)	7,479	1,721	0.2301

4.1.2.1 Autumn acoustic survey (JUVENA): 8abcd

Mean weight and length of juvenile anchovy were calculated from individuals of 57 trawls, to evaluate annual trends in the subdivision 8abcd. There has been a general decreasing trend in mean size and weight over the historical series, reaching one of the lowest values in 2021, with mean length of 5.3 cm and weight 1.2 gr. However, in 2022, juvenile anchovy reached values well above the average with 8.6 cm of mean length and 6 gr of mean weight, reaching the third highest values of the temporal series. In 2023, the mean size of anchovy was 7.4 cm and mean weight 2.33 gr, both values are lower than in the previous year but still above the average (Figure 4.33).

Figure 4.33 Evolution of mean weight (above) and length(below) of anchovy along JUVENA series in subdivision 8abcd

The biomass estimation of juvenile anchovy in 2023 in subdivisions 8abcd was 531,000 tons, which represents a high estimation, being among the 5 highest estimates of the temporal series (Figure 4.34**)**. The area of distribution of juvenile anchovy on the French shelf this year was different from last year in that it was concentrated in the more coastal area of the shelf and was not observed in the more oceanic area. The biomass of adult anchovy was ~73,000 tonnes, a bit lower than the mean of the temporal series. The combination of both results foresees a healthy and sustainable status of the overall anchovy stock for the next year.

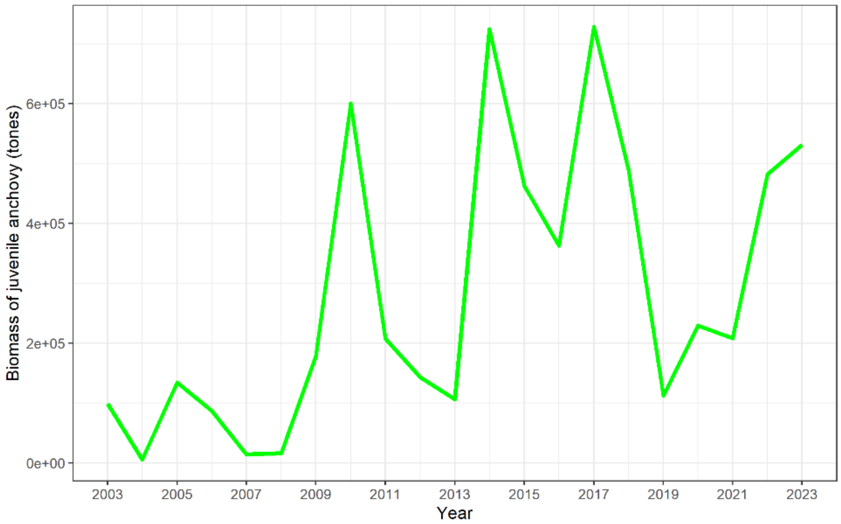


Figure 4.34 Juvenile anchovy biomass trend during JUVENA surveys in division 8abcd.

4.1.3 Anchovy in Division 7

4.1.3.1 Autum acoustic survey (PELTIC): 7ef

After decades of absence, anchovy reappeared in the English Channel and North Sea from the mid-1990s. These "northern" anchovies have since been demonstrated to be a separates stock from those in the Bay of Biscay (Petitgas et al., 2012; Huret et al. 2020). During autumn, anchovy derived from spawned populations in the southern North Sea, migrate into the English Channel to overwinter. While anchovy in Division 7 is not formally assessed, local pelagic fisheries target this species opportunistically. PELTIC has monitored anchovy in the western Channel in the autumn and as the northern stock biomass appears to be increasing, some basic stock parameters are provided in this report for any future stock assessments.

Anchovy biomass in area 7ef in 2023 was 243,392 t, approximately five times the previous highest estimate (2021), continuing an increasing trend (Figure 4.35). While some of the highest densities were found in the Eddystone Bay, anchovy was widespread throughout the survey area, including in the Bristol Channel.

As was observed in 2019 and 2020, in 2023 again large numbers of surface and mid-water schools of juvenile anchovy were found off the Brittany coast, from the Isle of Ouessant in the west to the Channel Islands in the east of the survey. A recent multi-disciplinary study, which included genetic methods, confirmed that these fish are very likely Bay of Biscay fish moving into the Channel. This new scenario of two stocks mixing in the Channel during the winter is likely to complicate future assessments (van der Kooij et al., in prep). The key questions around this observation are: what happens to the Biscay originated anchovy in spring? Do they remain in the western Channel and integrate with those of the northern population or do they retreat into the Bay of Biscay; the answer to this will influence future requirements and abilities to distinguish between the two populations during the autumn/winter as well the future management.

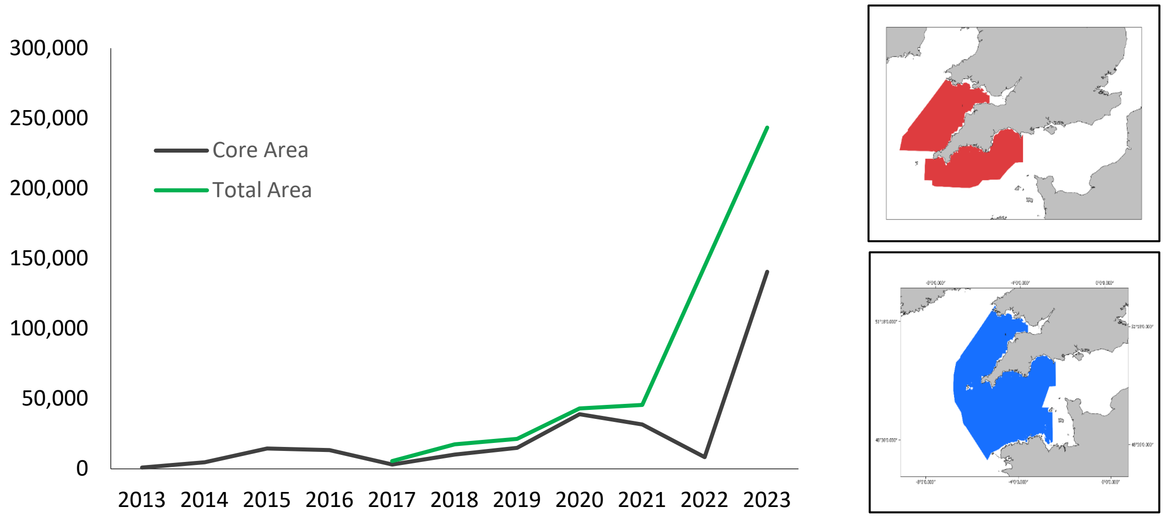


Figure 4.35 Trends in autumn anchovy biomass in ICES area 7 from the PELTIC time-series. Only English waters of ICES divisions 7e,f were covered from 2013 (Core Area in black and red stratum in map). Survey coverage expanded in 2017 to include also French waters, capturing the whole of ICES 7e,f (green line, and blue stratum in map). Please note that the 2022 biomass value for the Core Area only represented the English Channel Stratum and the value for the Total Area was interpolated (between 2021 and 2023), due to incomplete survey coverage as a result of technical issues.

4.1.4 Sardine in Division 8abd

4.1.4.1 Spring acoustic survey (PELAGO): 9a South and West

Sardine mean weight and length-at-age

Mean weights and length-at-age of sardine were calculated from the biomass and abundance at age estimated for the PELAGO series in the division 9a, to evaluate annual trends and regional variations. Figure 4.36 and Figure 4.37 show the evolution of mean weight and length-at-age, respectively, for sardine in the Western Portuguese coast (9aCN and 9aCS). We observe a strong decreasing trend in mean weight and length-at-age of sardine both in subdivisions 9aCN and 9aCS since 2018. This opposes to a long term increasing trend, which still remains in the older ages. Mean weights and length of sardine decreased in 2023 for all age groups in the Western Portuguese coast.

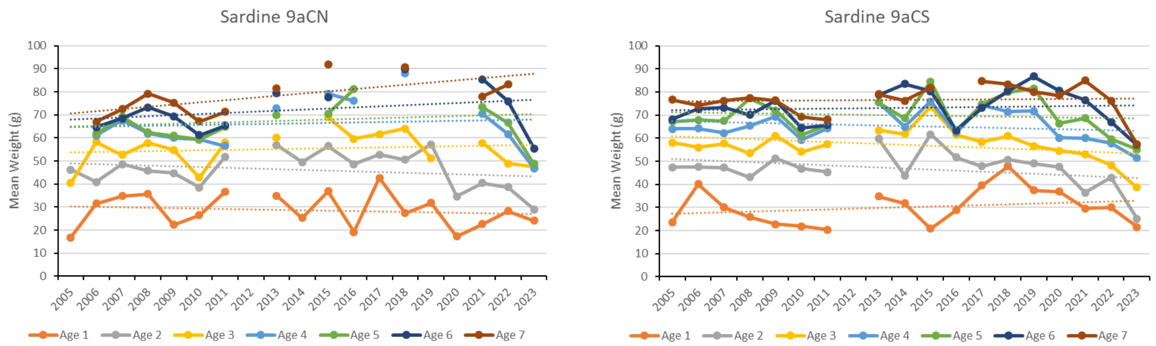


Figure 4.36 Evolution of mean weight-at-age of sardine along PELAGO series – subdivisions 9aCN and 9aCS

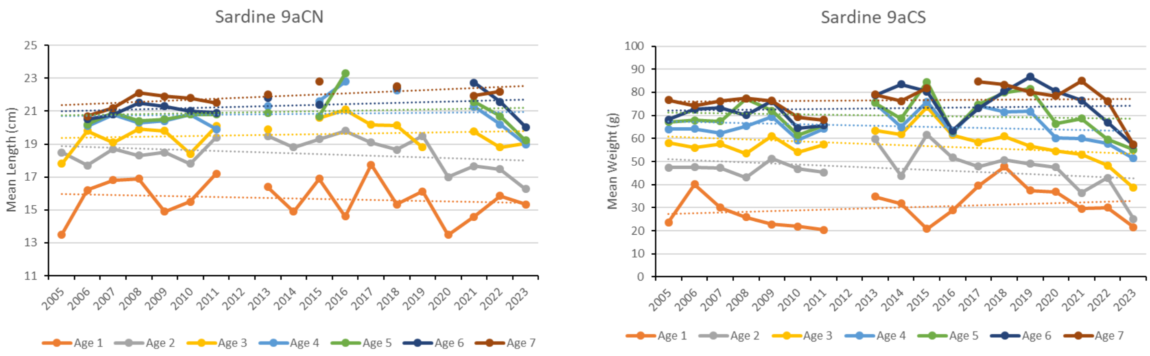


Figure 4.37 Evolution of mean length-at-age of sardine along PELAGO series – subdivisions 9aCN and 9aCS

Figure 4.38 and Figure 4.39 show the evolution of mean weight and length-at-age, respectively, for sardine in the Gulf of Cadiz (9aSA and 9aSC). In these areas, the long term trend at all ages is downwards. In 2023, the decrease of mean weight and length-at-age was particularly noticeable.

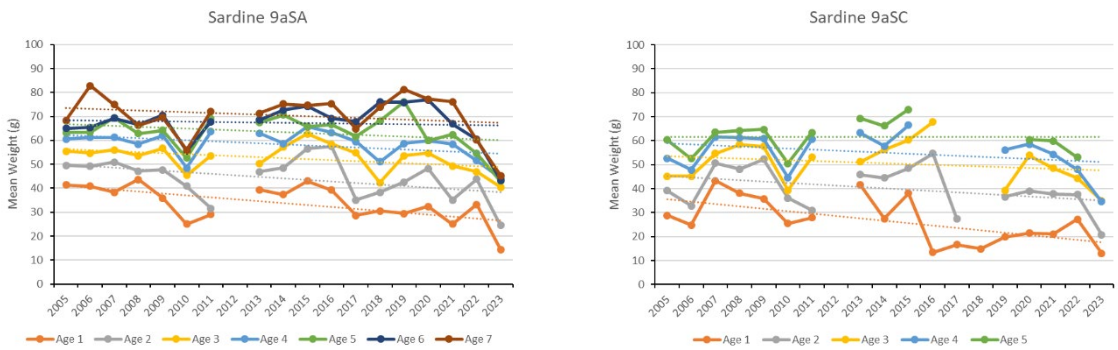


Figure 4.38 Evolution of mean weight-at-age of sardine along PELAGO series – subdivisions 9aSA and 9aSC.

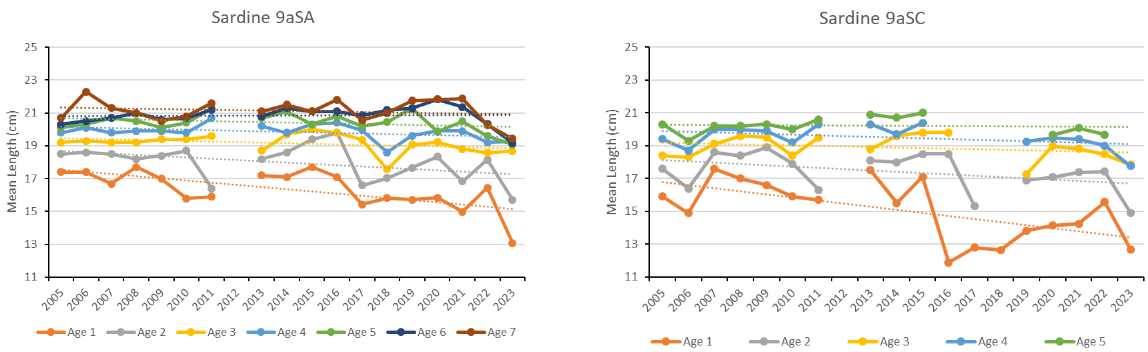


Figure 4.39 Evolution of mean length-at-age of sardine along PELAGO series – subdivisions 9aSA and 9aSC.

Sardine biomass and abundance estimates in Division 9a

Sardine biomass and abundance trend in PELAGO surveys is depicted in Figure 4.40 showing the substantial increase in 2020 and again in 2022. Both biomass and abundance of sardine follow an increasing trend since 2015. In 2023 biomass estimates decreased 46% in relation to PELAGO22 to levels similar to 2021. Abundance in 2023 decreased 28% in relation to PELAGO22.

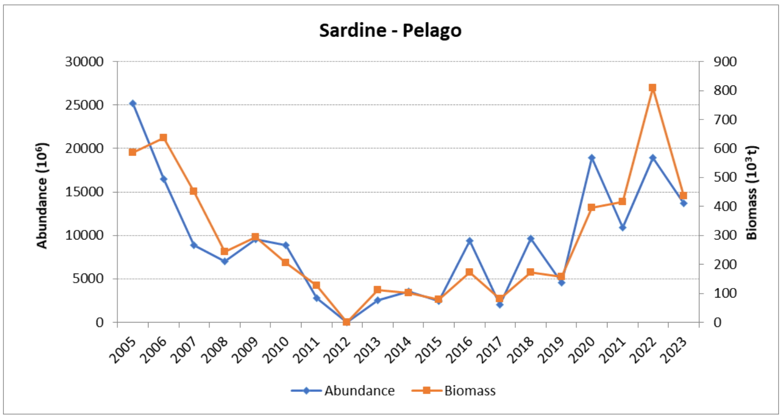


Figure 4.40 Sardine biomass and abundance trends in PELAGO surveys in division 9a.

The pattern of annual variation is, however, distinct between subdivisions (Fig. 4-41). The subdivision that had suffered the most significant reduction in abundance and biomass since 2005 was 9aCN, having in 2020 recovered to values close to those of 2006-2007. In 2021, biomass decrease slightly in 9aCN, but the abundance suffered an important decrease. In 2022 and 2023 both biomass and abundance increased in this area (14% and 36% respectively), having the highest geographic contribution for the total abundance (67%) and biomass (71%) of the PELAGO survey. It was in the subdivision 9aCS where the highest decrease in abundance and biomass of sardine was observed (82% and 87% respectively). The subdivision 9aSA showed an important decrease in biomass in 2023 (40%) but a slight increase in abundance (6%). In subdivision 9aSC, abundance and biomass maintained the usual highly fluctuating pattern with very steep annual variations. In 2023 abundance and biomass decreased in relation to 2022, 46% and 74% respectively.

Figure 4.41 Sardine biomass and abundance regional trends in PELAGO surveys.

4.1.4.2 Spring acoustic survey (PELACUS): 9a North and 8c

Sardine mean weight and length-at-age

Mean weight and length-at-age of sardine were calculated from the biomass and abundance at age estimated for the PELACUS survey series in the North part of division 9a and 8c. The blank data for 2020 in the series, corresponds to a year were PELACUS survey was not carried out due to the COVID19 pandemic.

Figure 4.42 shows the evolution of mean weight-at-age and mean length-at-age for sardine in the area 9a North. The mean weight oscillated in the youngest (age 1) and older classes (age 6), showing ups and downs in the series. For the remaining ages, mean weight was quite stable. Mean length was very stable through the whole series, except for age 1 were it showed a down in 2018 and then a high in 2022 (Figure 4.42).

In the Cantabrian coast (area 8c), the trend was very similar to the one observed in the division 9a: a stable mean length trough the whole data series, except one low value (13.25 g) in 2021 for sardine age 1 and an oscillating mean weight trough the series, with higher oscillations in age 1 and 6 (Figure 4.43).

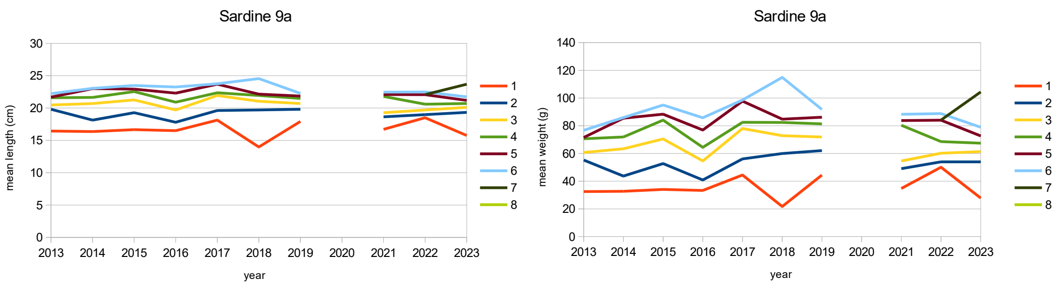


Figure 4.42 Evolution of mean weight-at-age (left) and length-at-age (right) of sardine by age (1-8) along PELACUS series in area 9aN

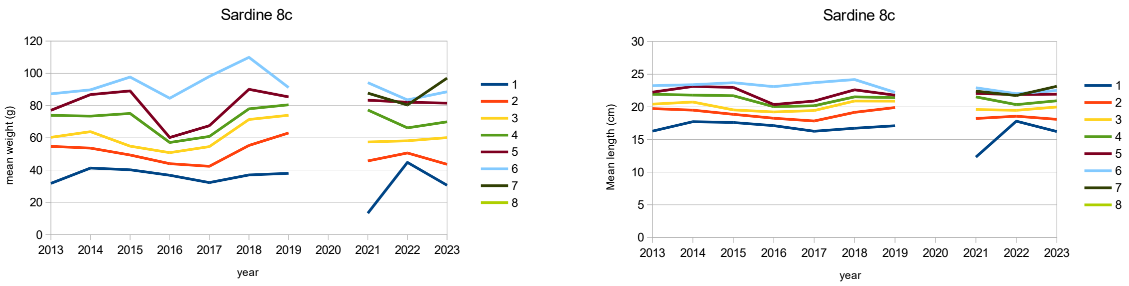


Figure 4.43 Evolution of mean weight-at-age (left) and length-at-age (right) of sardine by age (1-8) along PELACUS series in area 8c.

Sardine biomass and abundance estimates in Division 9a North and 8c

Sardine biomass and abundance age 1 and total trends in PELACUS survey are shown for subdivision 9aN (Figure 4.44) and 8c (Figure 4.45) and for the whole area surveyed (Figure 4.46). 2020 appears blank as due to the Covid-19 pandemic it was not possible to run the survey. In area 9aN, sardine shows an increasing trend, being 2023 the year with the highest biomass and abundance with 531 $*10^9$ tonnes corresponding to $10*10^9$ fish respectively (Figure 4.44). In the Cantabrian sea (area 8c), 2023 was the highest year recorded in abundance (2.8 $*10^9$ fish), but not in biomass (63 $*10^9$ tonnes)- where 2022 (with 118 $*10^9$ tonnes and 1.9 $*10^9$ fish) is the highest of the series. In biomass, sardine shows an increasing trend from 2013-2022, with a slight decrease in 2023. Looking at the abundance, sardine shows a clear increasing trend (Figure 4.45).

If we analyse the whole area surveyed, sardine shows an increasing trend, being the last years from 2021 to 2023 the years of the magnification, 2023 is the highest of the series with 595 $*10^9$ tonnes and 13.6 $*10^9$ fish (Figure 4.46).

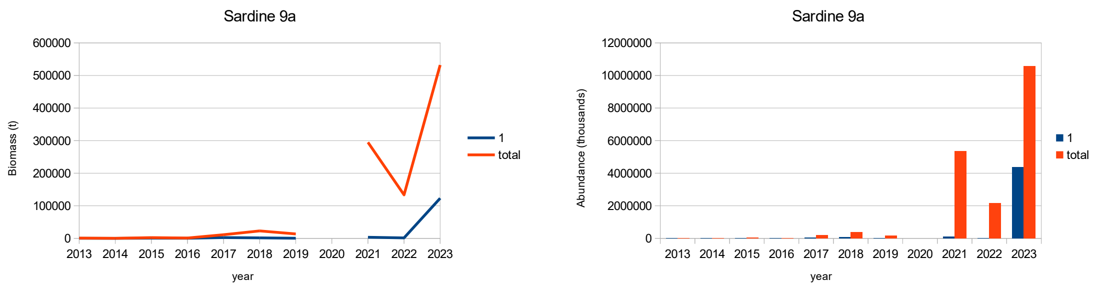


Figure 4.44 Sardine biomass and abundance trends (age 1 and total) in PELACUS survey series in 9aN.

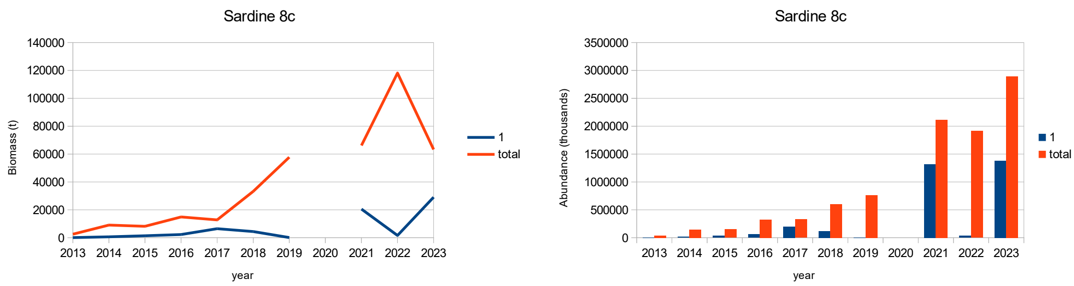


Figure 4.45 Sardine biomass and abundance trends (age 1 and total) in PELACUS survey series in 8c.

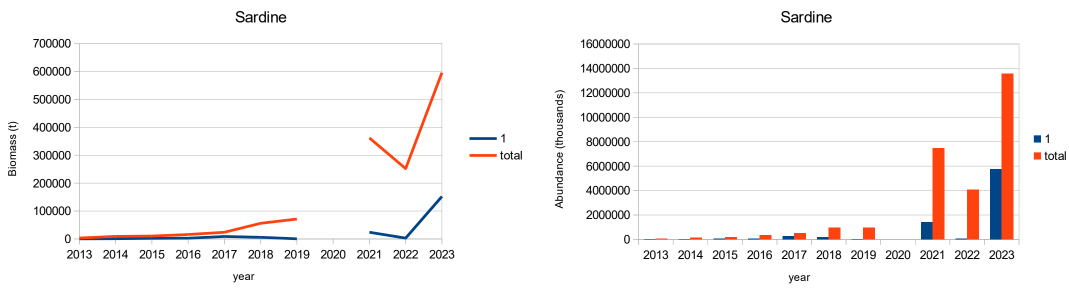


Figure 4.46 Sardine biomass and abundance trends (age 1 and total) in PELACUS survey series (all surveyed area).

4.1.4.3 Winter/Spring DEPM survey (PT-DEPM-PIL & SAREVA): 9a and 8c

The spawning stock biomass (SSB) of the Atlantic Iberian sardine (stock pil.27.8c9a, ICES divisions 8c and 9a) is estimated every three years by the Portuguese (IPMA) and the Spanish (IEO) institutes conducting a coordinated effort to cover the Iberian shores.

The Portuguese survey (PT-DEPM23-PIL) covers the waters from the entrance of the Strait of Gibraltar to the northern border of Portugal (ICES area 9.a, South and West), while the Spanish survey (SAREVA 0423) occupies the northern area of the stock from river Minho to the south of the Armorican shelf in French waters (ICES areas 9.a North and 8.c).

In 2023, the Portuguese and Spanish surveys (PT-DEPM23-PIL and SAREVA 0423) took place in the scheduled period, during the peak spawning season for sardine in the Atlantic-Iberian shores. The Portuguese survey was carried out on board the Spanish vessel, RV Vizconde de Eza from the 10th to the 24th of February. The Spanish survey, SAREVA 0423, was carried out in the same vessel, RV Vizconde de Eza, from the 10th to the 30th April and was coordinated with the Spanish PELACUS acoustic-trawl survey. It is worth noting that the previous DEPM for the southern and western strata occurred in 2020 but due to COVID-19 restrictions it was carried out in the northern stratum in 2021.

Due to logistic constraints in 2023, the number of vessel days available were reduced and therefore the initial grid for icthyoplankton stations (PairoVET and CUFES) was altered. The number of transects and distance between stations along the transects was reduced. From the planned 8x3 nm (transects x stations) it was changed to 10x4nm. However, during the SAREVA survey it was possible to carry out sampling according to the usual grid from 7.5ºW to the east only the Galician coast was covered with the adjusted grid.

Fish samples for IPMA survey were collected by a hired purse-seiner, which worked alongside the RV. In Cadiz, where the Portuguese purse-seiner couldn´t operate, some fishing hauls were conducted with the RV. Fish samples for IEO DEPM survey were collected during the Spanish PELACUS acoustics trawl survey, which took place in the same area simultaneously.

The eggs and adult parameters and the SSB estimates were calculated for the aggregated data from the two surveys considering three strata South (ICES area 9.a South), West (ICES area 9.a West) and North (ICES areas 9.a North and 8.c). All the parameters are available for the 3 strata separately and the spawning stock biomass (SSB) estimate for the whole stock was achieved adding the SSB calculated for each stratum.

This section includes a summary of the Portuguese (PT-DEPM23-PIL) and the Spanish (SAREVA 0423) DEPM surveys, the final estimates of eggs and adult parameters obtained for the South, West and North strata, and the SSB estimated for the whole sardine Iberian stock (pil. 27.8c9a). A more extensive description is presented in the survey reports (WD Angelico et al. 2023 and WD Díaz et al. 2023; SAREVA Survey Report)

Maturity and weights at age for the pil. 27.8c9a stock, are both obtained, since 2017, using the results from the DEPM surveys (WKPELA 2017, Nunes *et al*. 2017). The data from the two surveys is combined to produce the estimates by stratum and year. Mean weights and proportion of mature fish at age are attained using as weighting factor the abundances (based on DEPM SSB estimates) at age by stratum and year.

Egg parameter estimates

In total, 771 PairoVET (382 PT, 389 SP) and 776 CUFES (435 PT, 341 SP) samples were collected in 2023, along the 96 (45 PT, 51 SP) transects of the DEPM surveys. The CUFES samples from IPMA's campaign are still being processed. A total of 6632 sardine eggs were collected by the PairoVET sampler, 1686 in the southern coast, 3356 in the western shelf and 1590 in the northern coast. Overall, sardine eggs were observed in 30% of the samples, however the percentage of positive stations for sardine was higher in the north (33%) than in the south and west (24% and 28%, respectively). A summary of the observations is presented in Table 4.9

The egg distribution in 2023 was patchier in the south and in the west than in previous years, with some large areas without eggs. On the contrary, in the northern stratum a continuous layer of eggs was observed in the coastal waters, where an increase in density was clear (in 2021, in the same area the eggs were observed across the entire platform). In the west coast the areas with higher abundances were observed in the region between river Douro and the Galician rias and to the north of Lisbon close to Cape Carvoeiro. Low numbers of eggs were collected to the south of Lisbon and in western Algarve. In the south, the higher egg densities were observed in the coastal waters to the east of Cape Sta Maria.

In total 96213 km^2 were surveyed (18144 in the south, 36396 in the west and 41673 in the north), of which 31385 km^2 were considered the spawning area (5114 in the south, 10656 in the west and 15615 in the north). The spawning stratum decreased in 2023, comparing to 2020, in the south, is slightly lower in the north compared to 2021, but increased for the western region (Figure 4.47, Table 4.10).

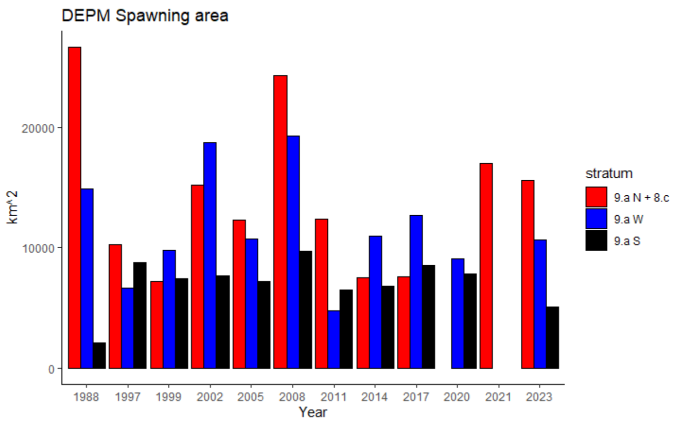


Figure 4.47 Spawning area (km2) by spatial stratum (black = 9.a South, blue = 9.a West, red = 9.a North and 8.c) for the historic series 1988-2023.

The mortality estimates obtained (considering survey temperatures and the data from the whole historic series) were within the range observed for the DEPM series (revised in 2016) but slightly lower in the west and south and higher in the north compared to the previous estimates in 2020-2021 (Table 4.10 and Table 4.11).

The Daily Egg Production (eggs/m²/day) was lower in the south and higher in the west and in the north, in 2023 (S: 319.08, W: 276.46; N: 151.65), than during the 2020-21 surveys (Table 4.10 and Table 4.11). The Total Egg Production (P_{Tot}) estimated for the southern, western and northern strata of the Atlantic Iberian stock (areas 9.a South, 9.a West and 9.a North and 8.c) during the 2023 (Figure 4.48, Table 4.10 and Table 4.11) survey was $6.96x10^{12}$ ($1.63x10^{12}$ corresponding to the south, $2.95x10^{12}$ to the west and $2.37x10^{12}$ to the north). These results represent an increase of the overall egg production but a decrease to a half, approximately, in the south, while in the west and north the upward trend continued with increases over 30%.

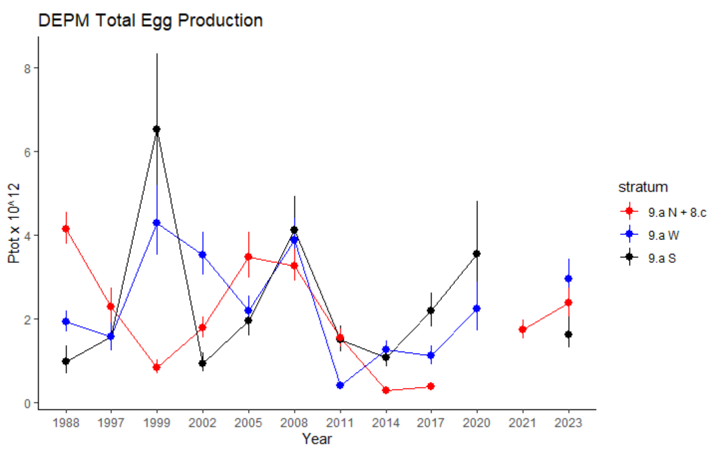


Figure 4.48 Total egg production (eggs/day*1012) by spatial strata (black = south, blue = west, red = north) for the historic series 1988-2023. Dots and whiskers indicate the estimates of egg production and confidence intervals respectively.

Adult parameter estimates

As mentioned at the beginning of this section the fishing hauls for the IPMA survey were conducted using a purse-seiner that was hired to work alongside with the RV, that was carrying out the ichthyoplankton sampling, in the Portuguese coast, while in the Spanish waters of Cadiz pelagic trawling was undertaken onboard the RV. The fish samples for the IEO survey were collected by pelagic trawling during the acoustics survey (PELACUS) which took place at the same time as the DEPM survey.

In total 57 sardine samples (hauls) were obtained in the Iberian waters (9a,8c); 11 in the South, 23 in the West and 23 in the North. On the whole, 3575 sardines were sampled (729 S, 1422 W, 1424 N) and 1532 ovaries were collected and preserved (327 in the S, 634 in the W and 571 in the N). The number of hydrated females was lower than in other years especially in the western strata (21 S, 11 W, 60 N). A total of 2500 otoliths were removed for age determination (653 S, 1286 W, 561 N). A summary of the observations is presented in Table 4.9

The fish sampled showed bimodal length/age distributions in all the strata, sizes ranging from 9.5 to 25 cm, and ages from 0 to 10 years-old (information not shown here). Small individuals were observed in Cadiz but also in some hauls from the W coast. As usual, the larger (heavier and more fecund) sardines were collected in the Cantabrian Sea. A large proportion (99%) of the sardines sampled were mature (91.6 in the S, 98.4 in the W, 99.2 in the N) but some individuals in Cadiz and also in the NW were likely first-time spawners.

Female mean weight (W) decreased in the west coast (19.2%) and increased in the southern and northern strata (11.8% and 2.6%, respectively). The sardine mean weight for the west shores were the lighter of the time series possibly related to good recruitment in the previous year (presence of small/young fish). Conversely in the south and in the north the mean weight increased. In agreement with the mean weight changes the batch fecundity followed a decrease in the west whereas in the south and north the estimations were higher compared to the values observed during the previous surveys (in 2020 for IPMA and 2021 for IEO). Plots of the adult parameters are presented in Figure 4.49

The spawning fraction (S) estimates obtained per haul showed a relatively high dispersion (from 0 to 20%) and a decrease in all the three strata.

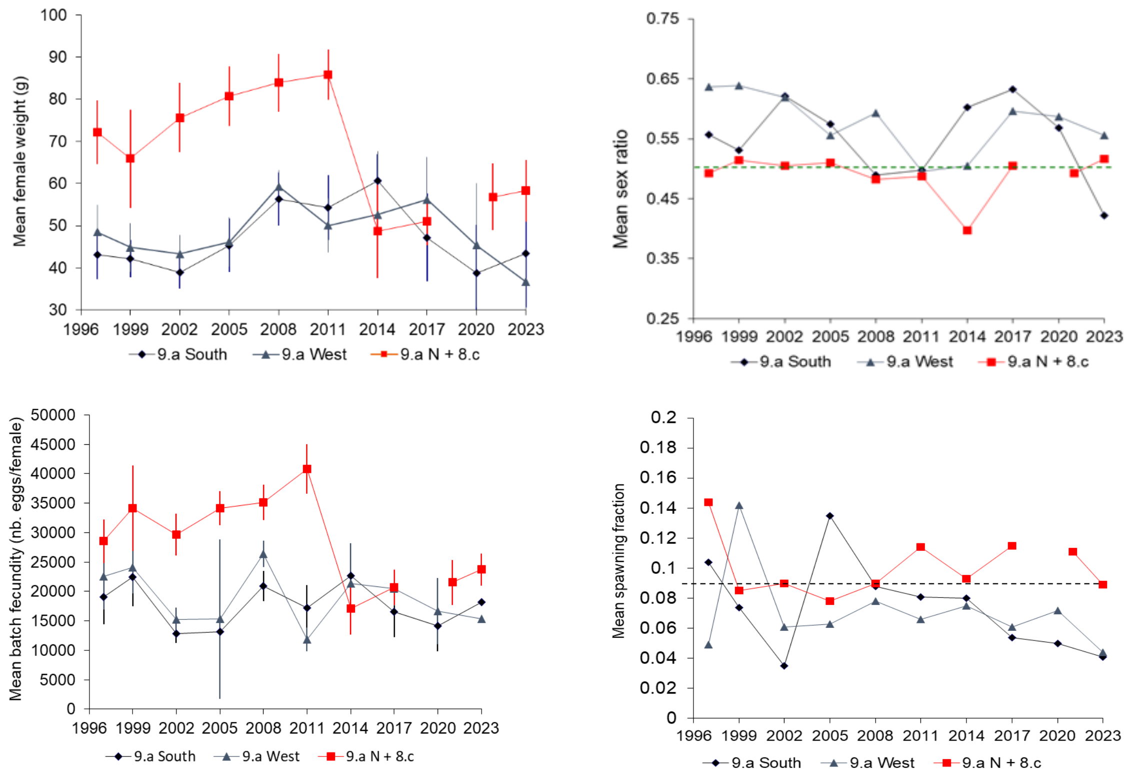
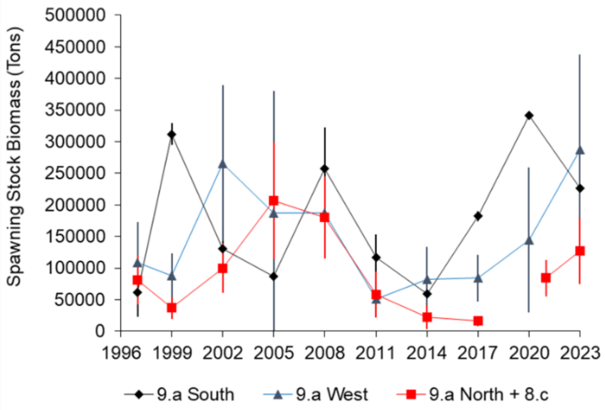


Figure 4.49 Time series (1997-2023) of mean female weight (W) (in grams), Sex ratio (R), Batch fecundity (F) (number eggs/female) and Spawning fraction (S) estimates for the three strata (9a South - black, 9a West – blue, and 9a North and 8c - red); whiskers indicate 95% confidence intervals (i.e. ± 2 standard-deviations).

Spawning Stock Biomass (SSB)

The SSB index estimated for the total Iberian Peninsula accounts for 640.8x10^3 tons, which slightly increased in relation to 2020 (630.7x10^3 tons; Figure 4.50and Table 4.11).

The final SSB estimates obtained from the application of the DEPM in 2023 to the western and northern strata, increased compared with the previous survey (an increase of 50% and 56%, respectively), for the West and for the North: 287.6x10^3 and 126.9x10^3 tons) (Figure 4.50, Table 4.10 and Table 4.11). By the contrary, the SSB in the southern strata, decreased 30% (226.3x10^3 tons) with respect to the 2020 (341.2x10^3) estimate.



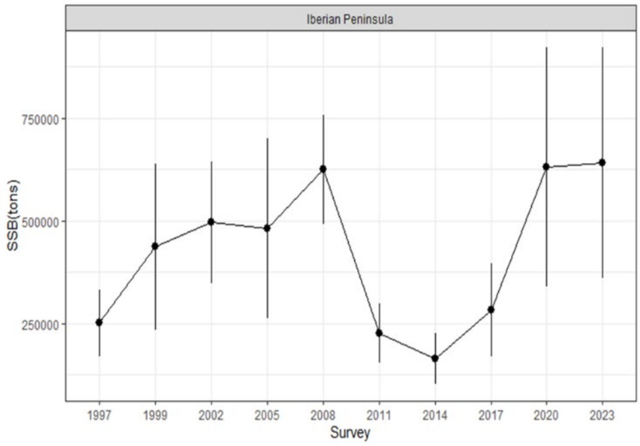


Figure 4.50 Spawning Stock Biomass (Tons) by geographical stratum (top panel) and for the total area (bottom panel) for the historical series 1997-2023; black – 9.a South, blue – 9.a West, red – 9.a North + 8.c. Dots and lines indicate the estimates of SSB and their confidence intervals. For the total Iberian stock estimate, the 2020 SSB representing the northern stratum was obtained as described in Díaz et al., 2020. In 2020 the Spanish survey was cancelled due to COVID-19 pandemic but it was then conducted in 2021.

Weight-at-age and maturity ogive-at-age

While the weight-at-age estimates in 2023 fall within the range observed in the series (since 1998), there is a gradual decline in the average weight across all ages since the mid-2000s. However, this trend seems reversed since 2020 for ages 2 and 3 (Figure 4.51).

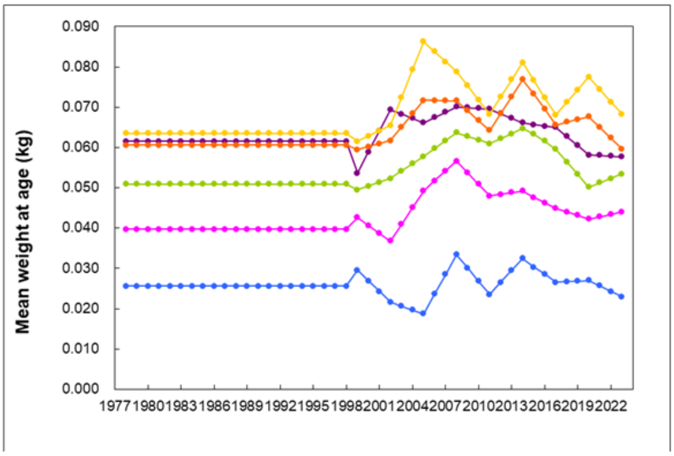


Figure 4.51 Weight at age (in kg) estimates based on the DEPM surveys (PT-DEPM23-PIL and SAREVA 0423).

In 2023, it has not been possible to estimate a maturity ogive at age or size, as nearly 100% of the sampled individuals were mature, even at sizes below 12 cm. The impact of sampling bias derived from delay in survey dates and/or gear used for collecting adult specimens could partially be the reason behind these results. Nonetheless, the presence of small mature fish should be analysed in depth.

Within the whole series, the lower proportions of mature specimens were observed in 2002 and 2005 (Figure 4.52), likely related to the strong recruitments of 2000/2001 and 2004. The proportion of mature individuals older than 2 years in 2002 and 2005 was the lowest in the series due to the high recruitment in 2000/2001 and 2004, which resulted in the influx of a large number of age 1 individuals into the spawning stock in the following year.

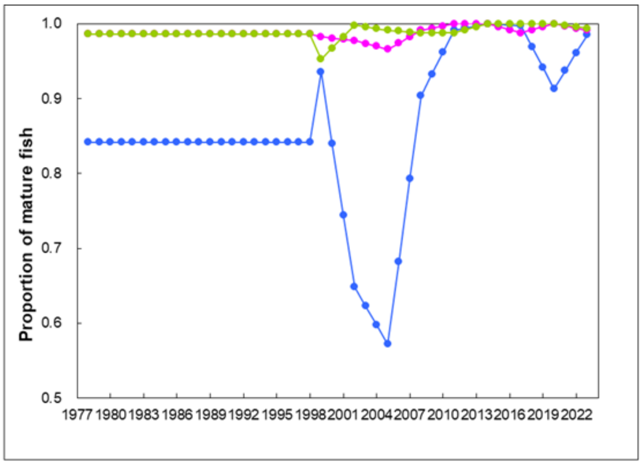


Figure 4.52 Proportion of sardine mature fish at age, obtained from the DEPM surveys (PT-DEPM23-PIL and SAREVA 0423).

Table 4.9 Sardine DEPM surveys for the Atlanto-Iberian stock (pil.27.8c9a). Summary of the eggs and adults sam-pling.

Institute	**IPMA**	**IPMA**	**IEO**
Survey	PT-DEPM23-PIL	PT-DEPM23-PIL	SAREVA 0423
Survey area *(stratum)*	9.a South	9.a West	9.a North + 8.c
SURVEY EGGS			
Dates	19-24/2	10-19/2	10-30 April
Transects	17	28	51
PairoVET stations	125	257	389
Positive stations (with eggs of target sp)	34 (27)	72 (28)	127
Tot. Eggs	1686	3356	1590
Max eggs/m2	4156	4726	4257
Temp (ºC) min/mean/max	15.7/16.2/16.8	13/14.4/15.8	13.09/ 14.25/15.97
CUFES stations	141	294	341
Positive CUFES stations	Ongoing work	Ongoing work	139
Tot. Eggs CUFES	Ongoing work	Ongoing work	9421
Max eggs/m3	Ongoing work	Ongoing work	93.6
CTDF stations	125	257	341
SURVEY ADULTS			
Number Hauls R/V	4	-	34
Number Hauls C/V	8	23	-
Number R/V (+) trawls	3	-	23
Date	19-25/02	10-19/02	8-30 April
Depth range (m)	13 – 72	15 – 99	31-203
Time range (hh:mm)	01:30 – 22:40	01:00 – 23:00	6:10-15:40 GMT
Total individuals target species sampled	729	1422	1424
Length range (cm)	9.5 – 22.6	10.8 – 22.2	13.9-25.0
Weight range (g)	5.0 – 89.92	9.03 – 88.9	16.6-118
Females for histology	327	634	571
Hydrated females	21	11	60
Otoliths	653	1286	561

Table 4.10 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	IEO	TOTAL
Survey	PT-DEPM23-PIL	PT-DEPM23-PIL	SAREVA 0423	
Study area *(stratum)*	9.a South	9.a West	9.a North & 8.c	
Survey area (Km^2)	18144	36396	41673	96213
Positive area (Km^2)	5114	10656	15615	31385
Z ($hour^{-1}$)(CV%)	-0.029 (7.6)	-0.02 (6.0)	-0.021 (5.7)	
P0 (eggs/m2/day)(CV%)	319.08 (18)	276.46 (12)	151.65 (11)	747.19 (8)
P0 tot (eggs/day) ($x10^{12}$) (CV%)	1.63 (18)	2.95 (12)	2.37 (11)	6.96 (8)
Female Weight (g)	43.39 (15)	36.7 (10)	58.31 (6)	
Batch Fecundity	18172 (15)	15388 (10)	23718 (6)	
Sex Ratio	0.422 (12)	0.556 (4)	0.516 (6)	
Spawning Fraction	0.041 (41)	0.044 (18)	0.089 (14)	
Spawning Biomass (tons) (CV%)	226326 (51)	287593 (26)	126874 (21)	640793 (22)

Table 4.11 Sardine DEPM surveys for the Atlanto-Iberian stock (pil.27.8c9a). Summary of the historical series results for eggs, adults and SSB estimates

Year	Institute (Survey)	Strata	Mortality Estim	Mortality C.V	Ptot Estim	Ptot C.V.	W Estim	W C.V.	R Estim	R C.V.	F Estim	F C.V.	S Estim	S C.V.	SSB Estim	SSB C.V.
1988	IPMA (PT-DEPM-PIL)	9a South	-0.026	0.08	0.98	0.26										
		9a West	-0.019	0.07	1.93	0.10										
	IEO (SAREVA)	9a North+8c	-0.018	0.09	4.15	0.07										
		Total 8c9a			**7.06**	**0.06**										
1997	IPMA (PT-DEPM-PIL)	9a South	-0.032	0.11	1.57	0.16	43.1	0.07	0.557	0.05	19062	0.12	0.104	0.13	61337	0.25
		9a West	-0.028	0.09	1.58	0.18	48.5	0.07	0.637	0.04	22569	0.13	0.049	0.18	108870	0.30
	IEO (SAREVA)	9a North+8c	-0.022	0.07	2.28	0.14	72.2	0.05	0.493	0.14	28544	0.07	0.144	0.1	81180	0.24
		Total 8c9a			**5.43**	**0.09**									**251387**	**0.16**
1999	IPMA (PT-DEPM-PIL)	9a South	-0.029	0.09	6.53	0.19	42.1	0.05	0.531	0.03	22436	0.11	0.074	0.22	311982	0.32
		9a West	-0.022	0.06	4.28	0.15	44.9	0.06	0.639	0.05	24086	0.09	0.142	0.05	87832	0.20
	IEO (SAREVA)	9a North+8c	-0.014	0.16	0.84	0.16	65.9	0.09	0.514	0.04	34137	0.1	0.09	0.09	37104	0.23
		Total 8c9a			**11.66**	**0.12**									**436919**	**0.23**
2002	IPMA (PT-DEPM-PIL)	9a South	-0.029	0.09	0.94	0.18	38.8	0.05	0.621	0.05	12881	0.06	0.035	0.19	130406	0.28
		9a West	-0.025	0.07	3.53	0.11	43.3	0.05	0.619	0.03	15212	0.07	0.061	0.18	265984	0.23
	IEO (SAREVA)	9a North+8c	-0.018	0.08	1.78	0.11	75.6	0.05	0.505	0.08	29623	0.06	0.09	0.11	99989	0.20
		Total 8c9a			**6.25**	**0.07**									**496379**	**0.15**
2005	IPMA (PT-DEPM-PIL)	9a South	-0.021	0.07	1.96	0.16	45.4	0.07	0.574	0.11	13169	0.08	0.135	0.13	87103	0.26
		9a West	-0.018	0.08	2.18	0.12	46.2	0.06	0.556	0.06	15304	0.44	0.063	0.21	187676	0.51
	IEO (SAREVA)	9a North+8c	-0.018	0.08	3.48	0.12	80.7	0.04	0.51	0.07	34147	0.04	0.078	0.17	206668	0.23
		Total 8c9a			**7.63**	**0.08**									**481447**	**0.23**
2008	IPMA (PT-DEPM-PIL)	9a South	-0.03	0.1	4.12	0.14	56.3	0.06	0.489	0.07	20956	0.06	0.088	0.08	257403	0.19
		9a West	-0.024	0.07	3.87	0.10	59.3	0.03	0.593	0.03	26424	0.04	0.078	0.1	187640	0.15
	IEO (SAREVA)	9a North+8c	-0.018	0.09	3.27	0.09	83.9	0.04	0.482	0.06	35139	0.04	0.09	0.13	179983	0.18
		Total 8c9a			**11.27**	**0.07**									**625026**	**0.11**
2011	IPMA (PT-DEPM-PIL)	9a South	-0.028	0.09	1.49	0.16	54.3	0.07	0.498	0.09	17157	0.11	0.081	0.09	116566	0.24
		9a West	-0.021	0.07	0.40	0.18	50.1	0.06	0.496	0.04	11838	0.09	0.066	0.08	51502	0.23
	IEO (SAREVA)	9a North+8c	-0.017	0.09	1.54	0.11	85.9	0.03	0.487	0.12	40844	0.05	0.114	0.26	58304	0.31
		Total 8c9a			**3.43**	**0.09**									**226372**	**0.16**
2014	IPMA (PT-DEPM-PIL)	9a South	-0.027	0.09	1.07	0.16	60.72	0.05	0.602	0.08	22673	0.07	0.080	0.15	59500	0.25
		9a West	-0.023	0.07	1.27	0.12	52.63	0.14	0.505	0.06	21322	0.16	0.075	0.19	82767	0.31
	IEO (SAREVA)	9a North+8c	-0.016	0.12	0.29	0.14	48.70	0.11	0.397	0.15	17118	0.12	0.093	0.34	22346	0.43
		Total 8c9a			**2.63**	**0.09**									**164613**	**0.19**
2017	IPMA (PT-DEPM-PIL)	9a South	-0.026	0.07	2.18	0.14	47.39	0.11	0.609	0.08	16546	0.13	0.054	0.18	182486	0.29
		9a West	-0.026	0.07	1.11	0.16	57.82	0.11	0.637	0.07	20444	0.07	0.061	0.08	84099	0.22
	IEO (SAREVA)	9a North+8c	-0.017	0.94	0.38	0.15	50.95	0.06	0.505	0.06	20698	0.07	0.115	0.16	16129	0.25
		Total 8c9a			**3.68**	**0.1**									**282714**	**0.2**
2020	IPMA (PT-DEPM-PIL)	9a South	-0.03	0.07	3.54	0.24	38.8	0.15	0.568	0.08	14176	0.15	0.05	0.22	341164	0.39
		9a West	-0.023	0.06	2.23	0.2	45.4	0.16	0.587	0.07	16637	0.17	0.072	0.24	143984	0.4
		9a North+8c														
		Total 8c9a			**5.77**	**0.17**									**630692**	**0.3**
2021		9a South														
		9a West														
	IEO (SAREVA)	9a North+8c	-0.015	0.11	1.74	0.1	56.85	0.07	0.492	0.08	21546	0.09	0.111		84067	0.17
		Total 8c9a														
2023	IPMA (PT-DEPM-PIL)	9.a South	-0.029	0.08	1.64	0.18	43.39	0.15	0.422	0.12	18172	0.15	0.041	0.41	226326	0.51
		9.a West	-0.02	0.06	2.95	0.12	36.7	0.1	0.556	0.04	15388	0.1	0.044	0.18	287593	0.26
	IEO (SAREVA)	9.a North + 8.c	-0.021	0.06	2.37	0.11	58.31	0.06	0.516	0.06	23718	0.06	0.089	0.14	126874	0.21
		Total 8c9a			**6.96**	**0.08**									**640793**	**0.22**

Note: Eggs and adult parameters for the ICES Subdivision 9a North and Division 8c were 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) by 1.3 (see section 4.4.2.1 and WD, Díaz et al., 2020, for the analyses that resulted in this index). In 2021, to avoid a large information gap in the historical series of sardine DEPM data from the northern Atlantic Iberian waters and the Cantabrian Sea (ICES divisions 9aN and 8c), the IEO decided to carried out the SAREVA 0321 survey to estimate the sardine spawning biomass through the area.

4.1.4.4 Summer acoustic survey (ECOCÁDIZ): 9a South

The *ECOCADIZ 2023-07* Spanish (pelagic ecosystem-) acoustic-trawl survey was conducted by IEO between July 29th and August 8th 2023 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cádiz (GoC) onboard the R/V *Ramón Margalef*. For more details see section 4.1.1.4.

Age-structure of the 2023 acoustic estimates was not available to the WG. The information provided in the following sections only corresponds to a review of the time-series, with special reference to the last available data in 2023.

Sardine mean weight and length-at-age

Figure 4.53 shows the mean length- and weight at age along the time-series. These estimates are available since 2015, but no information is available for these variables since 2021 on. The 2023 summer estimates of mean size and weight for the whole population (14.1 cm, 27.1 g) not experienced great changes in relation to the previous year estimates. Mean length in summer 2023 was close to the historical average (15.0 cm) and mean weight was higher than the historical mean value (22.8 g), a probable consequence of the relative importance of a secondary modal component (at the 18.5 cm size class) in the estimated population biomass. In recent years increased mean length and weight were also recorded in age-0 and age-1 groups, whereas the opposite trend was observed in the age-2 and age-3 groups.

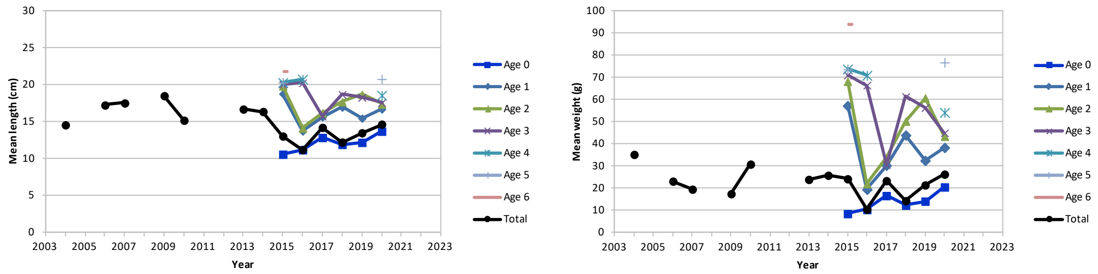


Figure 4.53 Sardine mean length and weight at-age throughout the ECOCADIZ Gulf of Cadiz summer acoustic surveys series (gaps mean no survey). This series has temporarily been suspended in 2021 and 2022. No age-structured estimates from the 2023 survey.

Sardine biomass and abundance estimates

GoC sardine was widely distributed all over the surveyed area in summer 2023 with high density areas being recorded in the inner-shelf parts of the GoC. Sardine abundance (2294 million fish) and biomass (62 216 t) estimates (Figure 4.54) increased (19% in abundance and 22% in biomass), when compared to 2020 estimates (1923 million and 50 720 t), but with no increasing or decreasing trend clearly detected. Sizes of the assessed sardine population in summer 2023 ranged between 9.5 and 20.5 cm size classes, showing a clearly bimodal length frequency distribution, with one main mode at 10.5 cm size class, a secondary one at 18.0 cm and a third smaller mode at 13.0 cm. Spanish waters accounted for 65% and 30% of the total estimated abundance and biomass, respectively, but recorded relatively low population levels (1481 million and 18 973 t), mainly supported by small sardines (9.5-13.0 cm). The estimates for Portuguese waters were 813 million and 43 243 t, where larger, heavier sardines were observed. No information on the age structure of the estimated population in 2023 is available to the WG.

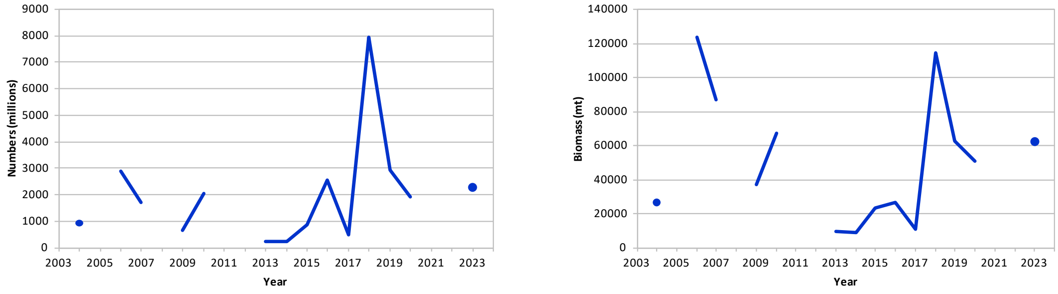


Figure 4.54 Sardine abundance (million fish) (left) and biomass (t) (right) estimates through the ECOCADIZ Gulf of Cadiz summer acoustic surveys series (gaps mean no survey). This series has temporarily been suspended in 2021 and 2022. No age-structured estimates f

4.1.4.5 Autumn acoustic survey (ECOCÁDIZ-RECLUTAS): 9a South

A summary of the descriptive characteristics of the *ECOCADIZ-RECLUTAS 2023-10* survey is reported in section 4.1.1.5. A detailed survey report is given by Ramos *et al*. (WD 2023b). Age structure of the 2023 acoustic estimates was not available to the WG. The information provided in the following sections corresponds to an update (*i.e* age-structured estimates) of the 2022 data not showed in the last year's report and the last available size-based data provided by the 2023 survey.

Sardine mean weight and length-at-age

Figure 4.55 shows the mean length- and weight at age in the assessed population along the time-series. Estimates are available since 2014 on (the 2012 estimates only correspond to the Spanish waters and the 2017 estimates to only a part of the Spanish waters, because a RV's breakdown). The 2023 age-based data are not yet available. The 2022 autumn estimates of mean size and weight at age have been provided and presented in this WG.

The 2022 estimates for the whole population (13.5 cm, 19.3 g) experienced a notable decrease in relation to the previous years, especially the mean weight, and they were well below to the time-series averages in that moment (i,e. 15.9 cm, 39.3 g). All the age groups in autumn 2022 did show clear decreases in mean size and mean weight with respect to the previous most recent estimates.

The above decreasing trend in both descriptive parameters seems to be continuing in 2023, at least for the whole population, the only available information for the time being, with mean size and weight estimated at 12.1 cm and 12.9 g, respectively, values that are still well below their updated time-series averages (15.6 cm, 36.8 g), especially the mean weight.

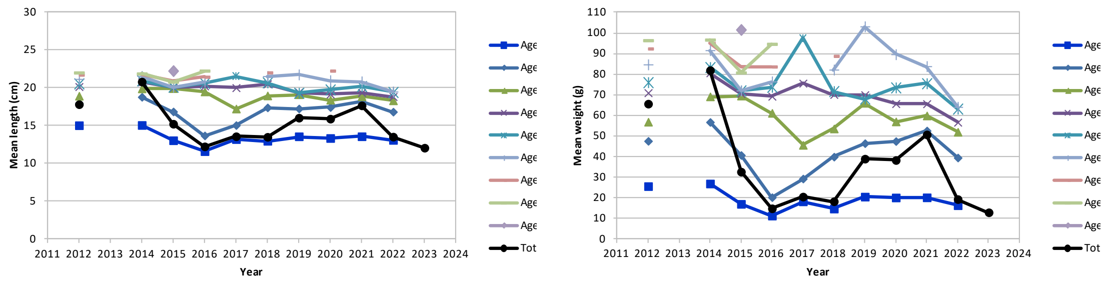


Figure 4.55 Sardine mean length and weight at-age throughout the ECOCADIZ-RECLUTAS Gulf of Cadiz autumn acoustic surveys series (gaps mean no survey). The 2012 estimates correspond to the Spanish waters only. The 2017 estimates correspond to a part of the Spanish waters only because a breakdown of the RV's propelling system. The 2022 estimates are shown by age group and for the whole population (not available last year). Age-structured estimates from the 2023 survey are not yet available.

Sardine biomass and abundance estimates

No acoustic estimates were available to the last year's WG from the 2022 autumn survey because the closeness of its ending dates to the starting dates of the meeting. Such estimates will be presented in this section together with those ones from the 2023 survey. In this last case, age-based acoustic estimates are not yet available and, therefore, neither the corresponding age 0-based recruitment index.

GoC sardine abundance and biomass in autumn 2022 were estimated at 1085 million fish and 20 909 t, amongst the lowest records within its respective series. Such values were 63% and 86% lower than 2021 estimates (2985 million and 151 320 t, one of the highest records in the series; Figure 4.56. Spanish waters comprised the 59% and 64% of the total estimated abundance and biomass, respectively (648 million and 13 255 t). The estimates for Portuguese waters were 437 million and 7 654 t.

Age-5 group was the oldest age group occurring in the GoC population in autumn 2022, although the occurrence of fishes older than Age-0 juveniles was very low. Thus, the population was mainly composed by these juvenile fishes, accounting for 91% (992 million) and 77% (16 177 t) of the total abundance and biomass, respectively. Age-0 sardines in autumn 2022 showed only a very slight increase in relation to the 2021 estimates. The abundance and biomass of this juvenile fraction was quite similar for both in Spanish (57% of both abundance and biomass) and Portuguese waters (43% of both abundance and biomass).

In autumn 2023 GoC sardine abundance and biomass were estimated at 2125 million fish and 27 372 t, which respectively were 96% and 30% higher than 2022 estimates (Figure 4.56). Spanish waters comprised the 96% and 93% of the total estimated abundance and biomass, respectively (2041 million and 25 474 t). The estimates for Portuguese waters were only 84 million and 1 898 t. Sizes of the assessed sardine population in autumn 2023 ranged between 9.5 and 22.0 cm size classes, showing a bimodal length frequency distribution, with one main mode at 12.5 cm size class and a secondary one at 18.5 cm. The largest fish mainly occurred in 2 spots located in western Algarve and in front of Bay of Cádiz, whereas the smallest fish were observed in the coastal waters of the central part of the Spanish waters.

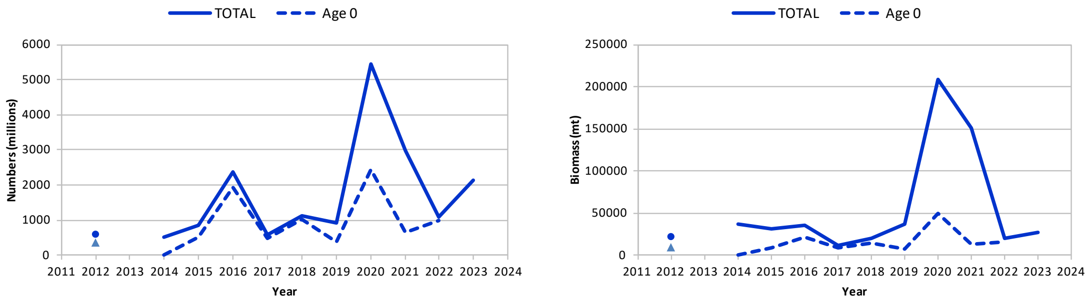


Figure 4.56 Sardine abundance (million fish) (left) and biomass (t) (right) estimates for the whole population and Age-0 fish through the ECOCADIZ-RECLUTAS Gulf of Cadiz autumn surveys series (gaps mean no survey). The 2012 estimates correspond to the Spanish water.

4.1.4.6 Autumn acoustic survey (IBERAS): 9a West

Sardine mean weight and length-at-age

Mean weights and length-at-age of sardine were calculated from the biomass and abundance at age estimated for the JUVESAR and IBERAS survey series in the western part of subdivision 9a. Figure 4.57 show the evolution of mean weight-at-age and mean length-at-age for sardine in the areas 9aN, 9aCN, and 9aCS. A long-term decreasing trend may be observed in mean weight and length-at-age of 1 to 6 years old sardines. Mean weight and length-at-age of 1+ sardines is generally higher in 9aN. Mean weight at age 0 decreased in 2022 and increased in 2023 in subdivisions 9aN and 9aCN. The opposite was observed in subdivision 9aCS, where the decrease in 2023 was significant.

Figure 4.57 Evolution of mean weight-at-age (left) and length-at-age (right) of sardine along JUVESAR-IBERAS series in areas 9aN, 9aCN, and 9aCS.

Surveys were conducted in November-December between 2015 and 2017 and anticipated to September since 2019, but no consistent effect of this change is detected in mean weight and length-at-age.

Sardine biomass and abundance estimates in Division 9a West

Sardine biomass and abundance trends for age group 0 and all ages in JUVESAR and IBERAS surveys is depicted for areas 9aN, 9aCN, and 9aCS separately (Figure 4.58), and for the whole survey (Figure 4.59). The highest abundance and biomass of age 0 sardines were observed in 2020 and 2022, mainly located in area 9CN. The highest abundance of age 0 sardines is recurrently located in the subdivision 9aCN, with exception of the years 2016, 2017 and 2023, where most age 0 individuals were recorded in subdivision 9sCS. The highest number of age 0 sardines in this time series was recorded in 2022, with an increase from 946 billion in 2021 to 8007 billion in 2022. In 2023, the number of age 0 sardines decreased to 2722 billion, 94.4% of these located in subdivision 9aCS, i.e. south of the main recruitment area. As these surveys target juveniles, do not cover the outer continental shelf, and had several changes in the extent of the sampled area through time, the total abundance and biomass (all ages) is merely indicative and may not be even comparable from year to year.

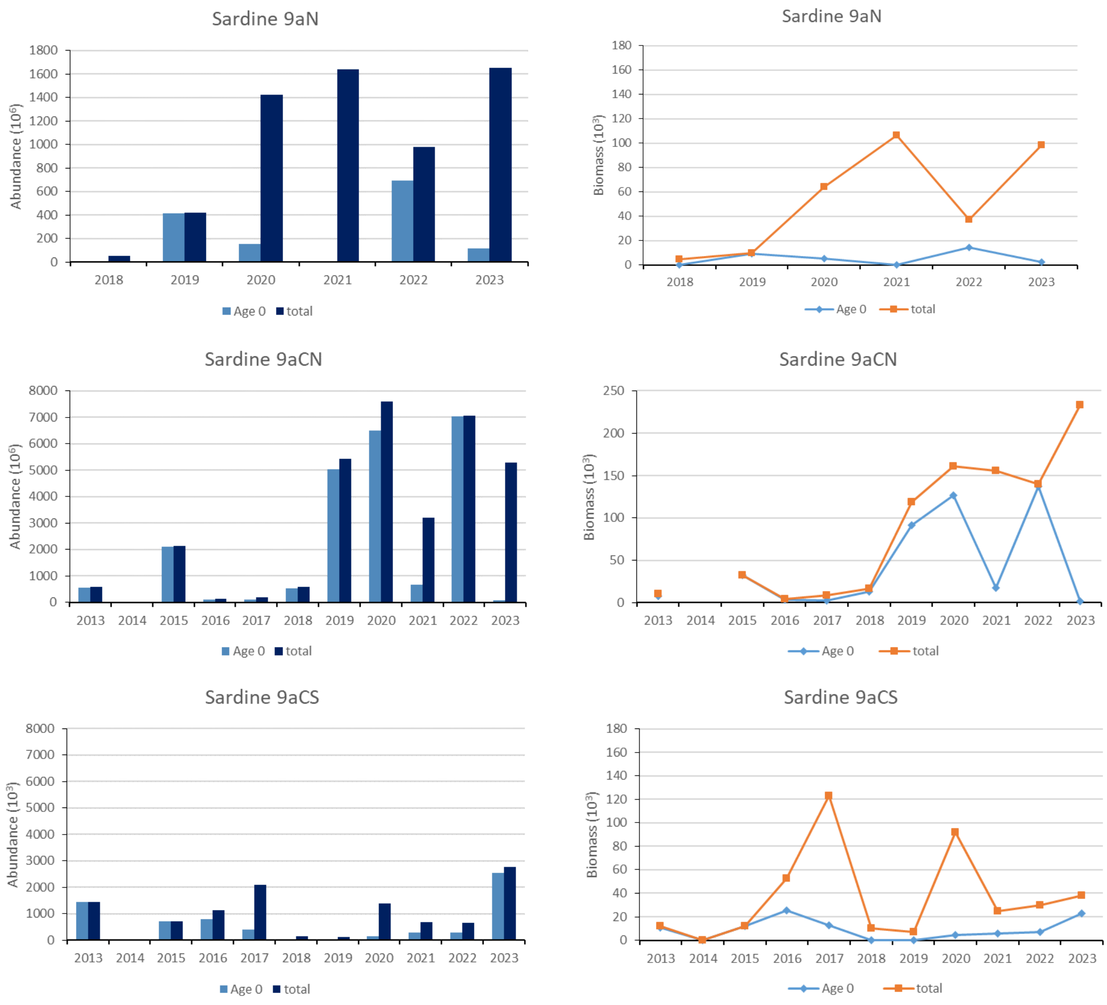


Figure 4.58 **Sardine regional biomass and abundance trends (age 0 and total) in JUVESAR and IBERAS surveys.**

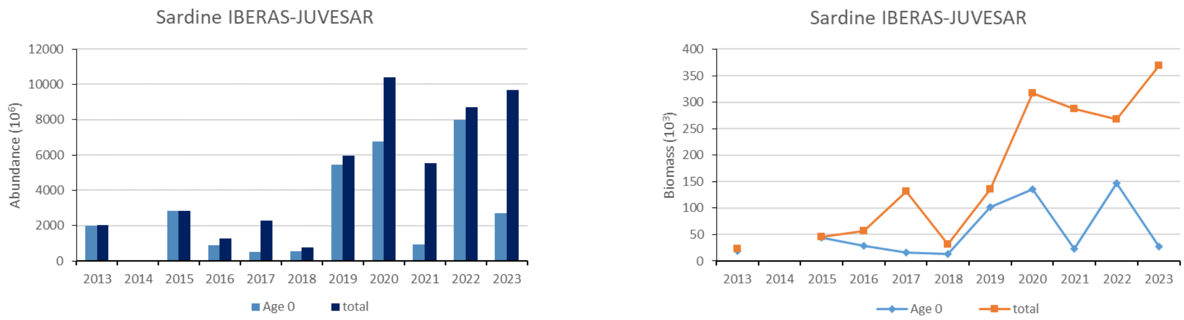


Figure 4.59 **Sardine biomass and abundance trends (age 0 and total) in JUVESAR and IBERAS surveys series (all surveyed area).**

4.1.5 Sardine in Division 8abd

4.1.5.1 Acoustic spring survey (PELGAS): 8ab

Sardine biomass and abundance estimates

Sardine biomass and abundance in ICES area 8ab have been calculated since 2000, based on acoustic and trawl data from PELGAS survey (cf. details in Doray et al. 2021) (Figure 4.60 and Figure 4.61).

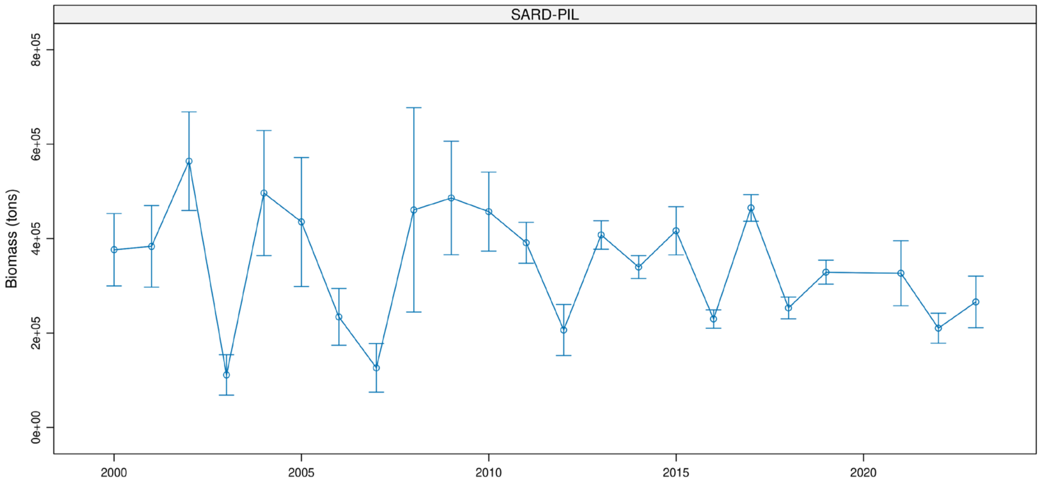


Figure 4.60 Time series of biomass estimates and CVs for spring sardine in ICES area 8ab, derived from PELGAS survey data.

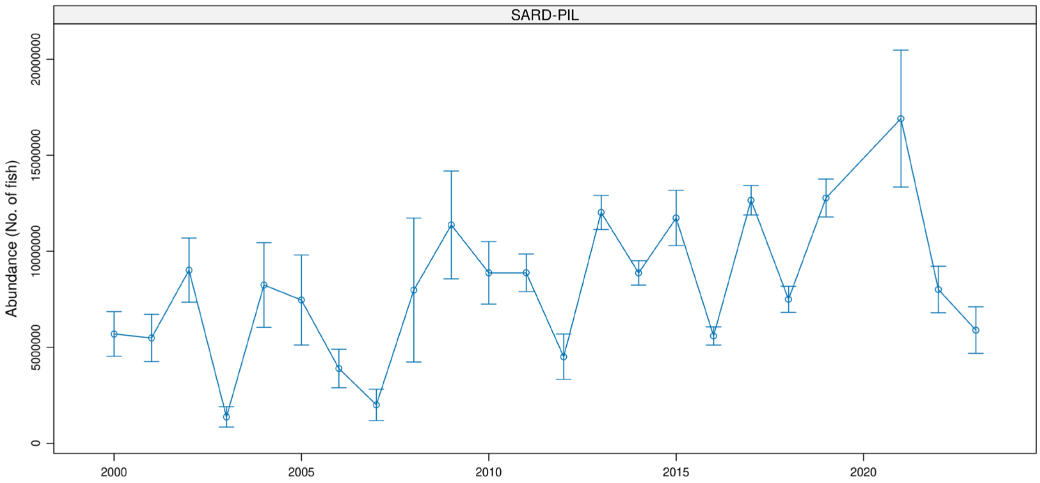


Figure 4.61 Time series of abundance estimates and CVs for spring sardine in ICES area 8ab, derived from PELGAS survey data.

Sardine acoustic biomass estimates in areas 8ab were on average stable from 2000 to 2017, with oscillations. They have slightly dropped since 2018. Sardine acoustic abundance estimates in areas 8ab have increased since 2007, with oscillations.

Sardine mean weight and length-at-age

Sardine mean weights and lengths-at-age in ICES area 8ab were calculated based on abundance-at-length, length-age and length-weight keys from PELGAS survey (cf. details in Doray et al. 2021). Time series of sardine mean weights and lengths-at-age are presented in Figure 4.62 and Figure 4.63.

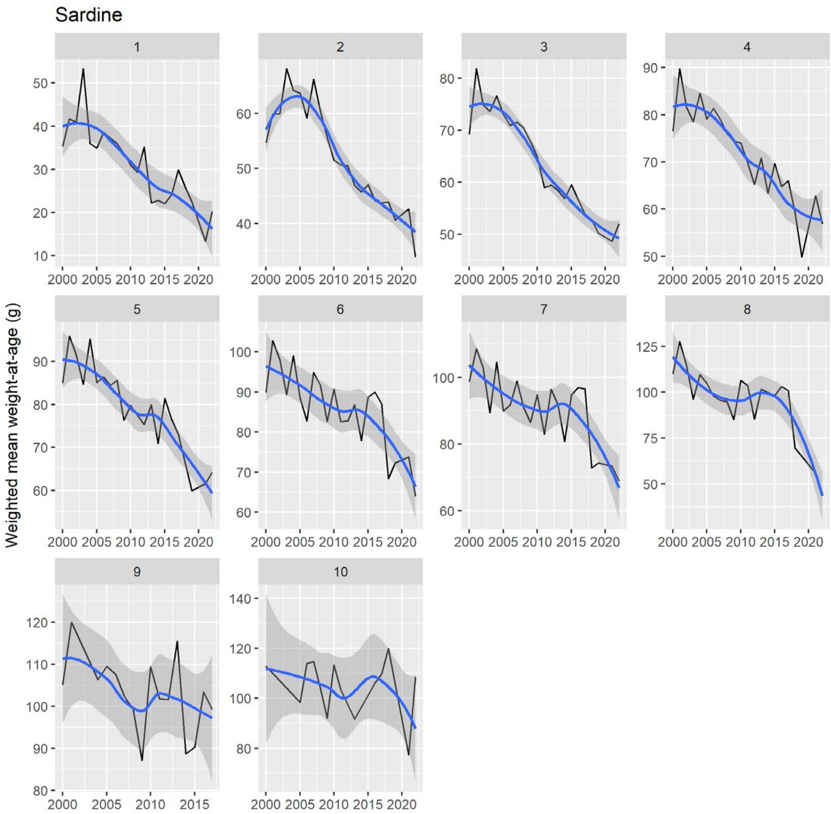


Figure 4.62 8ab Sardine mean weight at-age, PELGAS survey.

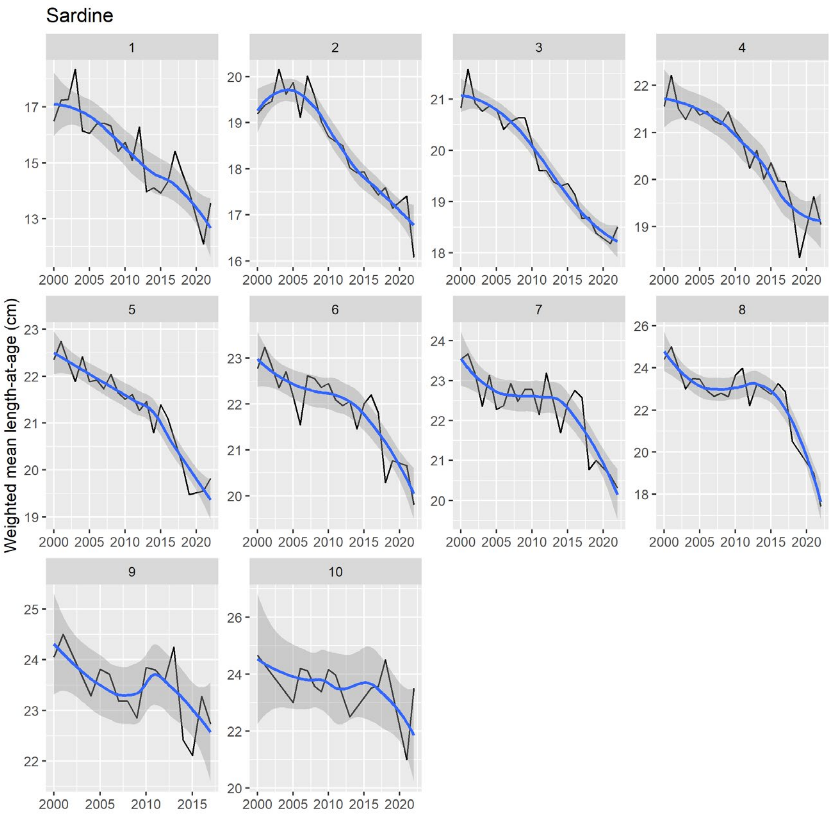


Figure 4.63 8ab Sardine mean length at-age, PELGAS survey.

Sardine mean weights and lengths-at-age in ICES area 8ab have been decreasing since 2005 (Figure 4.62 and Figure 4.63). Sardine mean weights-at-age have decreased by 20 to 30 g within 20 years, while mean lengths-at-age have decrease by 2 to 3 cm

4.1.5.2 Spring DEPM survey (BIOMAN): 8abcd

Currently, the triennial SSB and its CV since 2011 and the total egg abundance series (1999-2023) derived from this survey are used as inputs for the assessment of sardine in area ICES 27.8 abd

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 biomass at age in the Bay of Biscay (8abcd) and the egg abundance of sardine in 8abd. Triennially, the SSB of sardine was as well estimate since 2011. Since 2020 the SSB for sardine is estimate annually by the DEPM as well as the numbers at age, percentage at age, weight at age and length at age to be available as inputs for future assessments.

Survey description

The BIOMAN survey took place from the 3rd to the 26th of May. All the methodology concerning the survey and the estimates performance, are described in detail in stock annex - Sardine (*Sardina pilchardus*) in divisions 8.a–b and 8.d (Bay of Biscay) https://doi.org/10.17895/ices.pub.18623198.

A detailed report of the survey and results from 2023 in the link to the working document doi:10.13140/RG.2.2.10327.24485 (Santos Mocoroa. M *et al*. BIOMAN 2023).

This year the sardine eggs were scarce in the Cantabrian Sea without reaching the 200m depth isoline. In the French platform, there were sardine eggs from South to North all along the East of the 100m depth isoline area in general. Similar distribution to last year.

In the sampling with the PairoVET net (vertical sampling) from 778 stations a total of 276 (35%) had sardine eggs with an average of 108 eggs m^{-2} per station in the positive stations, a maximum of 1640 egg m^{-2} in a station and a total number of 29770 eggs m^{-2}. In the sampling with CUFES (horizontal sampling) a total of 607 stations (33%) had sardine from 1824 stations, with an average of 4.3 eggs m^{-3} per station in the positive stations and a maximum of 78 egg m^{-3} in a station.

Sardine Egg parameters estimates

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 estimates for assessment propose was 2.88E+12 eggs, considering the 8abd and removing part of the North-west, to be consistent with the historical series. It was below the time series average (5.68E+12) (Figure 4.64, Table 4.12).

The daily egg production (P_0) (eggs /m²), daily mortality rates (z) and total daily egg production (P_{tot})(eggs) estimates were obtained (Table 4.13). This year the historical series of these parameters were as well estimated for all the area surveyed (Figure 4.65), for 8abd and for 8abd without part of the Northwest to be consistent with the historical series.

Apart from the frequentist method that was applied up to now, to estimate P_0, z and P_{tot}, a Bayesian method was study (Citores et all, 2023 *in press*) with the aim to avoid incurring in incorrect sign for z. This was applied for all the historical series (Figure 4.66). In general, Bayesian and frequentist approaches led to very similar point estimates and associated variances of the key parameters.

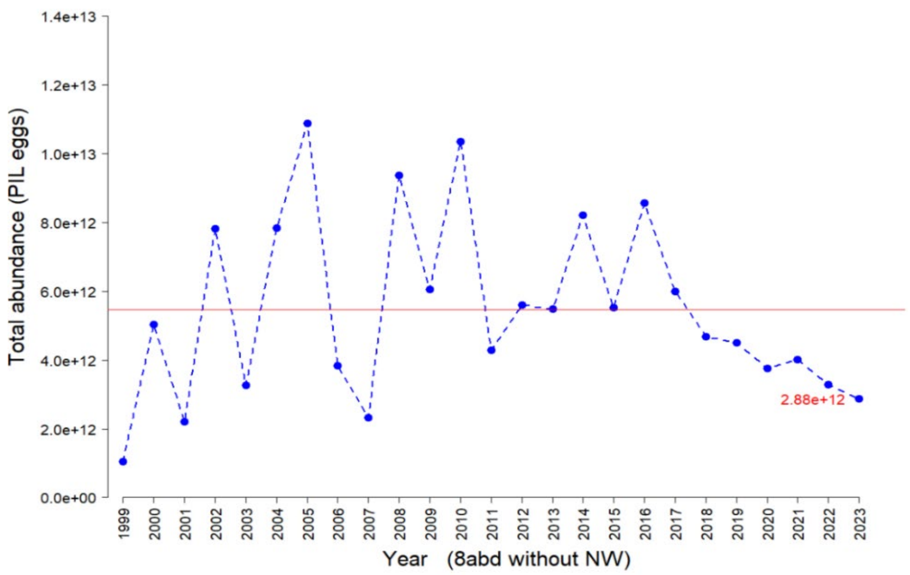


Figure 4.64 Historical series for sardine total egg abundances (eggs) in 8abd without the northwest part, the one for assessment proposes to be consistent with the historical series. The red line is the historical series average.

Table 4.12 Sardine in 8abd. Time-series for sardine, total egg abundances (⍰(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	totAb8abdwithoutNW
1999	1.06E+12
2000	5.03E+12
2001	2.20E+12
2002	7.82E+12
2003	3.26E+12
2004	7.83E+12
2005	1.09E+13
2006	3.84E+12
2007	2.33E+12
2008	9.37E+12
2009	6.05E+12
2010	1.03E+13
2011	4.29E+12
2012	5.60E+12
2013	5.47E+12
2014	8.21E+12
2015	5.52E+12
2016	8.56E+12
2017	5.99E+12
2018	4.67E+12
2019	4.49E+12
2020	3.75E+12
2021	4.02E+12
2022	3.29E+12
2023	2.88E+12

Table 4.13 Daily egg production (P0) (eggs/m²), daily mortality rates (z) and total daily egg production (Ptot)(eggs) estimates from the frequentist method and their corresponding standard error (S.e.) and coefficient of variation (CV) for all the area surveyed, 8

	ALL AREA			8abd			8abdwithoutNW		
Parameter	**Value**	**S.e.**	**CV**	**Value**	**S.e.**	**CV**	**Value**	**S.e.**	**CV**
P0	58.26	8.37	0.1436	63.66	9.53	0.1498	52.33	8.19	0.1565
z	0.27	0.101	0.3763	0.32	0.105	0.3290	0.22	0.112	0.5030
Ptot	2.1.E+12	3.1.E+11	0.1436	2.2.E+12	3.3.E+11	0.1498	1.5.E+12	2.4.E+11	0.1565

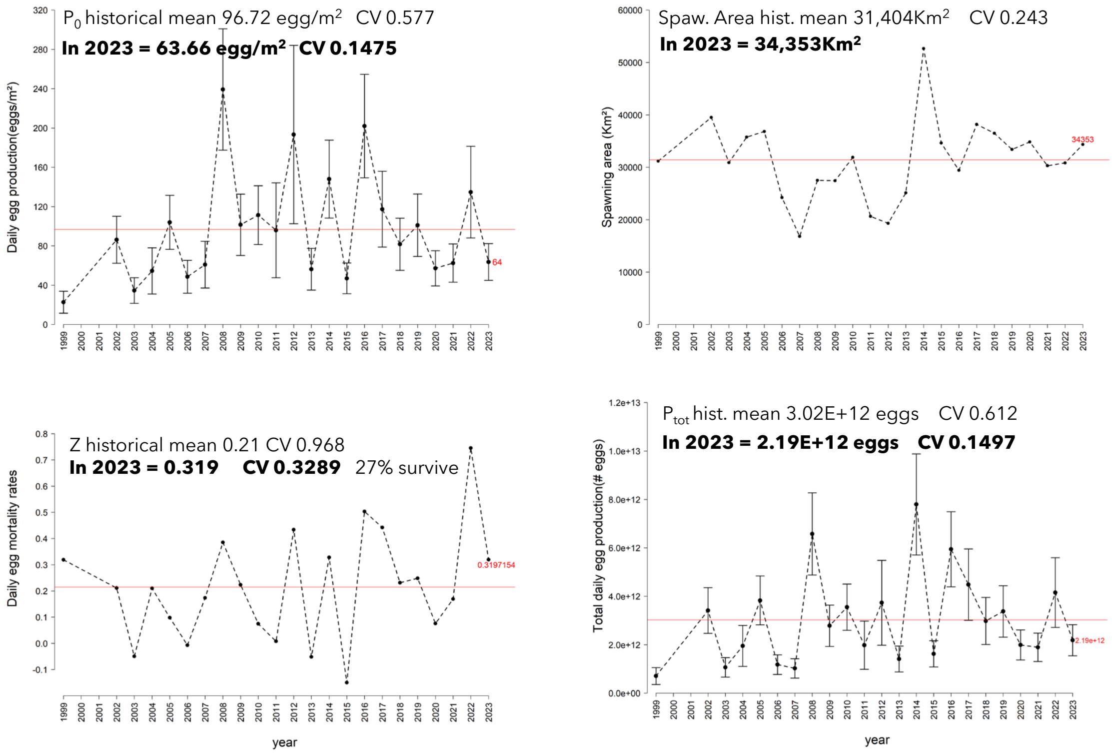


Figure 4.65 Historical series including 2023 estimates for daily egg production (P0) (egg/m²/day), spawning area (Km²), daily mortality rates (z) and total daily egg production (Ptot)(eggs/day) for sardine in the Bay of Biscay (ICES 8abcd). The red line is the historical mean.

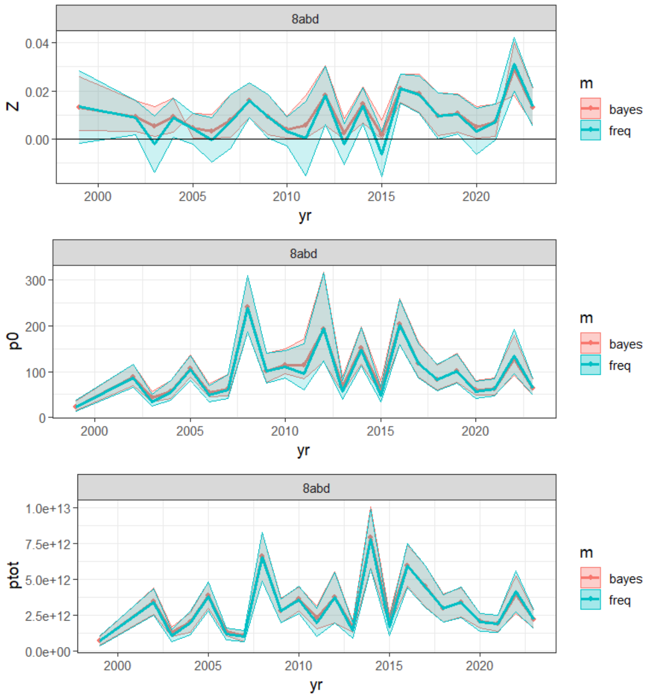


Figure 4.66 Point estimates (joined points) and 95% confidence intervals (shaded ribbons) for estimated parameters daily mortality rates (z), Daily egg production (P0) (eggs/m²) and total daily egg production (Ptot)(eggs) for all the historical series. Colours represent two different approaches: the Bayesian approach in red and the frequentist approach in blue. Frequentist confidence intervals are computed as mean ± 1.96se. These estimates are for the ICES 8abd.

Daily Fecundity and spawning stock biomass estimates in the Bay of Biscay

To estimate the spawning stock biomass (SSB) 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 sardine adults from the survey were used to estimate those parameters. 20 adult hauls were available. All the samples were processed, and the histology analysis and oocytes count were conducted. All the estimates were obtained from the mature population of 17 samples that represent 63 % of the individuals. This year one of the samples was pure immature and another one almost all immature and were eliminated for the SSB estimated (Table 4.14). Another sample was eliminated for being outside the 8abd. The results of the adult parameters are showed in table (Table 4.15). The final SSB obtained as the quotient between P_{tot} and DF was 200, 572 t with a CV of 0.3703. Numbers at age, percentage at age, SSB at age, length at age and weight at age are showed in Table 4.16

Table 4.14 Percentage of mature population with the 17 samples used for the DEPM estimates after eliminating 3 samples. And with all the samples obtained (20 samples) including the immature ones.

% mature in numb	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
3 hauls eliminated	63%	97%	100%	100%	100%	100%	100%
All hauls	57%	98%	100%	100%	100%	100%	100%

Table 4.15 Sardine spawning stock biomass (SSB) in Division 8abd, with the estimates of adult parameters for applying the DEPM: 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 with their standard error (S.e) and coefficient of variation (CV). Total egg production (Ptot)(eggs) estimate is showed as well.

Parameter	**estimate**	**S.e.**	**CV**
Ptot	2.19E+12	3.3E+11	0.1498
R'	0.53	0.007	0.0123
S	0.06	0.018	0.3163
F	17,399	2,246	0.1291
Wf	43.17	3.26	0.0756
DF	12.13	4.11	0.3387
SSB	**200,572**	74,269	0.3703

Table 4.16 Sardine spawning stock biomass (SSB) in Division 8abd, with information on the percentage at age, numbers at age, percentage at age in mass, spawning stock biomass at age in mass with the correspondent standard error (S.e.) and coefficient of variation (CV) from BIOMAN 2023. As well as the biological features mean weight at age(g) and mean length at age(mm).

SSB	**200,572**	74,269	0.3703
Wt	38.71	1.89	0.0489
Population (millions)	5,175	1865	0.3604
Percentage at age 1	0.18	0.079	0.4313
Percentage at age 2	0.39	0.076	0.1978
Percentage at age 3	0.26	0.056	0.2177
Percentage at age 4	0.08	0.038	0.4810
Percentage at age 5	0.07	0.036	0.5295
Percentage at age 6+	0.03	0.015	0.5627
Numbers at age 1	940	467.7	0.4973
Numbers at age 2	1,969	778.6	0.3954
Numbers at age 3	1,352	625.5	0.4627
Numbers at age 4	427	291.0	0.6809
Numbers at age 5	337	203.8	0.6043
Numbers at age 6+	148	111.3	0.7507
	0.14	0.066	0.4740
	0.37	0.084	0.2309
Perc. at age 3 in mass	0.28	0.050	0.1818
Perc. at age 4 in mass	0.09	0.041	0.4371
Perc. at age 5 in mass	0.09	0.043	0.5006
Perc. at age 6+ in mass	0.04	0.021	0.5370
SSB at age 1 (Tons)	27,279	13,380	0.4905
SSB at age 2 (Tons)	72,432	29,065	0.4013
SSB at age 3 (Tons)	56,386	26,286	0.4662
SSB at age 4 (Tons)	19,680	13,259	0.6737
SSB at age 5 (Tons)	16,509	9,954	0.6029
SSB at age 6+ (Tons)	8,285	6,290	0.7592

Biological Features	**estimate**	**S.e.**	**CV**
Weight at age 1 (g)	29.8	0.47	0.0157
Weight at age 2 (g)	37.3	0.89	0.0238
Weight at age 3 (g)	41.7	0.80	0.0191
Weight at age 4 (g)	45.3	0.91	0.0202
Weight at age 5 (g)	48.7	1.68	0.0344
Weight at age 6+ (g)	54.5	1.79	0.0328
Lenght at age 1 (cm)	160.5	0.47	0.0029
Lenght at age 2 (cm)	172.6	0.73	0.0042
Lenght at age 3 (cm)	180.4	1.62	0.0090
Lenght at age 4 (cm)	188.7	1.78	0.0094
Lenght at age 5 (cm)	192.9	2.85	0.0148
Lenght at age 6+ (cm)	200.9	2.54	0.0126

4.1.5.3 Autumn acoustic survey (JUVENA): 8abcd

The mean length and weight of sardine experienced a continuous decrease during 5 years, from 2011-2016, but a succession of highs and lows along the following years describe a general increasing trend of the means reaching 28 gr and 15 cm of length this year, but still under the mean of the temporal series.

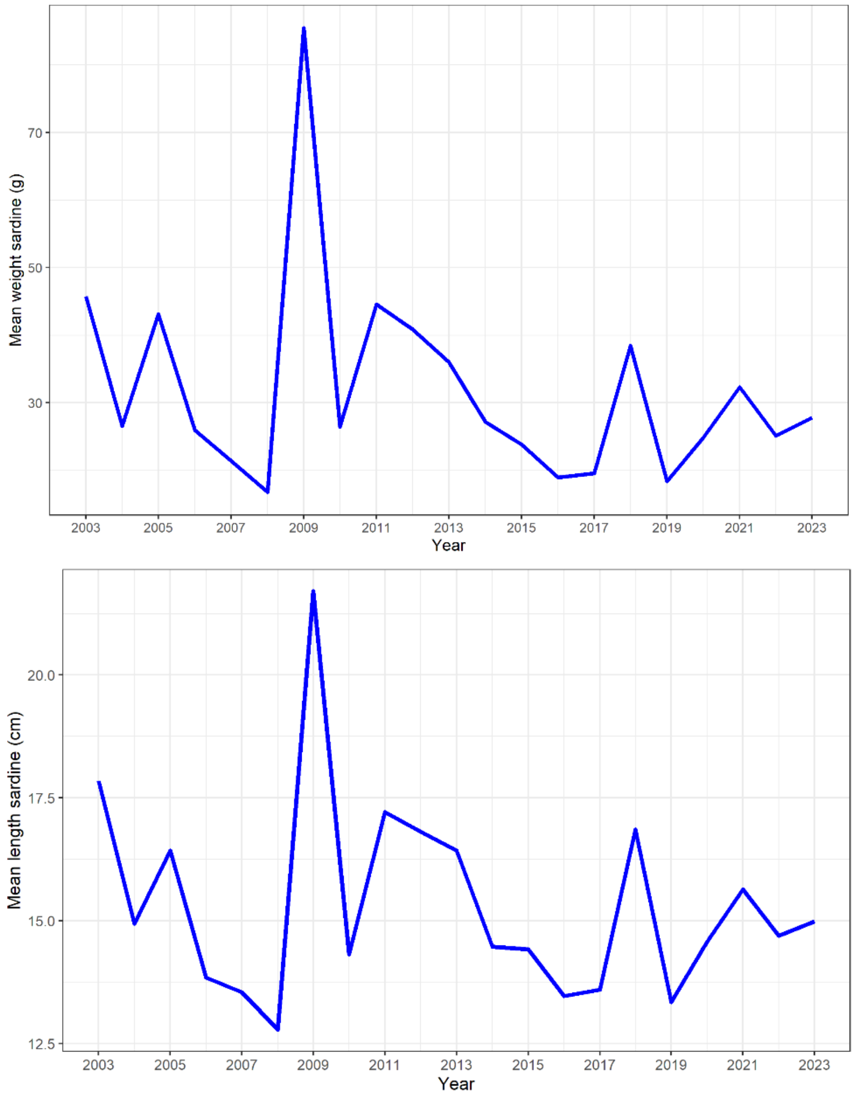


Figure 4.67 Evolution of mean weight (above) and length(below) of sardine along JUVENA series in subdivision 8abcd.

Sardine was mainly distributed between 45° and 47°N, well close to the French coast, specially near the Garonne and Loire River plumes, as expected from the temporal series. Some sardine was also observed in the Cantabrian Sea, but remarkedly less than in the previous year. The biomass of sardine was ~133,000 tones, still among the highest values of the temporal series. This year most of the sardine biomass was age 1, unlike last year when it was almost all age 0.

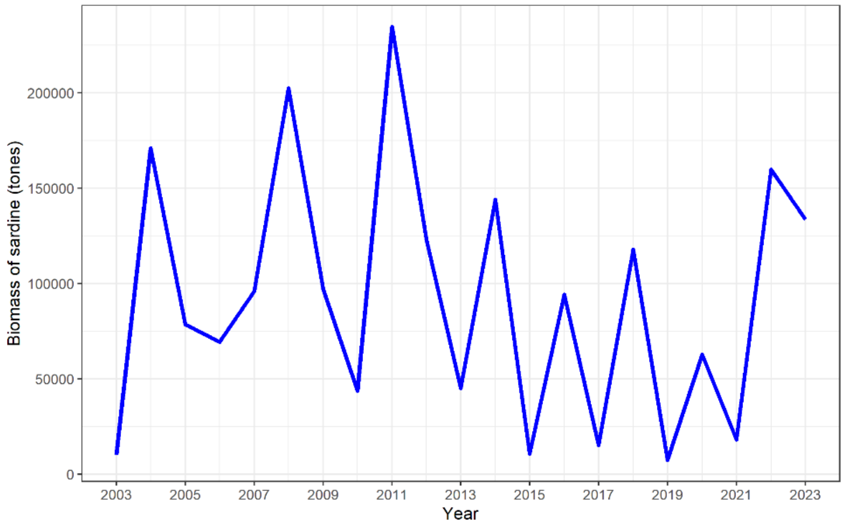


Figure 4.68 Sardine biomass trend during JUVENA surveys in division 8abcd.

4.1.6 Sardine in Division 7

4.1.6.1 Autumn acoustic survey (PELTIC): 7ef

In 2017, sardine in division 7e,f was separated from those in the Bay of Biscay (8abcd), prior to which sardine in areas 7 and 8 were assessed as a single stock unit. The 2017 split meant that sardine in area 7 was data limited. At a benchmark (WKWEST, 2021) the total area of the PELTIC survey series (from 2017, see Figure 4.69) was accepted as a suitable source of fisheries independent data for inclusion in the assessment of sardine in area 7e,f. Due to the relatively short PELTIC time-series several assessment models tested during the benchmark had too much uncertainty, and the sardine assessment was therefore based on trends in total biomass (Figure 4.38). Further efforys to improve the assessment model are underway.

Figure 4.69 Trends in autumn sardine total biomass in ICES area 7 from the PELTIC time-series for two survey areas: the original core survey area covering only UK waters of ICES divisions 7e,f (red line and associated with red stratum on map) from 2013 and the Total Area capturing the whole of ICES 7e,f (blue line, and corresponding map). Please note that in 2022 due to vessel issues only the western Channel stratum of the Core Area was surveyed. The 2022 biomass value for the total area was extrapolated at ICES WGHANSA using the ratio of previous years.

The 2023 biomass was the highest of the PELTIC time series at 456,482 t (CV 0.19). The highest sardine densities were found around the Isles of Scilly and south of west Cornwall. The coincidence of highest numbers of eggs in the plankton samples at these sites confirmed that these were spawning aggregations. Sardine was widespread with higher than usual numbers also found in the Bristol Channel and in Cardigan Bay.

4.1.7 Sprat in Division 7

4.1.7.1 Autumn acoustic survey (PELTIC): 7ef

The total stock biomass of sprat in the English Channel, provided by the PELTIC survey, feeds into the stock assessment of sprat in 7de. Only data from a small area in the western English Channel (English waters of 7e, see blue stratum “WC” in Figure 4-39), consistently sampled since 2013, is included in the assessment (Figure 4.70). As this does not represent the full extent of the management unit (by excluding French waters of 7e and the whole of 7d), this biomass can be considered an underestimate. Recent efforts to establish the stock structure of sprat in the NE Atlantic (McKeown et al., 2020) found no genetic evidence to separate the stocks in the North Sea, English Channel and the Celtic Sea. However, the consistent core distribution of western Channel sprat in Lyme Bay suggests that this population could be considered a separate unit from those found in other areas.

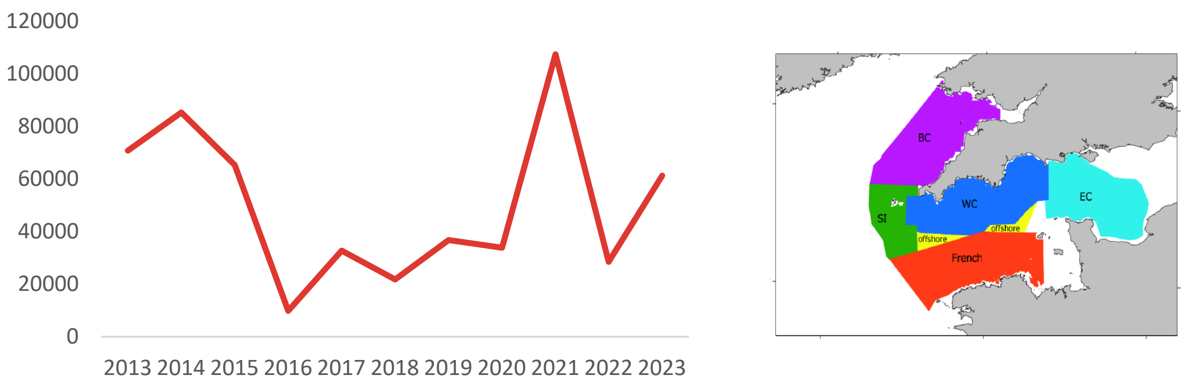


Figure 4.70 Trend in English Channel sprat biomass for the area consistently covered since 2013 (represented by the blue stratum: WC in map on right)

The 2023 sprat biomass in the western Channel of 61,270 t (CV 0.53) was up from 2022 and similar to long term average.

4.1.8 Herring in Division 7

4.1.8.1 Autumn acoustic survey (CSHAS): 7aS, 7g-j

Data from the 2023 survey is still being analysed and so no estimate is available for this year's report.

The 2022 estimate of biomass and abundance of herring at age and length are reported for consistency (Figure 4.71), as is the survey time-series (Table 4.17).

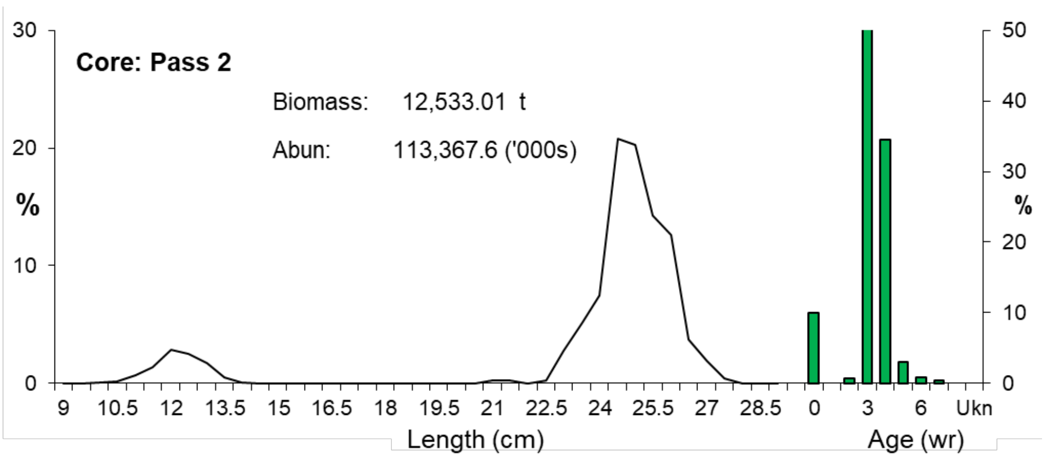


Figure 4.71 Age and length composition of herring standing stock biomass from the CSHAS 2022 survey in the Celtic Sea.

Table 4.17 Celtic herring acoustic survey time-series of total stock numbers and spawning stock biomass correct to 2022.

Age (wr) Year	0	1	2	3	4	5	6	7	8	9	TSN (mils)	SSB ('000t)	Design	CV
2002	0	42	185	151	30	7	7	3	0	0	423	41	AR	0.49
2003	24	13	62	60	17	2	1	0	0	0	183	20	AR	0.34
2004	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2005	2	65	137	28	54	22	5	1	0	0	312	33	ARS	0.48
2006	0	21	211	48	14	11	1	0	0	0	305	36	ARS	0.35
2007	1	106	70	220	31	9	13	4	1	0	454	46	ARS	0.25
2008	2	63	295	111	162	27	6	5	0	0	671	93	ARS	0.20
2009	239	381	112	210	57	125	12	4	6	1	1147	91	ARS	0.24
2010	5	346	549	156	193	65	91	7	3	0	1414	122	ARS	0.20
2011	0.1	342	479	299	47	71	24	33	4	2	1300	122	ARS	0.28
2012	31	270	856	615	330	49	121	25	23	3	2322	246	ARS	0.25
2013	3.8	698	291.4	197.4	43.7	37.9	9.8	4.7	0	0.2	1286	71	ARS	0.28
2014	0	41	117	112	69	20	24	7	17	1	408	48	ARM	0.59
2015	0	0	40	48	41	38	7	6	5	0	184	25	ARM	0.18
2016	0	125	21	43	40	36	25	5	6	0	301	30	CRM	0.33
2017	0	0	6	3	7	5	4	0	1	0	27	4	CRM	NA
2018	109	56	16	27	6	0	0	0	0	0	213	8	CRM	0.50
2019	87	19.5	0.1	0	0	0	0	0	0	0	106.9	0.009	CRM	0.55
2020	1	27.7	32.2	5	1	0	0	0	0	0	67	3.1	CRM	0.51
2021	25.3	0	1.7	3.5	0.3	0.1	0	0.1	0	0	310	6.6	CRM	0.44
2022	11.3	0	0.8	57.3	39.1	3.36	0.9	0.52	0	0	113	12.3	CRM	1.24

AR= Adaptive random, ARS= Adapt, random stratified, ARM= Adaptive random with mini surveys, CRM= Core random replicates with mini surveys

4.1.9 Horse Mackerel in Division 7 and 6

4.1.9.1 Summer acoustic survey (WESPAS): 7b-c, 7g, h, j and 6a

2022 Survey summary

The 2022 estimate of horse mackerel biomass and abundance is presented in Figure 4.72. Overall, the WESPAS survey provided continuous synoptic coverage from south to north over 42 days covering relating to an area coverage of almost 49,988 nmi^2 (horse mackerel strata) and transect mileage of over 5,084 nmi. In total, 40 trawl stations were undertaken with 15 hauls containing horse mackerel providing 215 individual lengths, length/weights and 257 otoliths for use during the analysis.

Of the seven strata surveyed, two contained horse mackerel; the Celtic Sea (33.9% of TSB) and the west coast stratum (66.1%). No echotraces were assigned to horse mackerel north of 53°N or the Porcupine Bank. Observations of horse mackerel along the west coast and Celtic Sea were comparable to previous years but lower in number and acoustic density. The overall acoustic density is the lowest in the time series.

The 2022 estimate is 21% lower in terms of biomass and 22% lower in terms of abundance compared to 2021. The 8-year-old fish dominated this year’s survey estimate representing 36.9% of TSB and 36.3% of TSN. Fourteen -year-old fish ranked second representing 7.6% of TSB and 7.8% of TSN and 5-year-old fish ranked third (5.5% to TSB & 7.6% TSN), Table 4.18. Combined these three age classes represented 56.8% of TSB and 56% of TSN. Otoliths collected during the survey were aged within year for inclusion into the age estimate. Maturity analysis of horse mackerel samples indicated 100% maturity.

2023 Survey summary

The 2023 estimate of horse mackerel biomass and abundance is presented in Figure 4.72. The WESPAS survey took place over 42 days relating to an area coverage of almost 61,486 nmi^2 (horse mackerel strata) and transect mileage of over 4,987 nmi. Survey effort and timing were comparable to 2022. In total, 53 trawl stations were undertaken, with 27 hauls containing horse mackerel providing 422 individual lengths, 383 length and weight measurements and 460 aged fish.

Horse mackerel TSB (total stock biomass) and abundance (TSN) estimates were 94,852.1 t and 342,763,900 individuals (CV 0.22) respectively. The 2023 estimate is almost 4 times greater in terms of biomass and abundance compared to 2022.

Overall, acoustic density was greater than in recent years and the total estimate represents the third highest in the time series (Table 4.18). Medium density and high density, monospecific aggregations of horse mackerel were encountered in the Celtic Sea and north of Scotland, the latter leading to the increased contribution of the northern strata to the total estimate. Horse mackerel were observed predominantly in the Celtic Sea (71% TSB) and to the north of Ireland and west of Scotland, representing 28% combined. No echotraces were assigned to the Porcupine Bank. The west coast strata contributed <1% of TSB as compared to 66% in 2022.

Nine-year-old fish dominated this year's survey estimate representing 29% of TSB and 26% of TSN. Six-year-old fish ranked second representing 17% of TSB and 20% of TSN, and 15-year-old fish ranked third (12% to TSB & 9% TSN). Combined these three age classes represented 58% of TSB and 54% of TSN.

Otolith aged samples from the survey ranged from 2-25 years old. Maturity analysis of horse mackerel samples indicated 100% maturity.

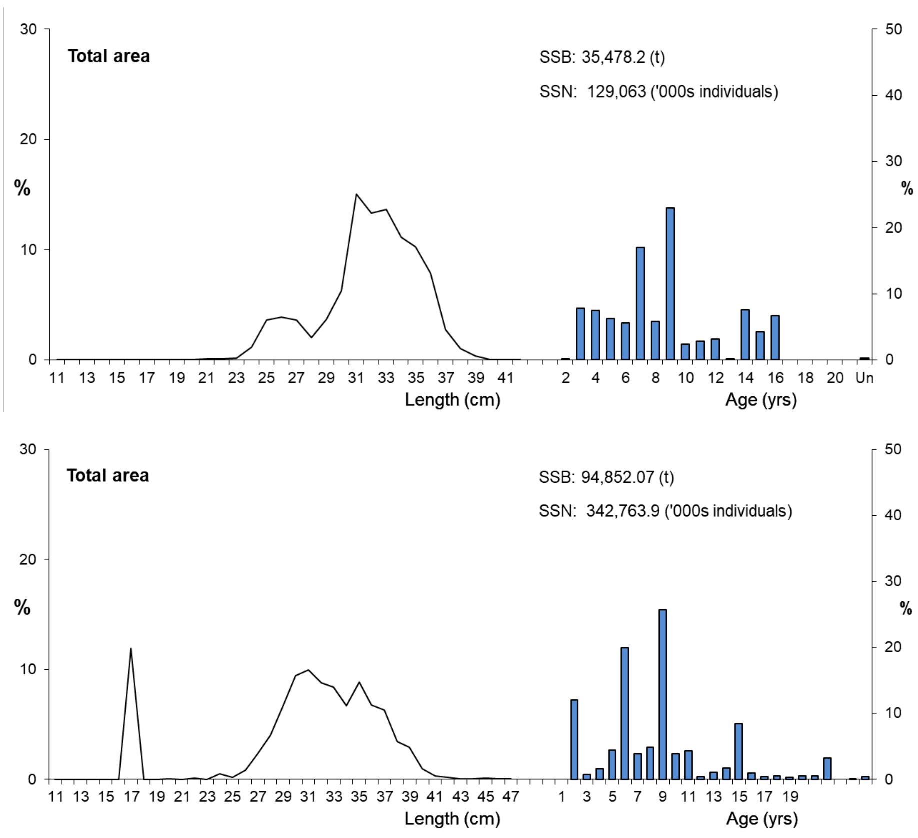


Figure 4.72 Age and length composition of horse mackerel standing stock biomass from the WESPAS 2022 (top panel) & WESPAS 2023 (bottom panel) survey in Divisions 6a, 7b, c, j, g & h.

Table 4.18 WESPAS acoustic survey time-series of horse mackerel total stock and spawning stock biomass and total abundance.

Age (Yrs)	2016	2017	2018	2019	2020	2021	2022	2023
0								
1	1.1	11.7	1.0	64.6				
2	100.2	181.8	72.4	15.2	6.2	0.1	7.7	41.4
3	4.9	147	243.3	9.2	91.9	10.0	0.3	2.4
4	43.5	45.4	85.3	46.4	51.5	9.7	2.3	5.5
5	19.0	16.2	10.5	30.9	24.3	8.1	7.8	15.1
6	7.6	46	7.6	18.5	27.0	7.3	7.6	68.3
7	40.6	113	49.3	29.8	35.1	21.9	1.5	13.3
8	66.6	67.7	13.3	6.2	5.2	7.5	36.5	16.5
9	8.5	25.4	10.0	26.7	13.1	29.7	5.1	88.2
10	1.8	33.2	1.5	0.4	1.5	3.1	5.8	13.5
11	9.5	32.6	1.5	1.9	0.5	3.6	1.4	14.7
12	10.6	37.7	7.4	3.9		4.10	1.4	1.5
13	4.7	37.6	8.5	0.6	0.6	0.1	1.1	3.7
14	21.1	160.8	27.5	23.2	5.5	9.8	12.0	5.9
15	6.5	8.6		10.0		5.5	1.0	29.1
16	1.6	5.2		28.4	2.1	8.6	1.6	3.3
17	5.3		0.3	-		0.3	0.2	1.3
18				17.7			0.2	1.8
19							0.4	0.9
20							2.0	1.8
21	1.1						4.0	1.6
22							0.4	11.2
23								
24							0.2	0.5
25								1.3
TSN (10^{-3})	354.5	969,655	540,422	333,501	264,314	129,431	100,449	342,764
TSB (t)	69,267	228,116	92,932	79,026	47,553	35,506	28,180	94,852
SSB (t)	65,194	227,395.6	89,050	77,529	43,527	35,478	28,180	94,852
CV	0.42	0.26	0.37	0.34	0.31	0.54	0.40	0.22

4.1.10 Boarfish in Division 7 and 6

4.1.10.1 Summer acoustic survey (WESPAS): 7b-c, 7g, h, j and 6a

2022 Survey summary

The 2022 estimate of boarfish biomass and abundance is presented in Figure 4.73. Overall, the WESPAS survey provided continuous coverage from south to north over 42 days relating to an area coverage of almost 49,998 nmi^2 (boarfish strata) and transect mileage of over 5,084 nmi. In total, 40 trawl stations were undertaken with 26 hauls containing boarfish, providing 6,575 individual lengths, 2,498 length and weight measurements and 1,270 otoliths for use during the analysis.

The 2022 estimate of TSB saw an increase of 2% compared to 2021, while TSN saw a reduction of 15%. Spawning stock biomass (SSB) was higher than 2021 (26%). The survey time-series is presented in Table 4.19. Geographical range was comparable to previous years with the greatest biomass occurring in the Celtic Sea (61.5 % of TSB and 66.6% of TSN), followed by the Irish west coast (32.5% TSB & 28.1% TSN). Within the Celtic Sea, the highest density of fish was observed in the southern survey area, south of 50°N. Mixed catches of mature and immature fish dominated catches in the Celtic Sea. Overall, TSB was lower in the Celtic Sea than observed in 2021 for reduced effort. The biomass of fish observed in the west coast stratum is comparable to 2021. However, abundance (TSN) is lower, driven by the older age profile of catches in 2022. The distribution of boarfish north of 55°N (South and West Hebrides strata), was characterised by medium and high density aggregations in close proximity to the shelf edge. The West Hebrides (northernmost) contained the largest proportion of older fish. The North Stanton strata (located on-shelf) contained an aggregation composed almost entirely of small fish of mixed maturity (ages 1-3 years). The stratum contributed 1.1% of TSB and 2.0% TSN. Although the contribution to the total estimate was small, this stratum has previously contained aggregations of immature fish, so the presence of mature fish is something new.

The age structure of the stock was determined using an established age length key. However, aging using survey otoliths is now underway using the SmartDots system with international collaboration in a bid to improve consistency in age reporting. The 3-year age class dominated the 2022 estimate contributing over 32% of TSB and 40.5% of TSN. Ranked second and third were the 4-year old and 2-year old fish (27.2% TSB & 22.9% TSN and 9.3% TSB & 17.4% TSN) respectively. Combined, these three age classes represented 68.6% of TSB and 80.7% of TSN. The 15+ age class, previously the dominant age class in the time series, represented 3% of TSB and 0.8% of TSN and is now somewhat superseded by the new, strong recent year classes. Maturity analysis of boarfish indicated 94.9% of observed biomass was mature (98.1% total abundance) compared to 79.3% biomass and 39.7% abundance in 2021. Immature fish were observed in fewer numbers than in 2021 and would indicate that these age cohorts were under represented in this year estimate.

2023 Survey summary

The 2023 estimate of boarfish biomass and abundance is presented in Figure 4.73. The WESPAS survey provided took place over 42 days relating to an area coverage of almost 59,632 nmi^2 (boarfish strata) and transect mileage of over 4,597 nmi. Survey effort and timing were comparable to 2022. In total, 53 trawl stations were undertaken with 26 hauls containing boarfish, providing 4,377 individual lengths, 1,800 length and weight measurements and 876 otoliths for use during the analysis.

Boarfish TSB (total stock biomass) and abundance (TSN) estimates were 525,701 t and 15,938,301,000 individuals (CV 0.11) respectively (Table 4.19). The 2023 estimate of TSB saw an increase of 16% compared to 2022, while TSN saw a reduction of 14%. Spawning stock biomass (SSB) increased by 18% as compared to 2022.

Geographical range was comparable to previous years across the wider survey area. The highest density of biomass was observed in the Celtic Sea (65.1 % of TSB and 50% of TSN), followed by the Irish west coast (28.3% TSB & 21.7% TSN). Within the Celtic Sea, the highest densities of boarfish were observed in the southern survey area, south of 50°N. Catches were dominated by mature fish with a smaller contribution of immature fish than in 2022. The west coast stratum ranked second contributing 28.4% of TSB (21.7% TSN). The total biomass within this stratum was comparable to 2022, but abundance (TSN) was lower, driven by the lower number of immature fish observed. The Porcupine Bank, contributed 1.7% TSB and 1.3% TSN, a moderate increase from 2022 for less effort. The distribution of boarfish north of 55°N (South and West Hebrides strata), was characterised by medium density aggregations in close proximity to the shelf edge. The West Hebrides (northernmost) contained the largest proportion of older fish.

The 4-year age class dominated the 2023 estimate contributing 25% of TSB and 29.4% of TSN. Ranked second and third were the 3-year old (16% TSB & 24.9% TSN) and 7-year old fish (14.1% TSB & 11.5% TSN) respectively. Ranked fourth is the 6-year old fish (12.2% TSB & 11.4% TSN). Combined, these three age classes represented 67% of TSB and 77% of TSN. The survey has successfully tracked these four cohorts from recruitment into the spawning stock. The 15+ age class represented 10.4% of TSB and 4.3% of TSN.

Maturity analysis showed over 99.6% of TSB and 99% of TSN was represented by mature fish. The proportion of immature fish in the stock estimate has decreased from a high in 2021 (41% TSN) over recent years (2022; 5% and 2023; 1%). This is in line with observations from the PELGAS survey where the abundance of boarfish has increased over the same period.

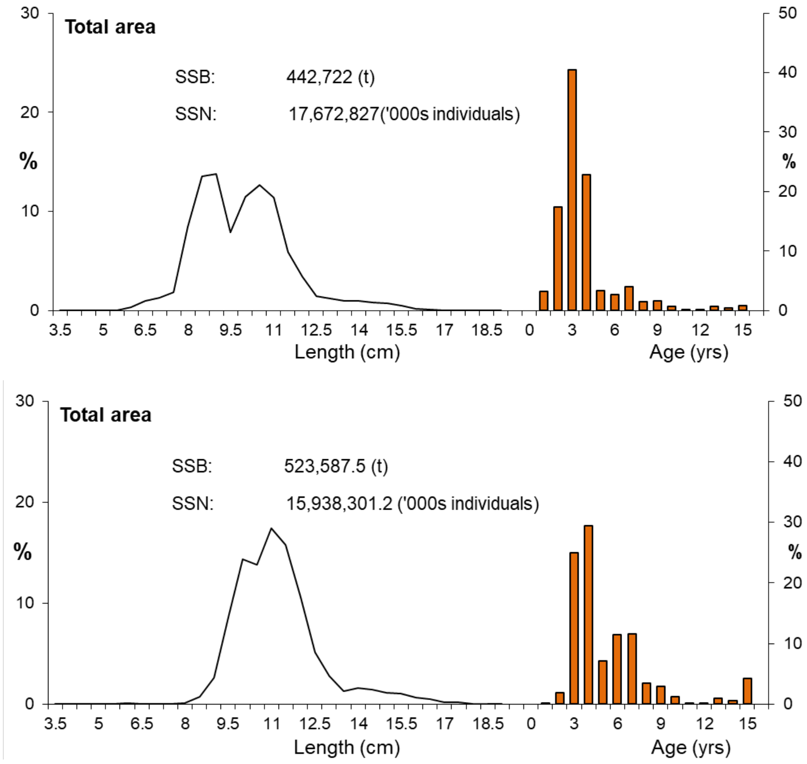


Figure 4.73 Age and length composition of boarfish standing stock biomass from the WESPAS 2022 (top panel) & 2023 (bottom panel) survey in Divisions 6a, 7b, c, j, g & h.

Table 4.19 WESPAS acoustic survey time-series of boarfish total stock and spawning stock biomass and total abundance.

Age (Yrs)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
0	-	-	-	-	-	-	-	-	-	1083.9	259.0		
1	5.0	21.5	-	-	198.5	4.6	110.9	76.7	782.3	896.5	9522.8	587.1	13.9
2	11.6	10.8	78.0	-	319.2	35.7	126.7	31.2	389.1	1156.7	3391.8	3234.2	298.9
3	57.8	174.1	1,842.9	15.0	16.6	45.5	344.6	115	96.8	966.5	2955.2	7536.6	4011.2
4	187.4	64.8	696.4	98.2	34.3	43.6	367.3	68.3	93.1	112.6	1315.5	4258.5	4737.4
5	436.7	95.0	381.6	102.3	80.0	6.0	156.0	106.7	88.2	157.3	462.8	618.6	1143.1
6	1,165.9	736.1	253.8	104.9	112.0	10.0	209.0	165.9	105.9	183.3	149.9	508.8	1834.1
7	1,184.2	973.8	1,056.6	414.6	437.4	169.0	493.1	320.7	445.7	912.9	953.3	751.6	1857.3
8	703.6	758.9	879.4	343.8	362.9	112.6	468.3	197.7	182.6	884.5	207.0	265.6	554.1
9	1,094.5	848.6	800.9	341.9	353.5	117.6	397.2	293.4	288	720.7	378.4	302.1	470.0
10	1,031.5	955.9	703.8	332.3	360.0	96.6	285.8	624.7	290.1	330.9	248.5	122.0	191.4
11	332.9	650.9	263.7	129.9	131.7	17.0	120.9	339.2	49.5	80.6	151.3	41.2	19.3
12	653.3	1,099.7	202.9	104.9	113.0	32.0	82.1	264.1	192.2	194.9	187.9	23.3	14.5
13	336.0	857.2	296.6	166.4	174.0	48.7	74.4	198.4	79.1	298.7	81.0	126.7	161.2
14	385.0	655.8	169.8	88.5	108.0	18.3	220.4	116.5	57.2	266.7	326.9	90.0	100.0
15+	3,519.0	6,353.7	1,464.3	855.1	1,195.0	400.1	931.0	302.4	758.9	1641.0	1213.3	147.5	685.4
TSN (10-6)	11,104	14,257	9,091	3,098	3,996	1,157	4,387	3,221	3,899	9,888	21,805	18,614	16,091
TSB (t)	670,176	863,446	439,890	187,779	232,634	69,690	223,860	186,252	179,156	399,872	443,777	451,415	525,701
SSB (t)	669,392	861,544	423,158	187,654	226,659	69,103	218,810	184,235	169,216	357,871	351,955	442,722	523,588
CV	0.21	0.11	0.18	0.15	0.17	0.16	0.22	0.20	0.25	0.35	0.31	0.24	0.11

4.2 Large scale distribution of eggs and adults of SPF in their environment in ICES Division 6 to 9

All surveys covered under the auspices of WGACEGG are considered ecosystem surveys and data collection is not limited to the target species alone. This section summarizes the combined survey results in the wider geographical region for all small pelagic fish species (adults and, where collected, eggs) as well as the oceanographic features for the different seasons.

4.2.1 Winter/Spring Surveys

4.2.1.1 Oceanography

In 2023, sea surface temperature (SST) and sea surface salinity (SSS) maps representing the winter-spring period in the region Iberian Peninsula-Bay of Biscay, were available from three DEPM surveys (PT-DEPM23-PIL, SAREVA0423, BIOMAN23) and three acoustics surveys (PELAGO23, PELACUS0323, PELGAS23) (see Table 4.1 and Figure 4.1and Figure 4.4for survey dates, area covered, and the survey reports for details on each campaign).

The gridded data distributions for SST and SSS (and its standard deviation taking into account the historic series) are presented in Figure 4.74and Figure 4.75. During winter in the southern and western Iberian shores, SST values varied from 15.5 to 17.5ºC and from 13 to 17 ºC respectively; in early spring, roughly a month later than the previous survey, the patterns in the south remained similar while in the west the water temperature raised broadly 1 ºC approximately; signals of the major freshwater outflows were apparent (colder waters) off NW Portugal and western Galicia. The Cantabrian shelf waters showed the largest areas with lower temperatures, below 14 ºC , in particular in the western region. In the Bay of Biscay SST varied from 13 to 16.5 ºC approximately with the usual patch of warmer waters (~ 16-16.5 ºC) in the inner corner of the Bay and much lower temperatures in the areas of river water influence (13-14 ºC). In these areas, a clearer layer of inshore fresher waters (less saline) was very evident in the sea surface salinity (SSS) maps (values below 34). In the more southern regions the river plumes were much less evident but still observable in the western Portugal and Galician shores. The major variability in SST and SSS, compared to the time series, represented in the maps of SST and SSS standard deviations (Figure 4.74and Figure 4.75, right panels) were associated with these regions where signs of the waters of continental origin were observed and particularly marked in SSS.

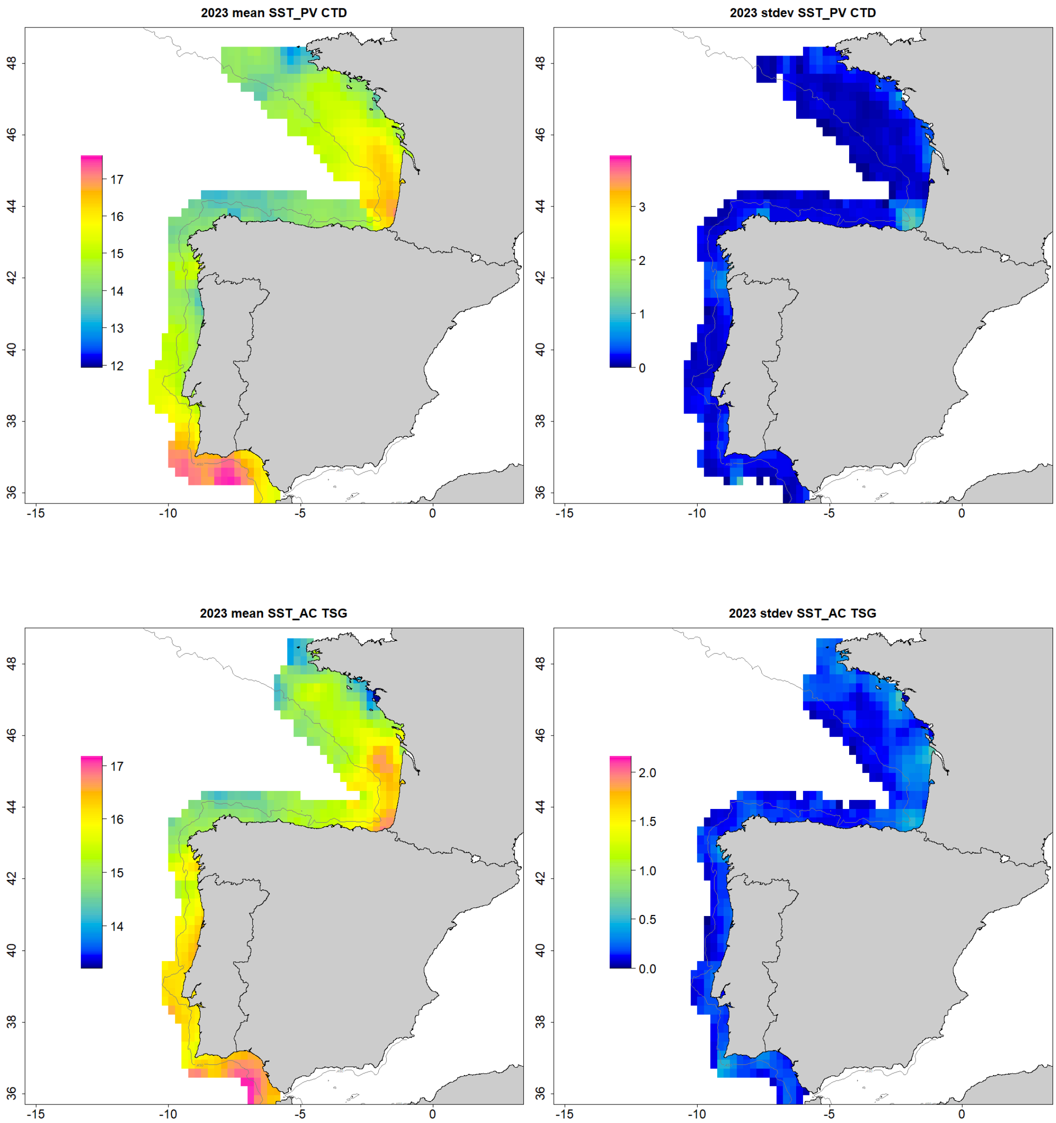


Figure 4.74 Sea surface, temperature distributions (left panels) and respective standard deviations (right panels) during winter/spring, DEPM surveys (PT-DEPM23-PIL; SAREVA0423; BIOMAN23) (top panels) and during, spring, acoustics surveys (PELAGO23, PELACUS0423, PELGAS23) (bottom panels). See Table 3-1 for survey dates and note the different colour scales in the figures. More details on the observations from these surveys can be found in the each survey report.

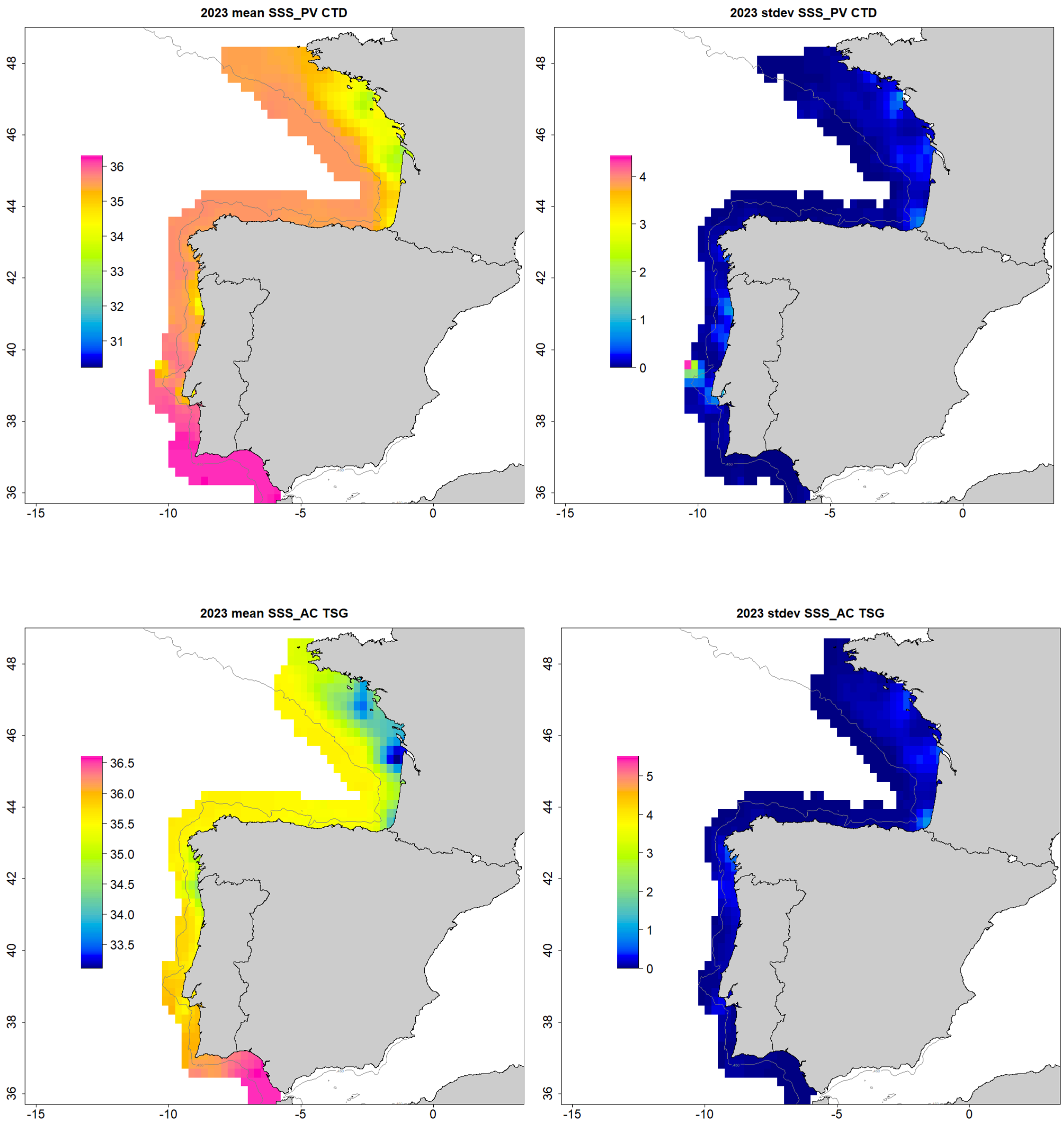


Figure 4.75 Sea surface, salinity distributions (left panels) and respective standard deviations (right panels) during winter/spring, DEPM surveys (PT-DEPM23-PIL; SAREVA0423; BIOMAN23) (top panels) and during, spring, acoustics surveys (PELAGO23, PELACUS0423, PELGAS23) (bottom panels). See Table 3-1 for survey dates and note the different colour scales in the figures. More details on the observations from these surveys can be found in the each survey report.

4.2.1.2 Trawl Catch composition from Acoustic Surveys

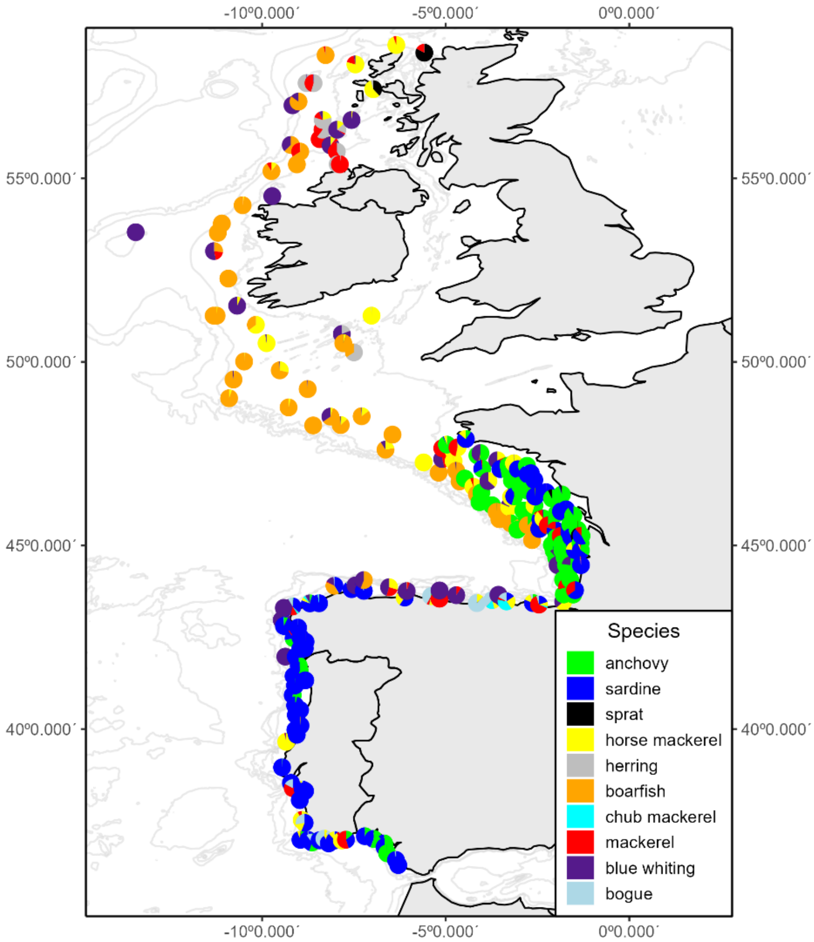


Figure 4.76 Trawl composition of 4 spring acoustic surveys: WESPAS, PELGAS, PELACUS and PELAGO.

In spring, a total of 220 pelagic trawls were performed by 4 surveys, describing the abundance and distribution of the main pelagic species found from 58° 37´N to 36° 29´N (Figure 4.76). Boarfish distribution was similar to previous years in terms of latitudinal range. The distribution of boarfish north of 55°N (South and West Hebrides strata), was characterized by medium density aggregations in close proximity to the shelf edge. The West Hebrides (northernmost) contained the largest proportion of older fish, which is in line with previous survey findings. Aggregations of Celtic Sea herring were encountered around the Labadie and Jones' Bank on traditional summer feeding grounds. Horse mackerel were observed predominantly in the Celtic Sea and to the north of Ireland and west of Scotland.

Anchovy was mainly present in the French area of the Bay of Biscay, with predominance of age 1 individuals, but was found all along the Iberian coast, down to the Gulf of Cádiz. Sardine was also widely distributed from the north of the Bay of Biscay down to the southernmost point of the spring surveyed area, with age composition mainly from 1 to 4, with a haul of pure age 0 close to 47°N. Other species such as horse mackerel, mackerel, blue whiting, chub mackerel, or sprat, were found in different proportions along the surveyed area.

4.2.1.3 SPF NASC distribution from Acoustic Surveys

Anchovy

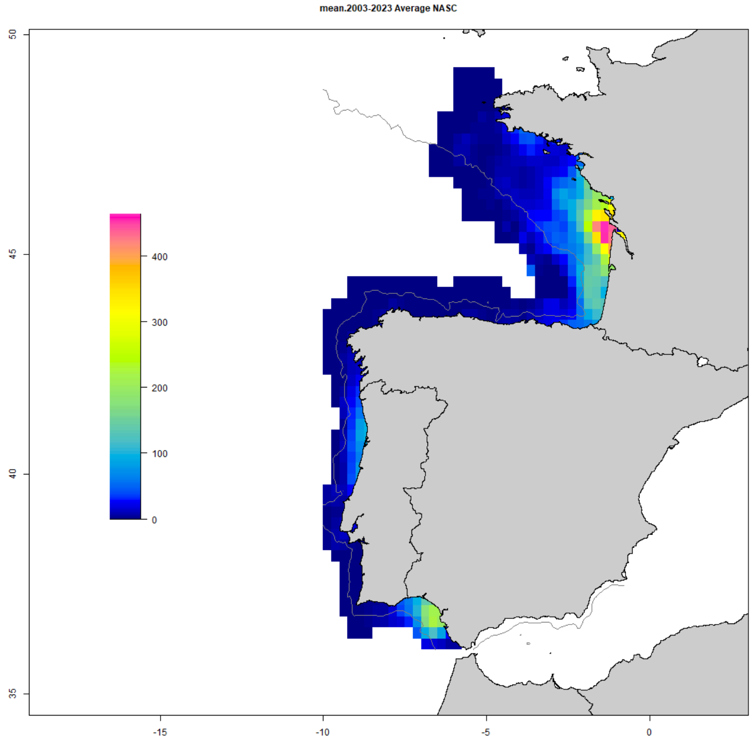


Figure 4.77 Adult anchovy mean acoustic density (NASC, m².NM-²) average map derived from the PELAGO, PELACUS and PELGAS surveys, 0.25° map cell.

Adult anchovy core distribution areas in springtime were, by decreasing order of importance: coastal areas in Southern Bay of Biscay (BoB, in Gironde and Landes coast, ~46°N), the Gulf of Cadiz (GoC, ~37°N), and in a small area North of Cape Mondego on the Western coast of Portugal (~40°N) (Figure 4.77).

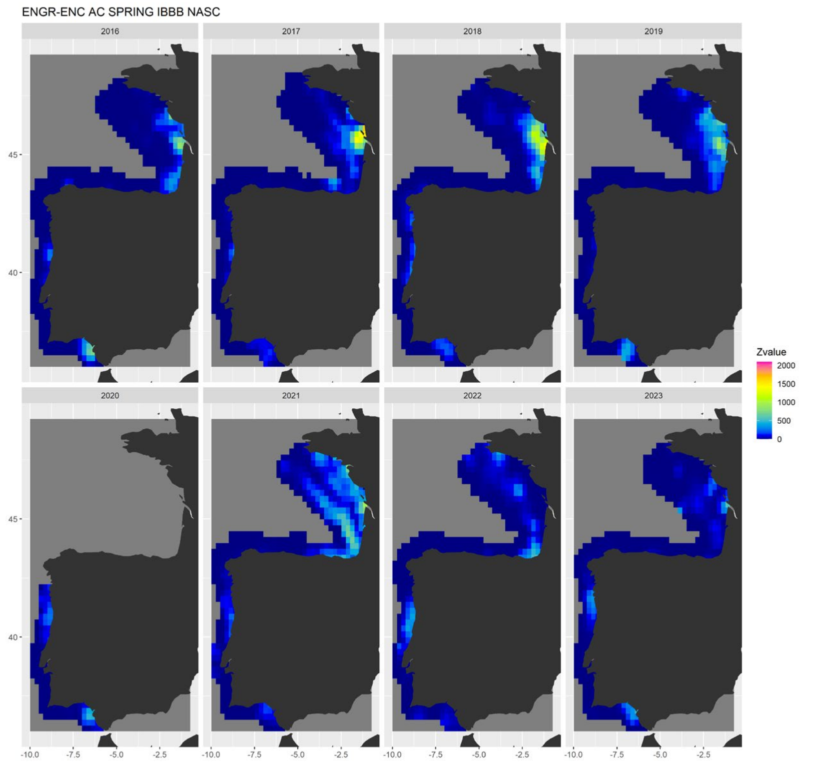


Figure 4.78 Adult anchovy mean acoustic density (NASC, m².NM-²) maps derived from the PELAGO, PELACUS and PELGAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

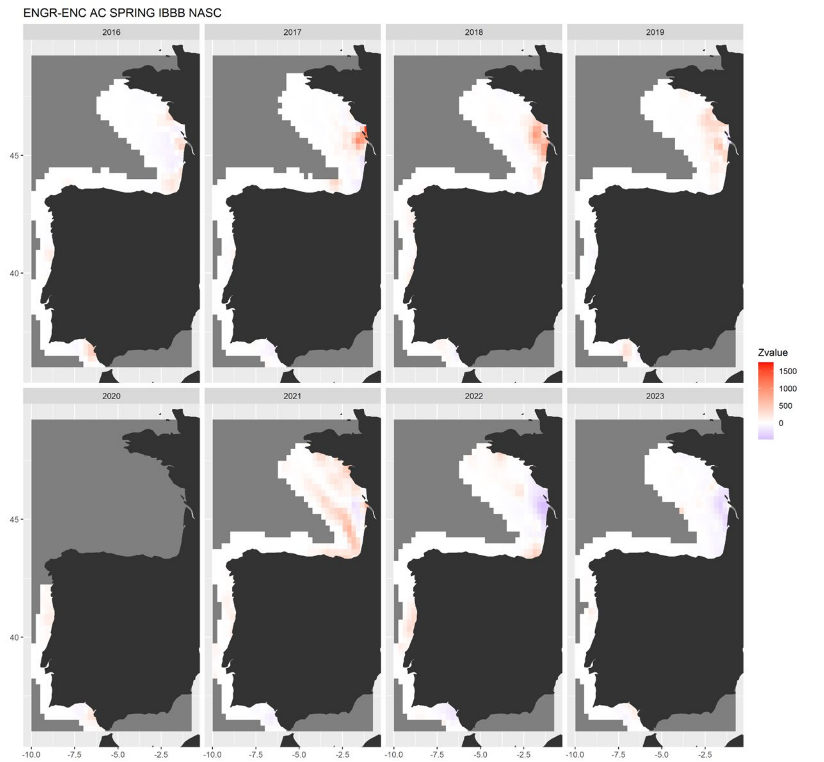


Figure 4.79 Adult anchovy mean acoustic density (NASC, m².NM-²) anomaly maps derived from the PELAGO, PELACUS and PELGAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

In 2023, anchovy density was average everywhere, except in the Gironde river mouth core distribution area (Figure 4.78 and Figure 4.79).

Sardine

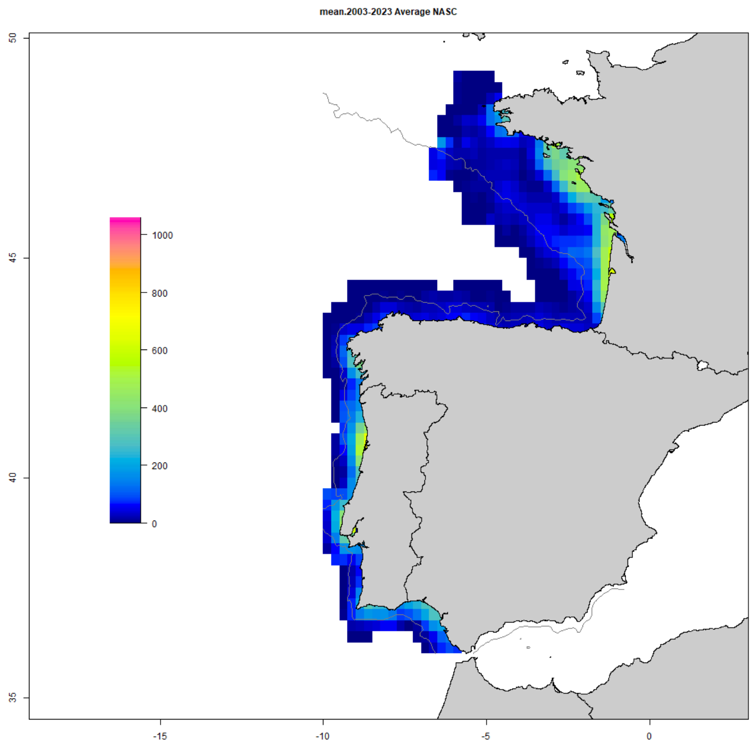


Figure 4.80 Adult sardine mean acoustic density (NASC, m².NM-²) average map derived from the PELAGO, PELACUS and PELGAS surveys, 0.25° map cell.

Sardine core distribution areas in springtime were, by decreasing order of importance: the coastal areas of the Bay of Biscay, the Gulf of Cadiz (~37°N), the South Western Portuguese coast, and Biscay shelf-break areas. (Figure 4.80).

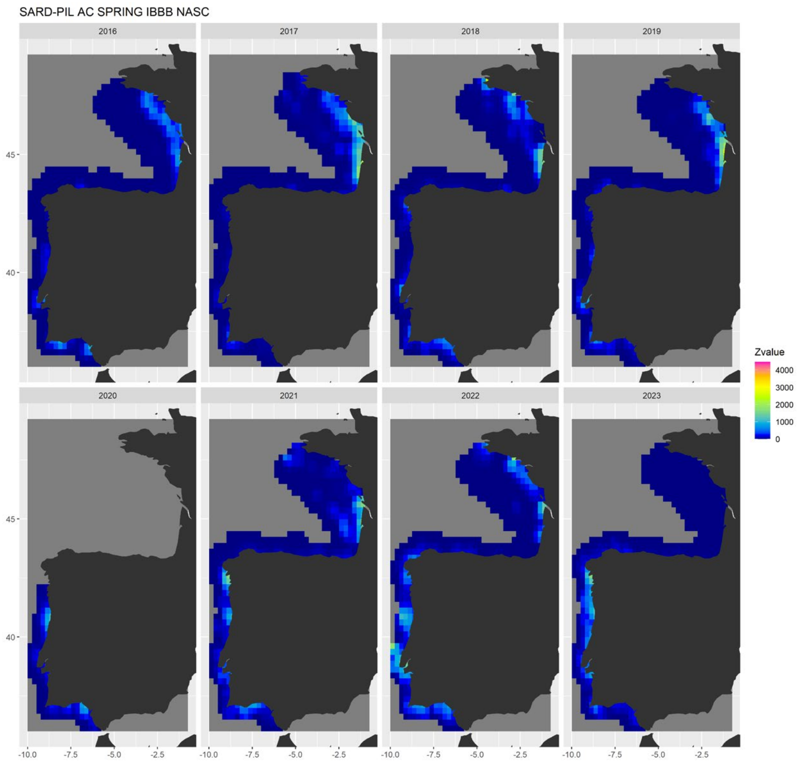


Figure 4.81 Adult sardine mean acoustic density (NASC, m².NM-²) maps derived from the PELAGO, PELACUS and PELGAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

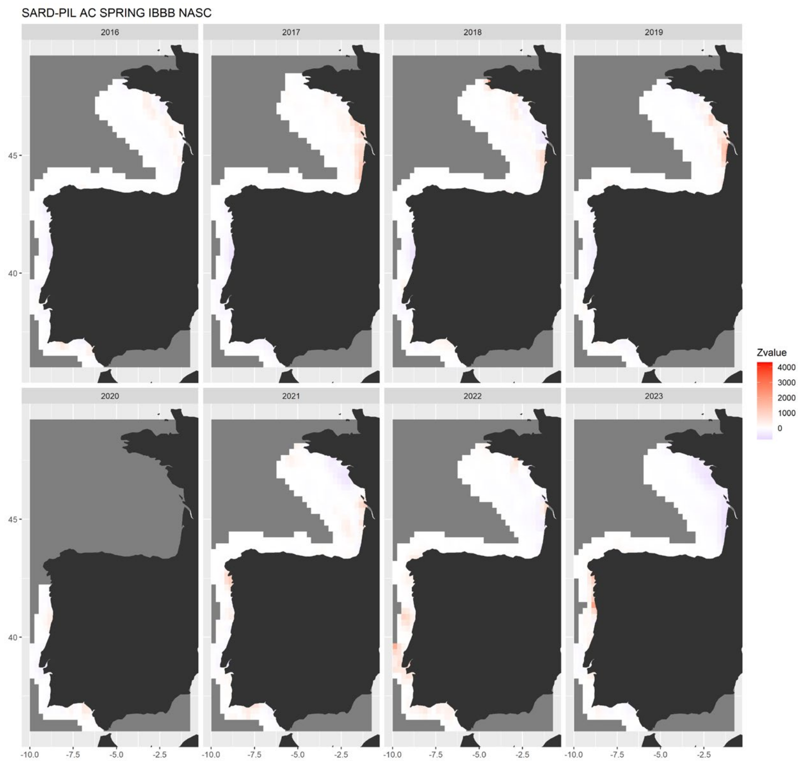


Figure 4.82 Adult sardine mean acoustic density (NASC, m².NM-²) anomaly maps derived from the PELAGO, PELACUS and PELGAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

In 2023, sardine abundance was above-average on Galician coasts, and below-average coastal BoB (Figure 4.82).

Chub mackerel

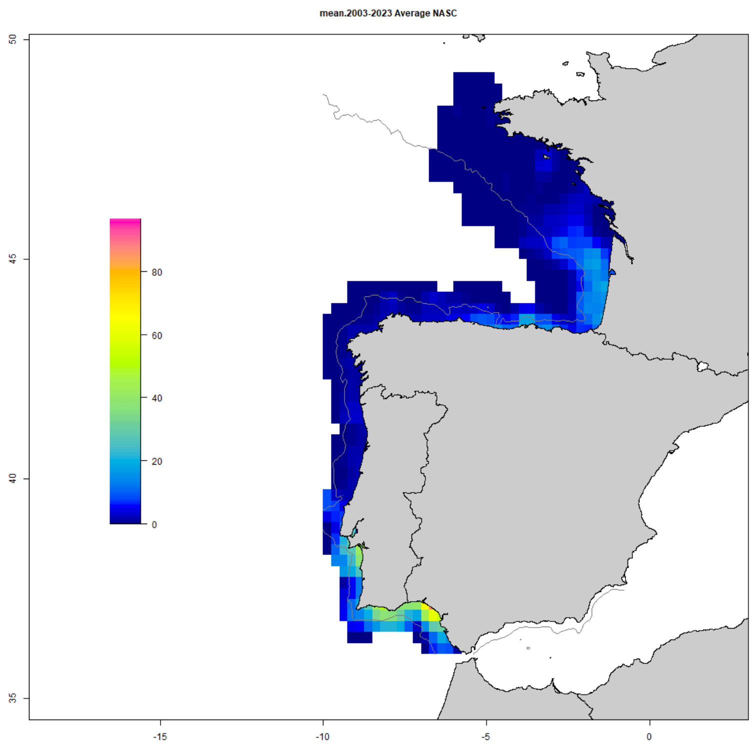


Figure 4.83 Adult chub mackerel mean acoustic density (NASC, m².NM-²) average map derived from the PELAGO, PELACUS and PELGAS surveys, 0.25° map cell.

Chub mackerel core distribution area in springtime was located in the Cantabrian Sea and Southern BoB (Figure 4.83).

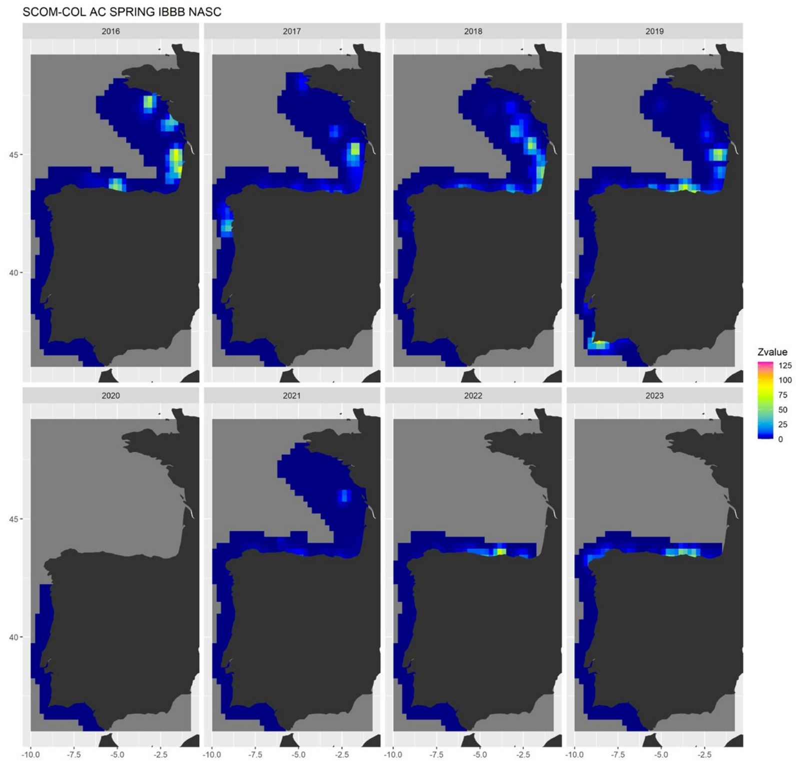


Figure 4.84 Adult chub mackerel mean acoustic density (NASC, m².NM-²) maps derived from the PELAGO, PELACUS and PELGAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

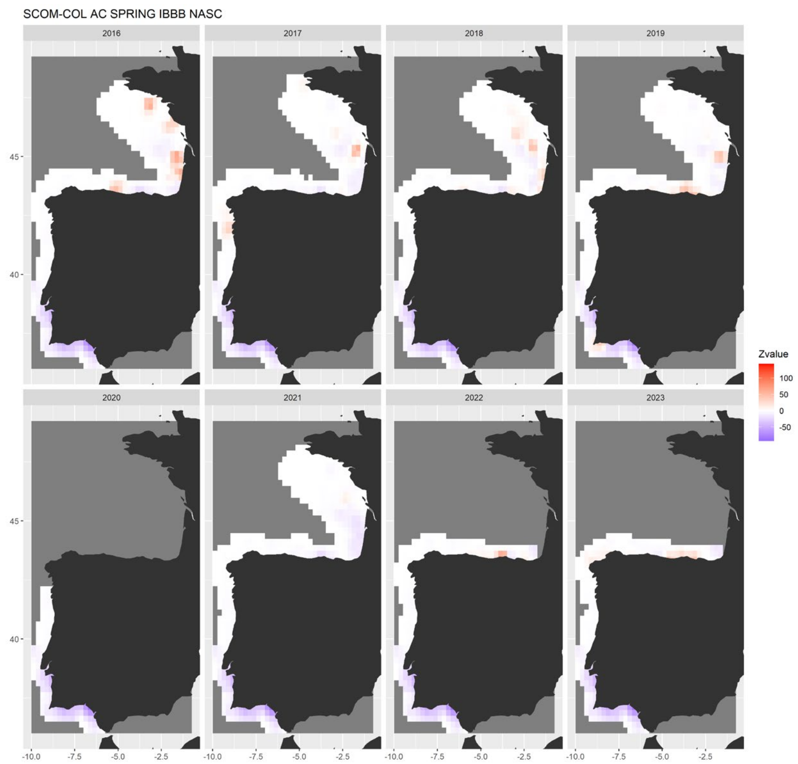


Figure 4.85 4.2.1.3.9 Adult chub mackerel mean acoustic density (NASC, m².NM-²) anomaly maps derived from the PELAGO, PELACUS and PELGAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

In 2023, chub mackerel distribution was close to average in the Cantabrian Sea, below average in Southern Iberia, and absent in the Bay of Biscay (Figure 4.85).

Boarfish

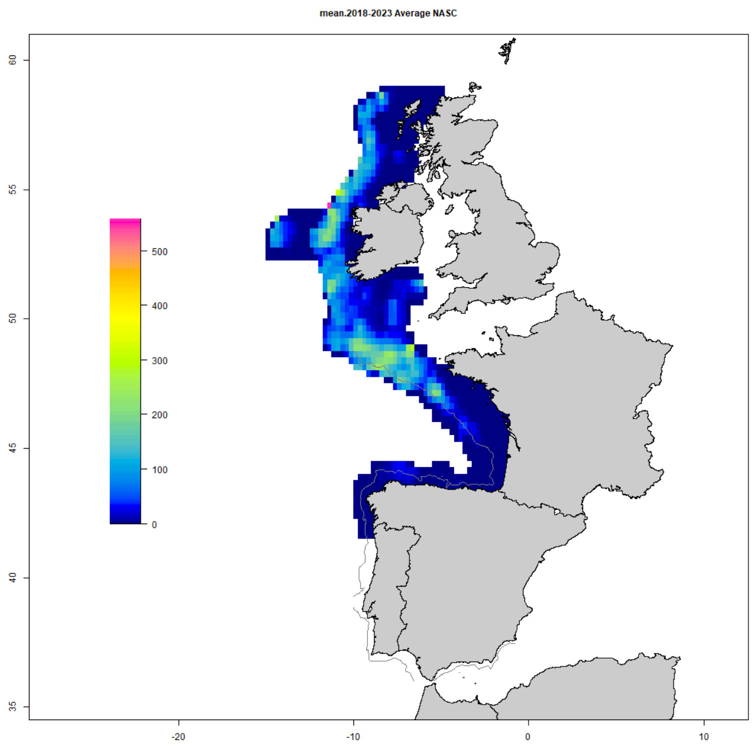


Figure 4.86 Adult boarfish mean acoustic density (NASC, $m^2.NM^{-2}$) average map derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell.

Boarfish core distribution areas were located along the continental shelf edge from 45 to 57°N, with higher concentrations in Northern Bay of Biscay and the Celtic Sea, between 46 and 48°N (Figure 4.86).

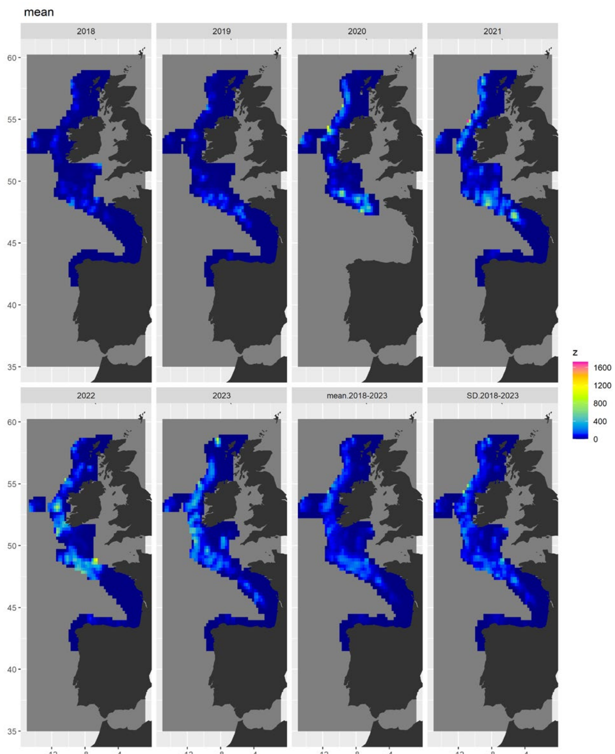


Figure 4.87 Adult boarfish mean acoustic density (NASC, m².NM-²) maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

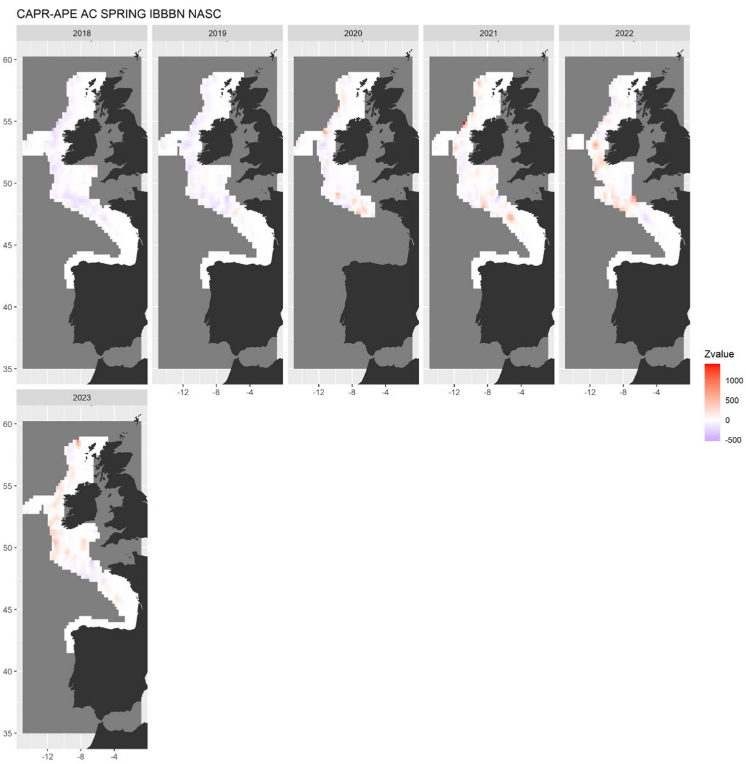


Figure 4.88 Adult boarfish mean acoustic density (NASC, m².NM-²) anomaly maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

Boarfish global density has increased since 2020. Higher than average boarfish concentrations were observed in 2023 from 45° to 58°N (Figure 4.88)

Herring

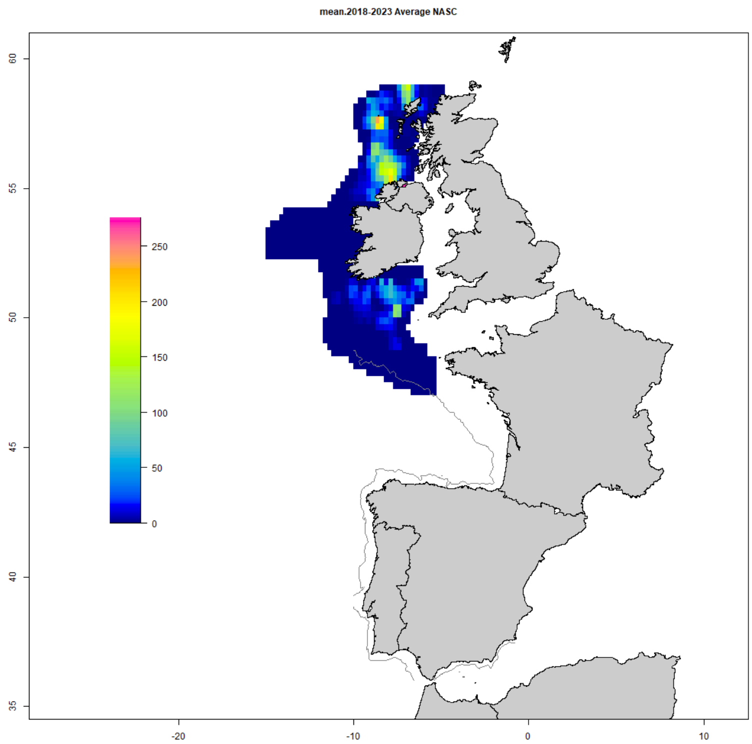


Figure 4.89 Adult herring mean acoustic density (NASC, m².NM-²) average map derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell.

Herring core distribution areas were in the North and South of Ireland, from 50° to 58°N (Figure 4.89 and Figure 4.90).

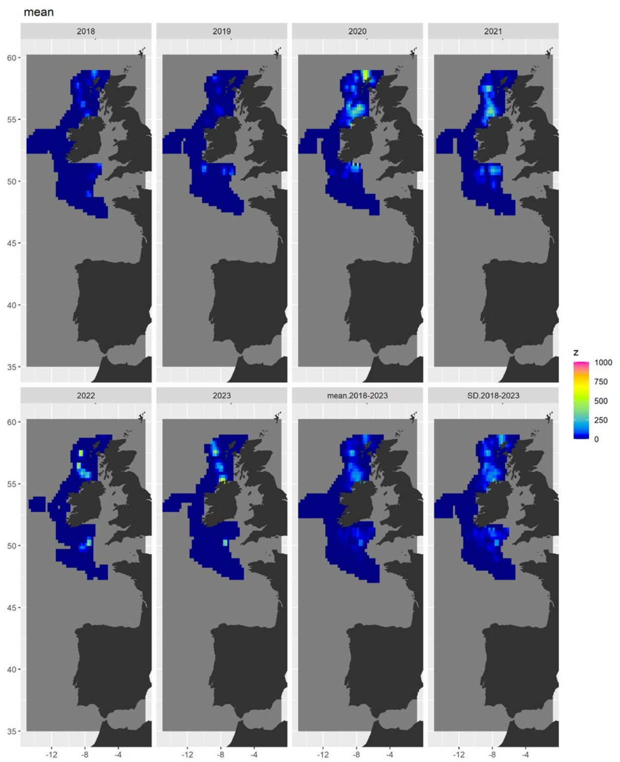


Figure 4.90 Adult herring mean acoustic density (NASC, m².NM-²) maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

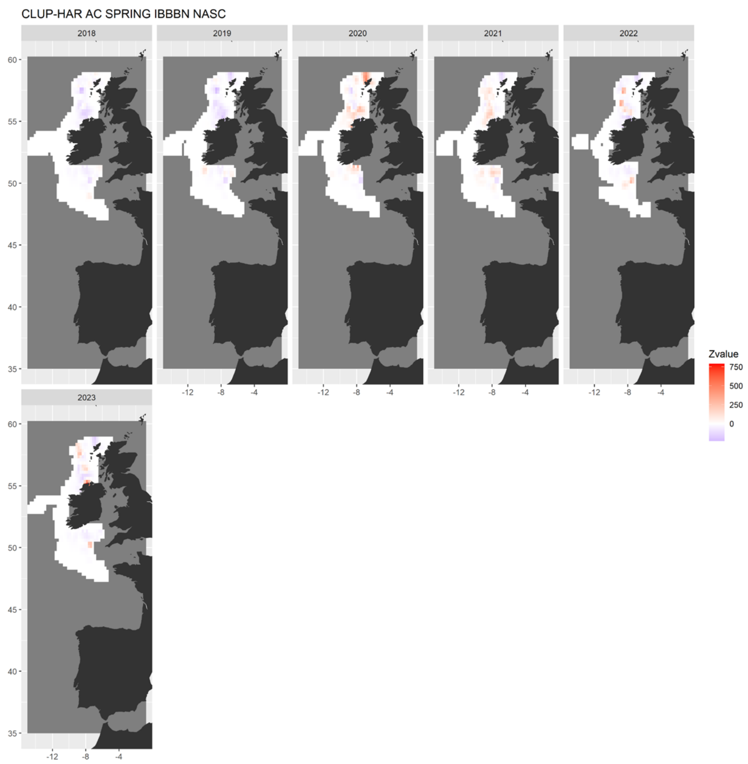


Figure 4.91 Adult herring mean acoustic density (NASC, m².NM-²) anomaly maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

Herring densities were average in 2023, with low and high density patches in the North and South of Ireland (Figure 4.91).

Blue whiting

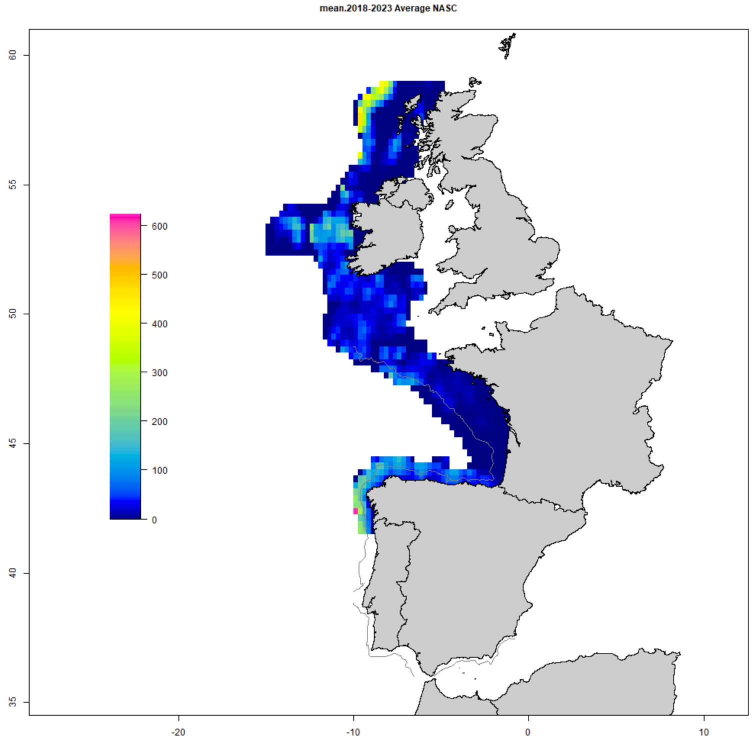


Figure 4.92 4.2.1.3.16 Adult blue whiting mean acoustic density (NASC, m².NM-²) average map derived from the PELACUS, PEL-GAS and WESPAS surveys, 0.25° map cell.

Blue whiting was scattered in the Celtic Sea, with higher density areas near the shelf edge in the North West of Spain and in the West of Scotland (57-58°N) (Figure 4.92 and Figure 4.93).

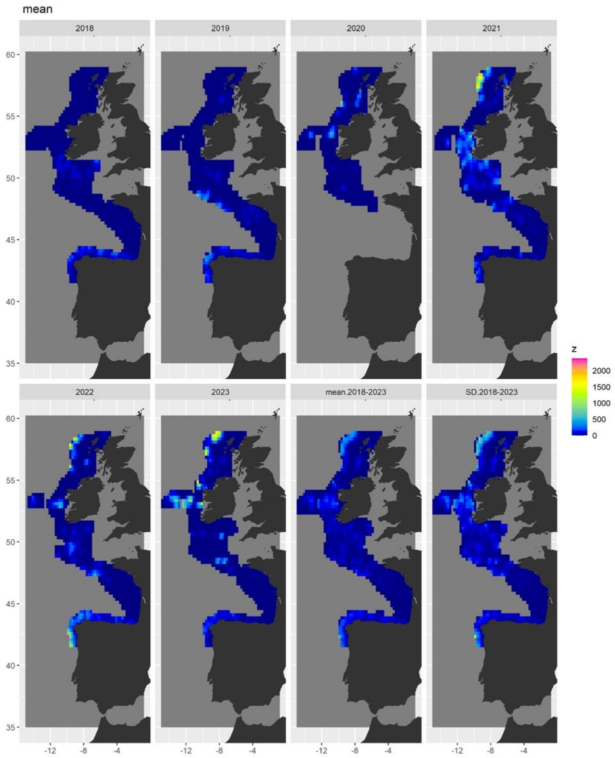


Figure 4.93 Adult blue whiting mean acoustic density (NASC, m².NM-²) maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

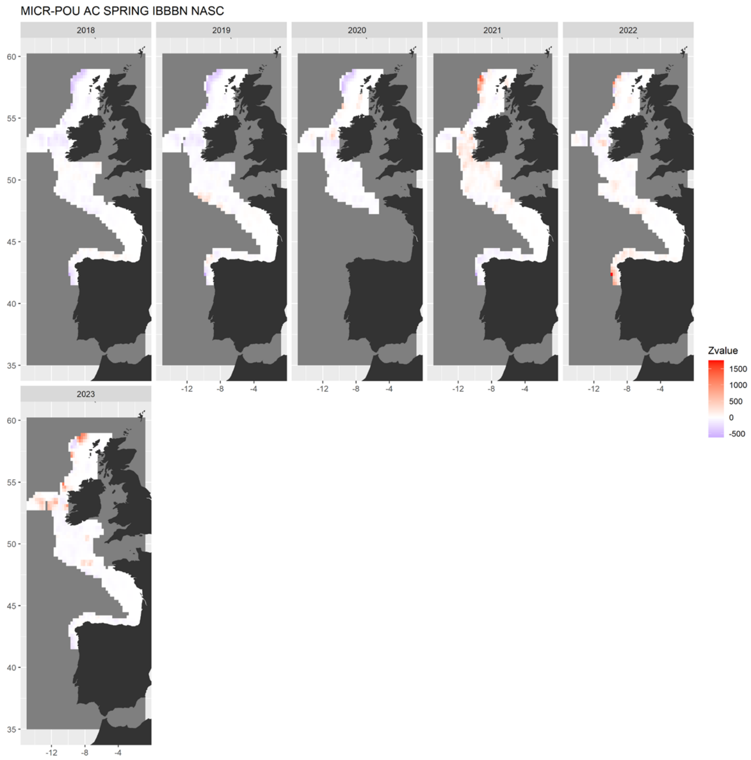


Figure 4.94 Adult blue whiting mean acoustic density (NASC, m².NM-²) anomaly maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

Blue whiting densities were average in 2023, except for high density patches West to Ireland and in the Northernmost part of the survey area (Figure 4.94).

Atlantic mackerel

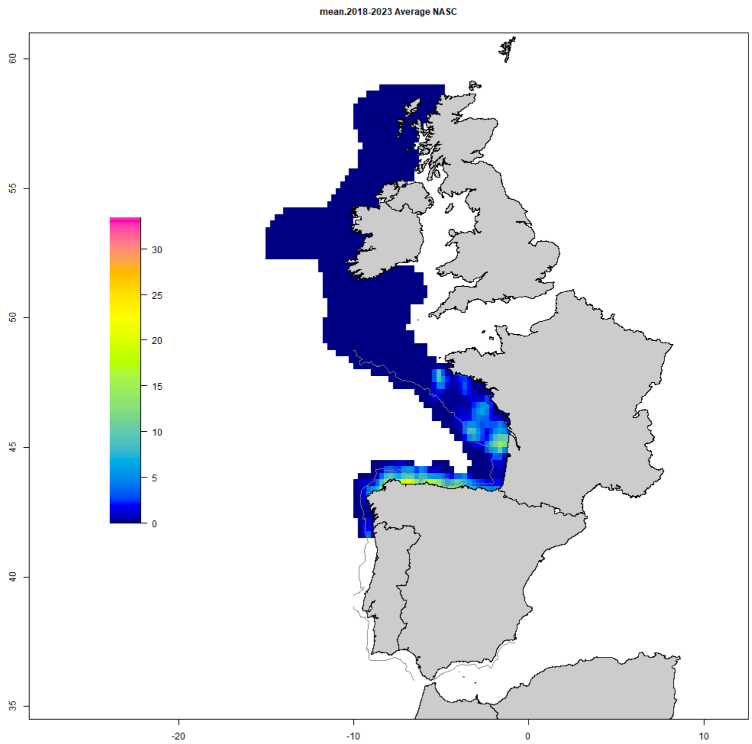


Figure 4.95 Adult Atlantic mackerel mean acoustic density (NASC, m².NM-²) average map derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell.

Atlantic mackerel core distribution areas were in the Cantabrian Sea and in the Center of the Bay of Biscay, up to 48°N (Figure 4.95 and Figure 4.96)

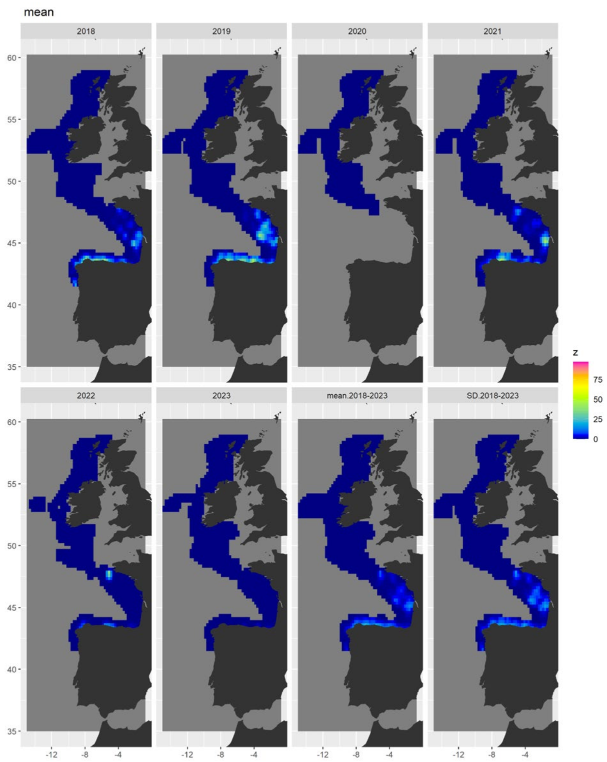


Figure 4.96 Adult Atlantic mackerel mean acoustic density (NASC, m².NM-²) maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

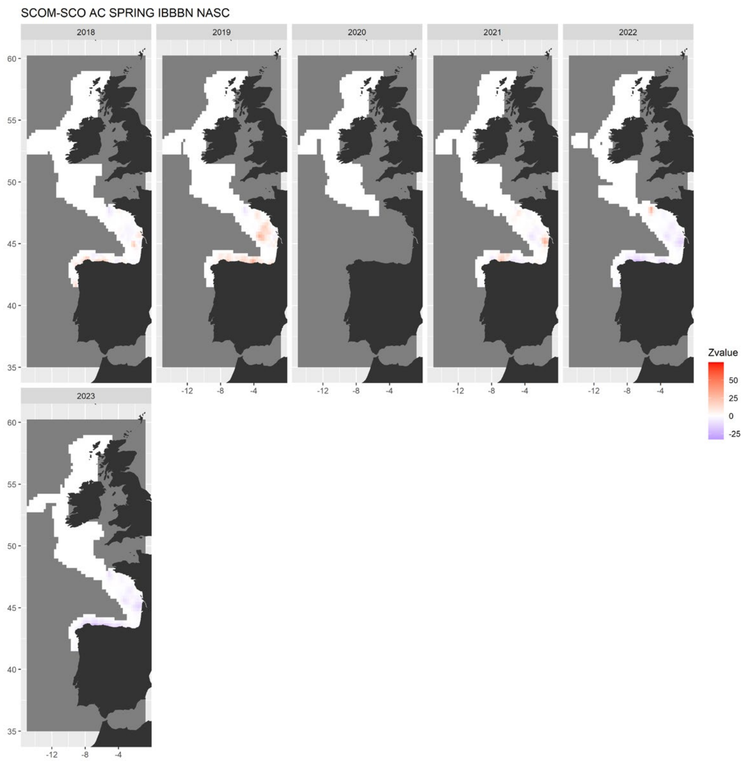


Figure 4.97 Adult Atlantic mackerel mean acoustic density (NASC, m².NM-²) anomaly maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

Atlantic mackerel densities were average in all areas in 2023, except near in the BoB and Cantabrian Sea.

Sprat

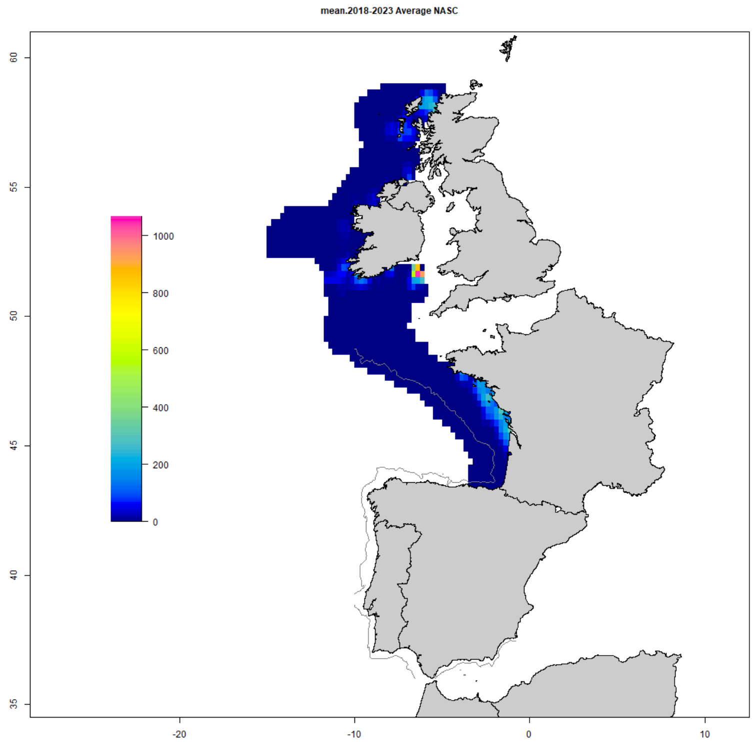


Figure 4.98 Adult sprat mean acoustic density (NASC, m².NM-²) average map derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell.

Sprat core distribution areas were onshore in the Bay of Biscay (45-47°N) and in Scotland (57-58°N) (Figure 4.98 and Figure 4.99)

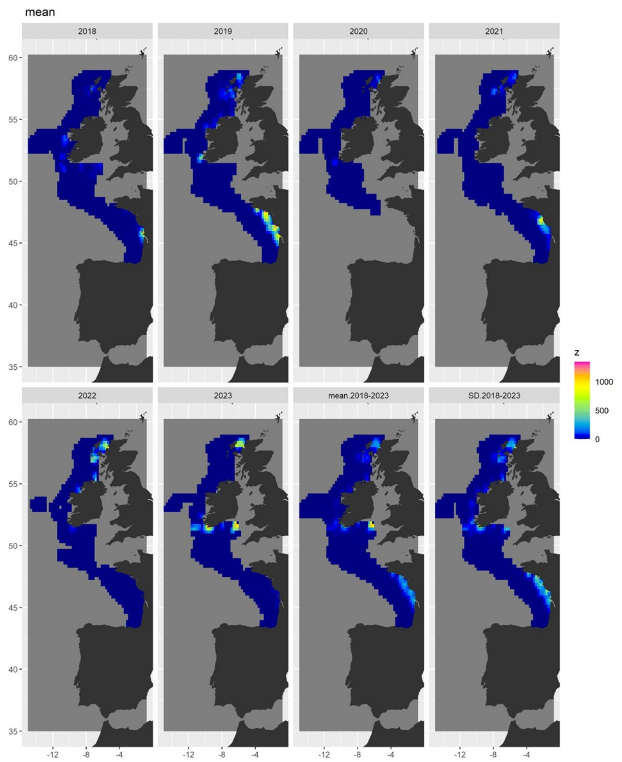


Figure 4.99 Adult sprat mean acoustic density (NASC, m².NM-²) maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

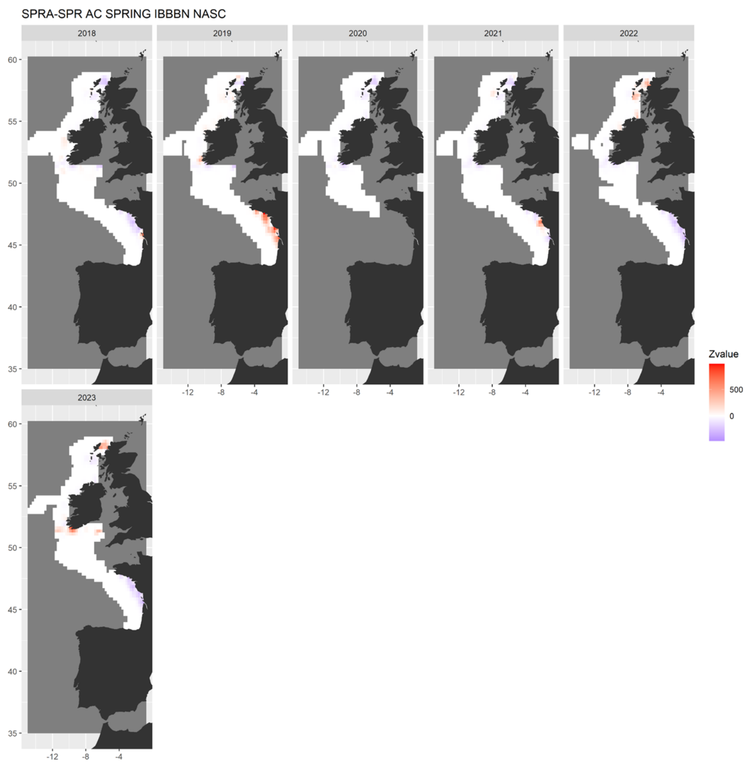


Figure 4.100 Adult sprat mean acoustic density (NASC, m².NM-²) anomaly maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

In 2023, sprat densities were below average in core distribution areas in the Bay of Biscay, and above average South to Ireland and in Northern Scotland (Figure 4.100)

Horse mackerel

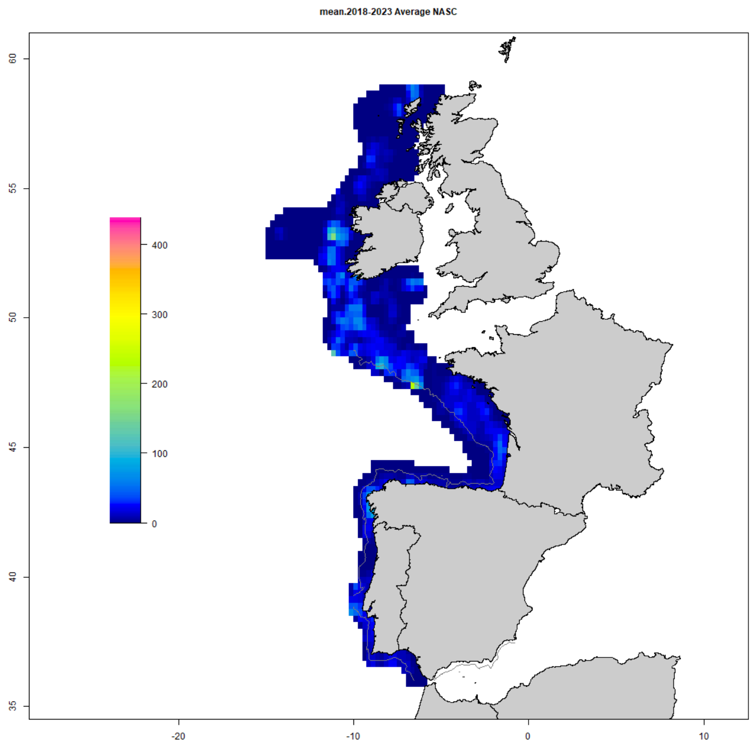


Figure 4.101 Adult horse mackerel mean acoustic density (NASC, m².NM-²) average map derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell.

Horse mackerel was scattered on the continental shelf fro 43 to 55°N, with higher density patches in the Celtic Sea (Figure 4.101)

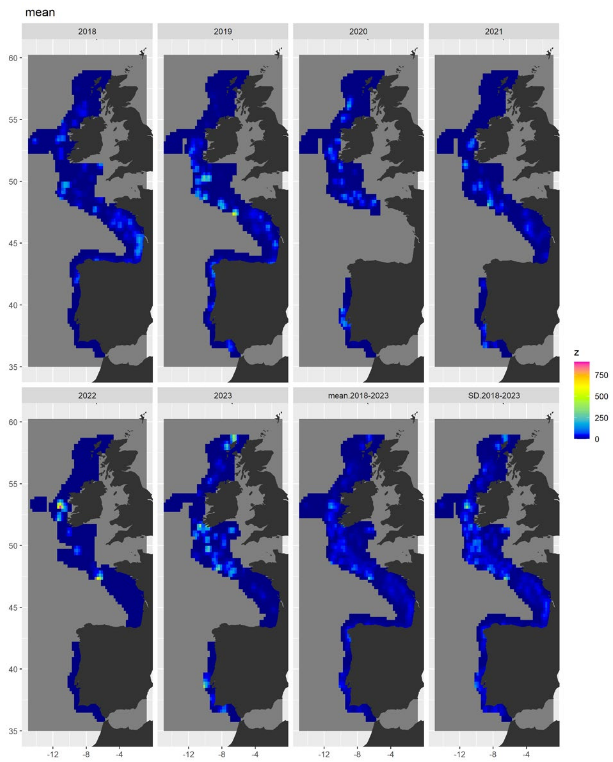


Figure 4.102 Adult horse mackerel mean acoustic density (NASC, m².NM-²) maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

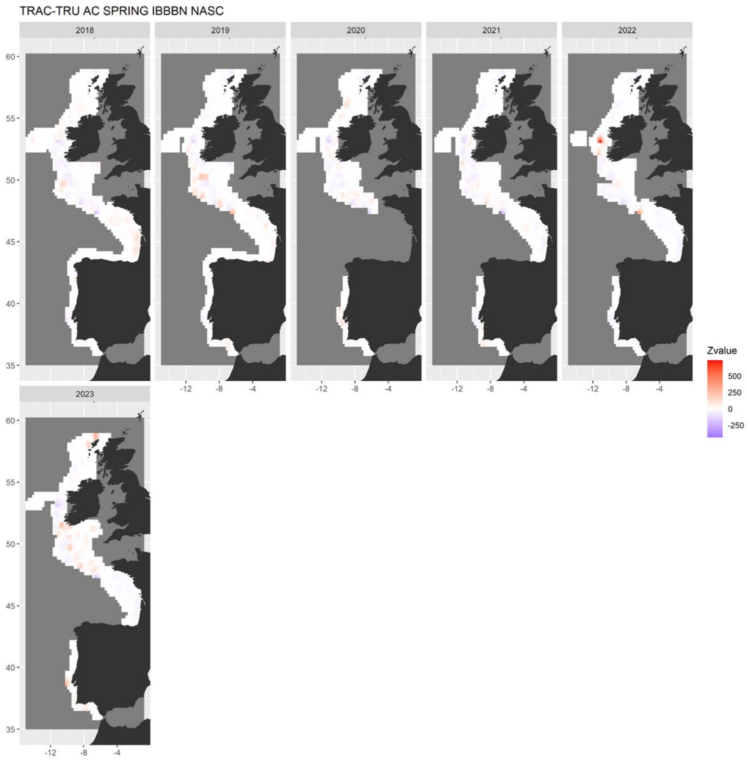


Figure 4.103 Adult horse mackerel mean acoustic density (NASC, m².NM-²) anomaly maps derived from the PELACUS, PELGAS and WESPAS surveys, 0.25° map cell. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

In 2023, horse mackerel distribution was close to average, with a higher density patches in the Celtic Sea and Northern Scotland (Figure 4.102 and Figure 4.103)

4.2.1.4 CUFES derived sardine and anchovy egg distribution from Acoustic Surveys

Sardine and anchovy egg distributions obtained with the data from CUFES sampling along the acoustic transects during the Spring acoustic surveys PELAGO, PELACUS and PELGAS are represented in Figure 4.104 to Figure 4.105.

In 2023 sardine eggs were more abundant in the western coast in the area of northern Portugal-Galicia and then further to the south, between Setúbal and Sines, in western Algarve and in the inner Cadiz Bay (Figure 4.104) Sardine egg anomaly maps need to be studied in more detail (Figure 4.105)

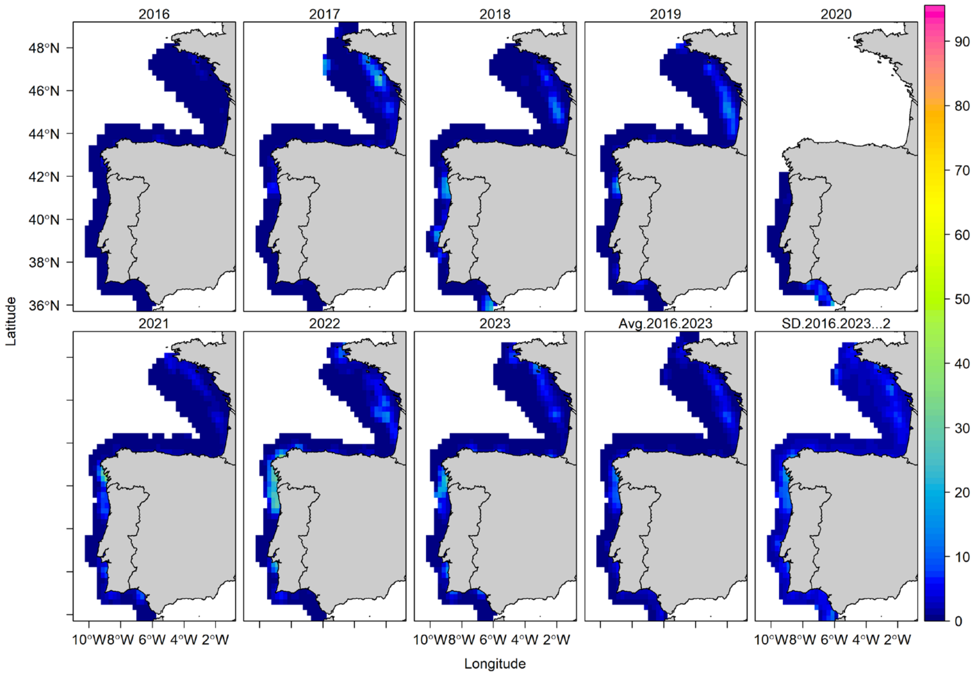


Figure 4.104 Sardine egg distribution, mean (eggs/m2), average and standard deviations maps derived from the PELAGO, PELACUS and PELGAS surveys (2016-2023) from CUFES sampling, 0.25° map cell (for more details on dates and other survey information see the survey reports). Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

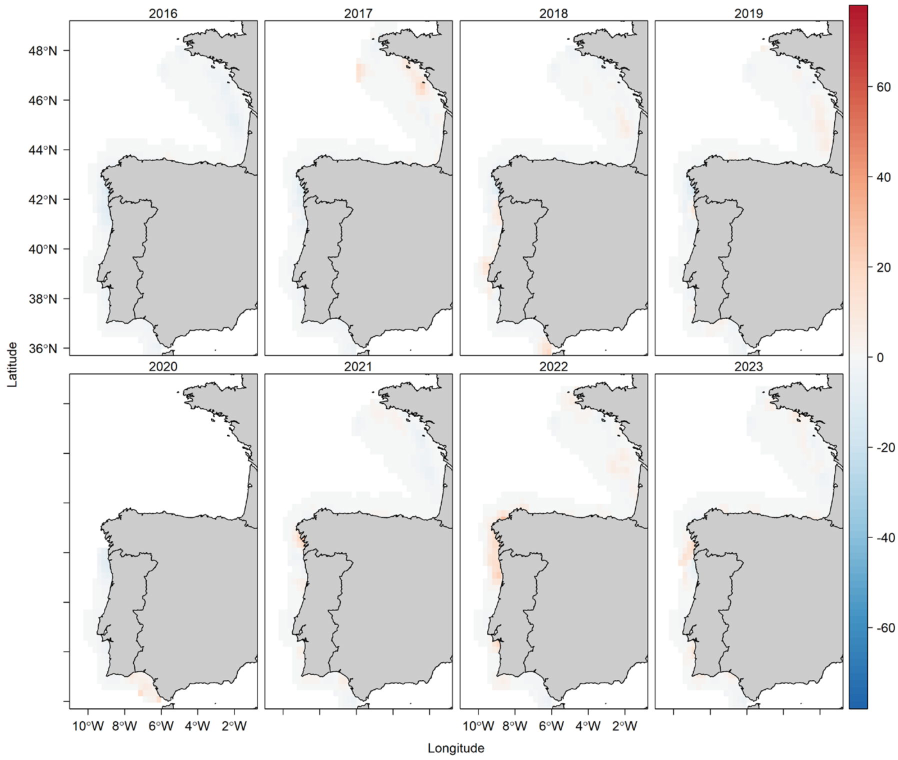


Figure 4.105 Sardine egg density (egg/m²) anomaly maps derived from the PELAGO, PELACUS and PELGAS surveys (2016-2023) from CUFES sampling, 0.25° map. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

The northern Portugal-Galicia area, where the higher sardine egg densities were observed, was also the spot in the western shores where the larger numbers of anchovy eggs appeared (Figure 4.106). However, the higher anchovy egg abundances were found in the usual areas, in the Bay of Biscay, but also extended to the Cantabrian Sea, and in the south, in the inner corner of Cadiz Bay. The distribution patterns observed were similar during the acoustics and DEPM surveys but the anchovy egg abundances observed during the PELAGO survey were considerably higher than the numbers obtained during the DEPM, which is explained by the fact that the Portuguese DEPM (directed at sardine) is a bit early in the season for anchovy spawning. Anchovy egg anomaly maps need to be studied in more detail (Figure 4.107)

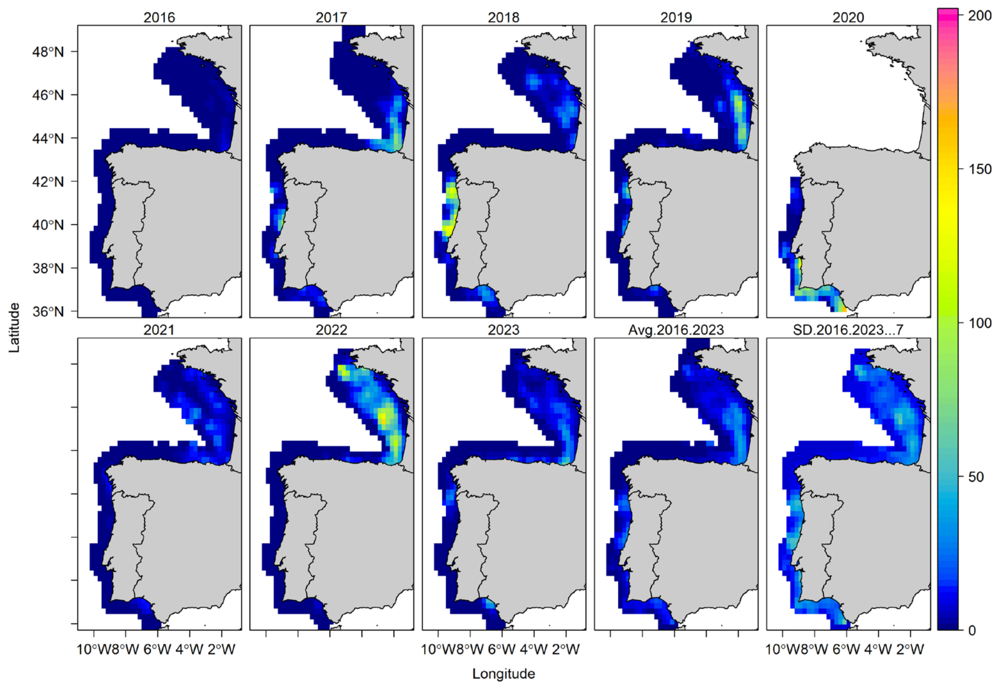


Figure 4.106 Anchovy egg distribution, mean (eggs/m2), average and standard deviations maps derived from the PELAGO, PELACUS and PELGAS surveys (2016-2023) from CUFES sampling, 0.25° map cell (for more details on dates and other survey information see the survey reports). Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

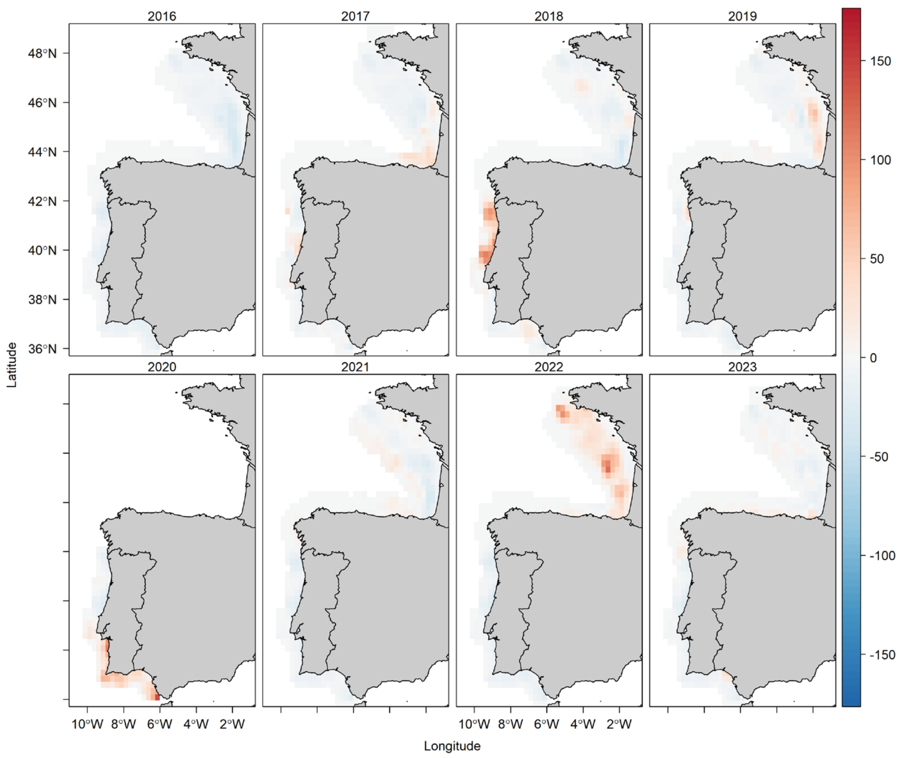


Figure 4.107 Anchovy egg density (egg/m²) anomaly maps derived from the PELAGO, PELACUS and PELGAS surveys (2016-2023) from CUFES sampling, 0.25° map. Note: PELACUS and PELGAS surveys were cancelled in 2020 due to the COVID pandemic.

4.2.1.5 CUFES and PairoVET Egg distribution from DEPM Surveys

Sardine and anchovy egg distributions obtained with the data from CUFES and PairoVET sampling along the stations during the Winter/Spring DEPM surveys PT-DEPM-PIL, SAREVA and BIOMAN are represented in Figure 4.108 and Figure 4.109(see Table 4.1 and Figure 4.4for survey dates, area covered, and the survey reports for details on each campaign).

Sardine egg distribution patterns derived from PairoVET observations during the 2023 DEPM surveys show higher abundances in the Gulf of Cádiz coast area, north Iberian and Galician coasts and on the French platform in the area below the 100m depth isoline with a high spot in the limit of the ICES 8a (48ºN). Sardine egg abundances were lower in the South Iberian coast, the Cantabrian Sea and were not found at the French platform below the 100m depth isoline. The distribution found with both samplers are similar. (Figure 4.108).

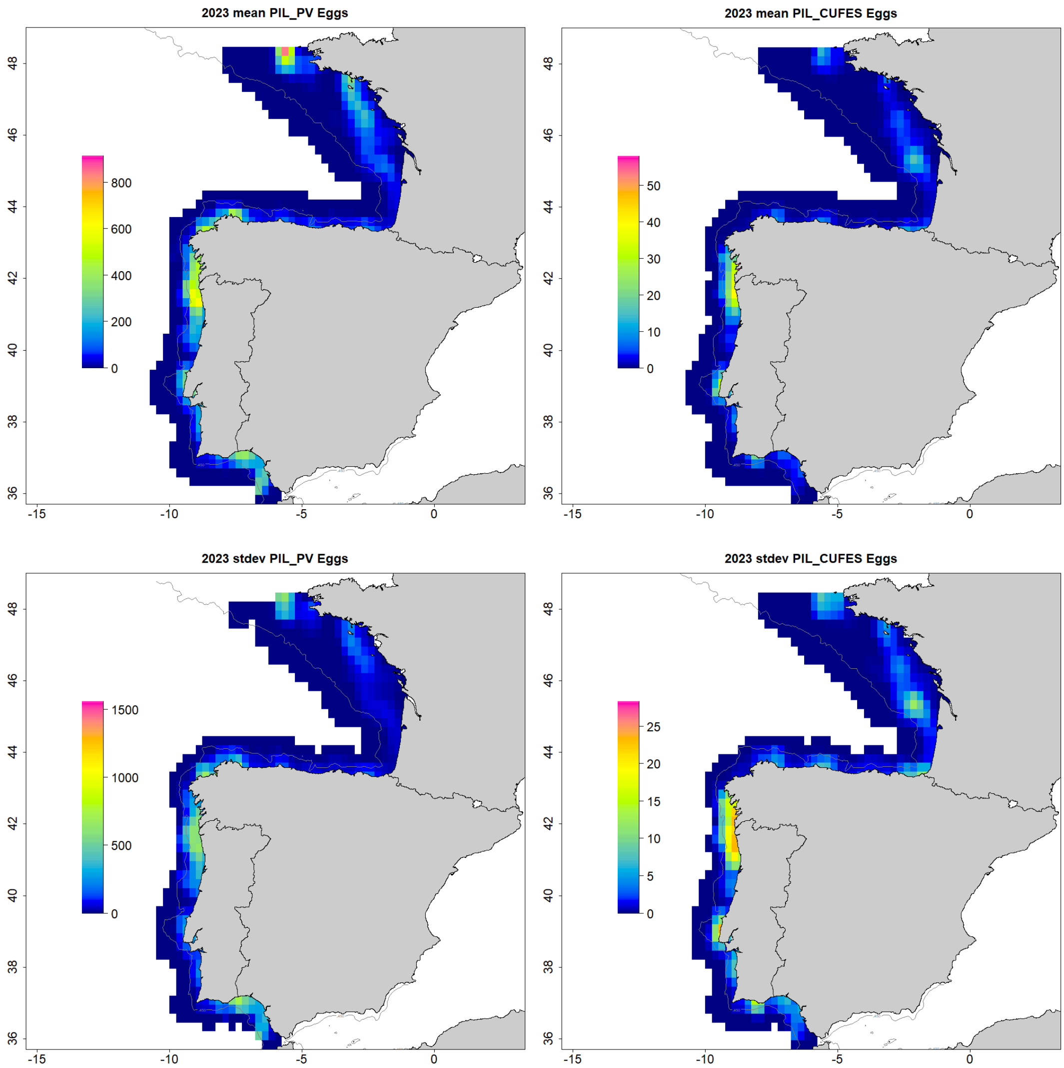


Figure 4.108 Sardine egg distributions from PairoVET (upper left panel; eggs/m2) and CUFES (upper right panel; eggs/m3) observations collected during the DEPM surveys (PT-DEPM23-PIL, SAREVA 0423 and BIOMAN2023). Bottom panels represent the standard deviation for each sampler.

Anchovy egg distribution patterns derived from PairoVET observations during the 2023 DEPM surveys show higher abundances from the cape Breton canyon area to the height of the Garonne from 100 to 200m in general in the French platforms and in all the French platform and all the Cantabrian Sea including the Galician coast and in the Gulf of Cadiz. Is remarkable that this year there were eggs all along the Cantabrian coast including the Galician area until the Portugal border. The distribution found with both samplers are similar. (Figure 4.109). It is worth noting that the Portuguese survey took place in February, during sardine peak spawning period, and therefore early in the season for anchovy reproduction, in particular in the western coast. Nevertheless, eggs of anchovy were collected, especially in the Cadiz area, where the water warms up earlier in the year.

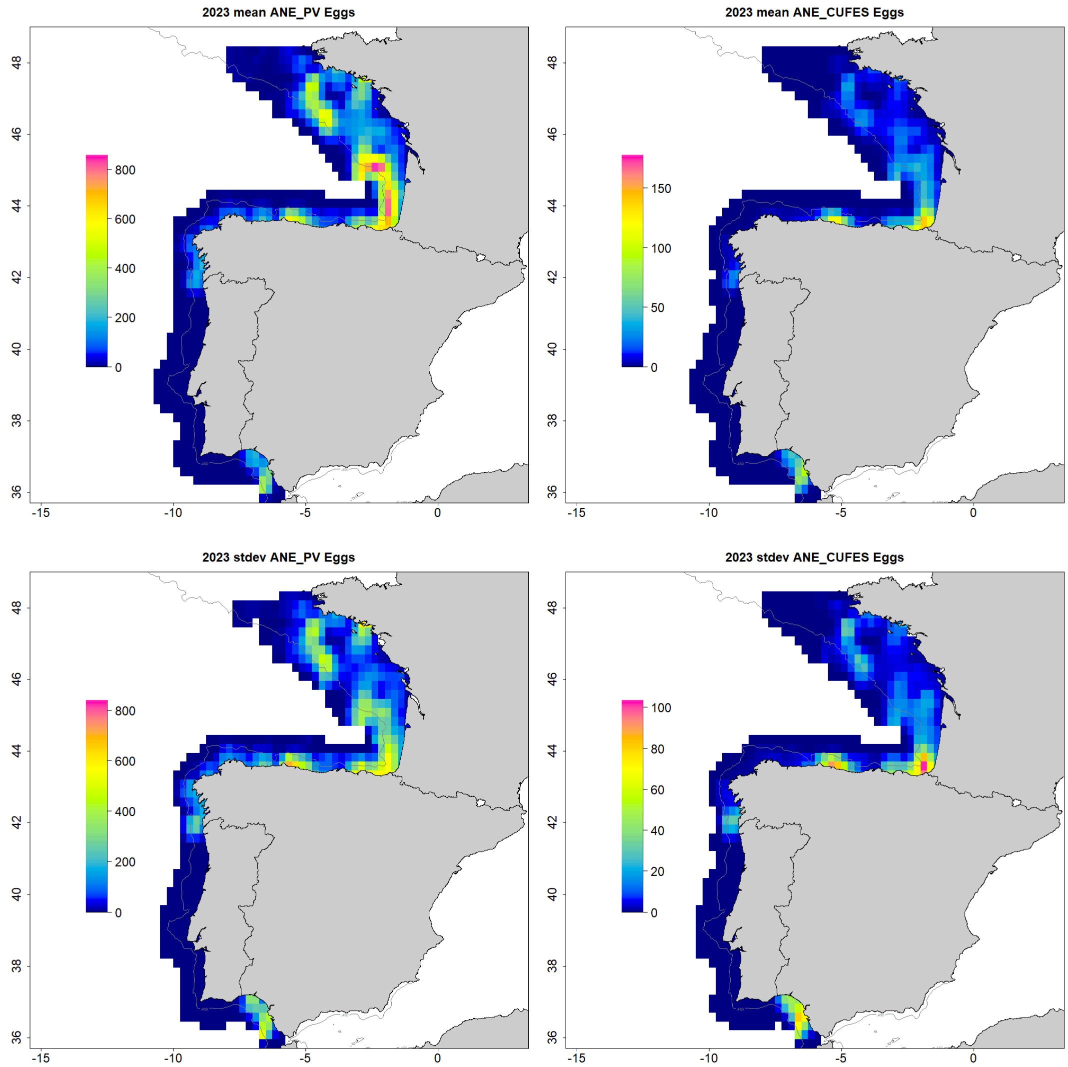


Figure 4.109 Anchovy egg distributions from PairoVET (upper left panel; eggs/m2) and CUFES (upper right panel; eggs/m3) observations collected during the DEPM surveys (PT-DEPM23-PIL, SAREVA 0423 and BIOMAN2023). Bottom panels represent the standard deviation for each sampler.

4.2.2 Summer Surveys

The *ECOCADIZ* acoustic-trawl survey, routinely conducted by IEO in summer in the Spanish and Portuguese waters of the Gulf of Cadiz, was conducted neither in 2021 nor in 2022. Exceptionally, the *ECOCADIZ 2023-07* Spanish (pelagic ecosystem-) acoustic-trawl survey, was conducted by IEO between July 29th and August 8th 2023 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cádiz (GoC) onboard the R/V *Ramón Margalef*. The survey was the acoustic component of a combined anchovy egg (*BOCADEVA*) and acoustic-trawl (*ECOCADIZ*) *ad hoc* survey (*ECO/BOCADEVA_0723* survey), which were performed one after the other, the egg survey first. This year's acoustic-trawl survey was marked by a reduction of 3-4 days to the usual survey length (ca. 14 days at sea), due to the R/V tight schedule.

4.2.2.1 Oceanography

The ocean surface winds at the Puertos del Estado Gulf of Cadiz buoy (7ºW 36.5ºN) indicate that westerlies had been established at least 10 days before the cruise. Throughout most of the cruise, upwelling-favorable westerly winds predominated. A sudden, energetic easterly event occurred on August 8th. As this event took place after the hydrographic sampling, it did not impact the oceanographic characterization.

During the cruise, near-surface temperatures ranged from 14.29 ºC (at the southern Portuguese region) to 23.59 ºC off Cádiz (Figure 4.110). Similarly, salinity ranged between 35.84 and 36.54, with the lowest values observed in the western area (Figure 4.110). This distribution illustrates an upwelling scenario, where cold, low-salinity waters dominate the entire area west of 7ºW while warmer waters prevail in the eastern Gulf.

To mitigate the direct influence of ocean-atmosphere heat flux, our focus is on the subsurface thermohaline properties, specifically between depths of 15 and 20 meters. The surface current velocity vectors illustrate a well-defined, vigorous eastward jet that draws the upwelled waters across the entire region. As these waters enter the inner Gulf of Cadiz, they gradually warm due to atmospheric influence and the mixing with local waters. The upwelling jet bifurcates upon nearing the cross-section at the Guadalquivir River mouth. The inner branch appears to recirculate in a counter-clockwise direction, while the offshore branch undergoes a sharp clockwise deflection along the isobaths. Velocities intensify towards the east, likely influenced by tidal effects and the water exchange across the Strait of Gibraltar.

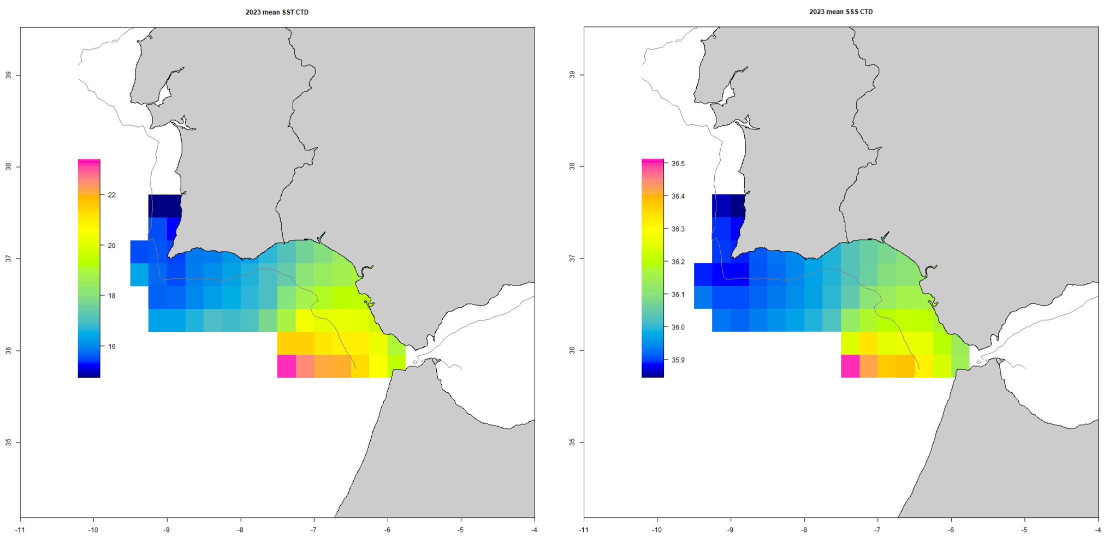


Figure 4.110 (left) underway SST during the ECOCADIZ 2023-07 survey. To unmask solar heating effects on SST we incorporate subsurface (15-20 m) temperature from the CTD profiler. (right) Subsurface Salinity from CTD measurements.

4.2.2.2 Trawl Catch composition

A total of 16 fishing operations for echotraces ground-truthing (all of them valid hauls based on gear performance and resulting catches), were carried out during the survey (Figure 4.111).

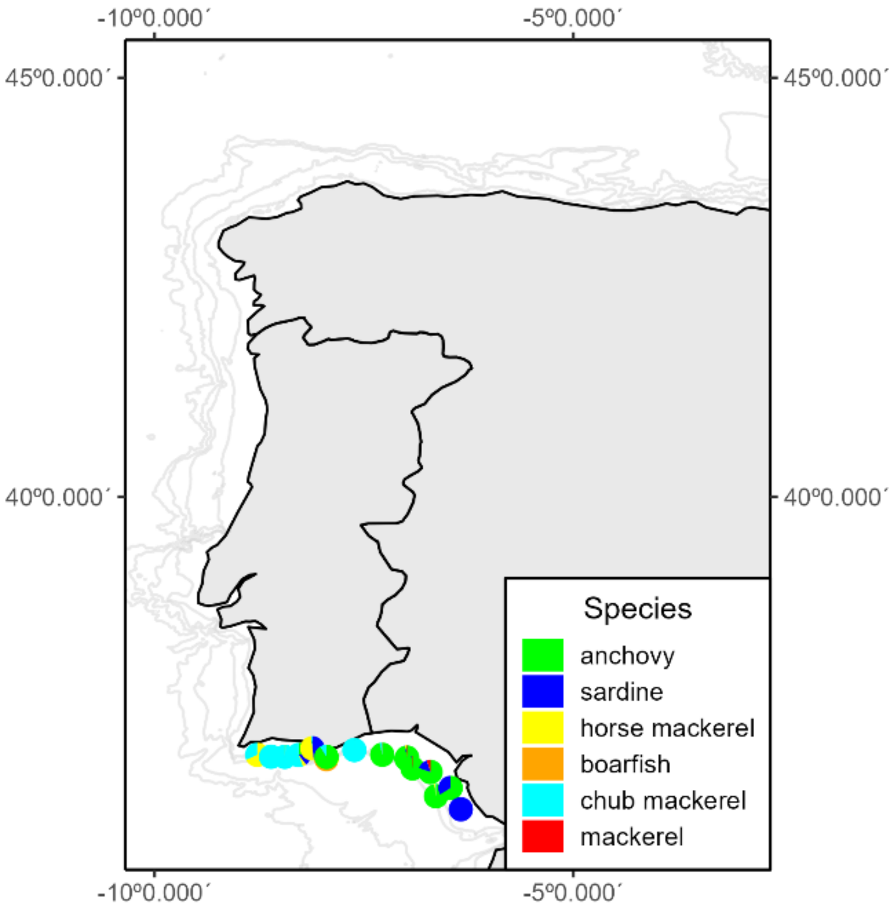


Figure 4.111 ECOCADIZ 2023-07 survey. Trawl hauls catch composition during the survey.

During the survey were captured 1 Chondrichthyan, 36 Osteichthyes, 10 Cephalopod, 7 Echinoderm, and several Cnidarian and Ascidian species. The species composition in each valid fish station is shown in Figure 4.111. 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 (69%) was the most frequent small pelagic species in the valid hauls, followed by anchovy, sardine and horse mackerel *Trachurus trachurus* (the three with 56% occurrences each). Mediterranean horse mackerel *T. mediterraneus*, Longspine snipefish *Macroramphosus scolopax* and pearlside *Maurolicus muelleri* (13% each) showed an incidental occurrence in the hauls performed in the surveyed area.

A total of 3 736 kg and 108 thousand fish were captured. Seventy-nine per cent (79%) of this "total" of fished biomass corresponded to chub mackerel, 16% to anchovy, 1% to longspine snipefish, while the remaining species had contributions lower than 1%. The most abundant species in ground-truthing trawl hauls was anchovy (47%), followed by chub mackerel (46%), longspine snipefish (3%) and sardine (2%), with each of the remaining species accounting for equal to or less than 1%. In general, the hauls' yields were very low in this survey.

4.2.2.3 SPF NASC distribution from Acoustic Surveys

Adult sardine and anchovy acoustic density (NASC) distribution

A total of 95 940 m^2 nmi^{-2} were allocated to the sampled "pelagic fish assemblage", 62% lower than the maximum value recorded throughout the time-series, estimated in 2019 (259 503 m^2 nmi^{-2}), and 21% below the historical mean (153 181 m^2 nmi^{-2}). The highest NASC value (7 269 m^2 nmi^{-2}) was observed in the middle-shelf waters (100 m) between Punta Umbria and Matalascañas (transect R08), with relatively high values being also recorded in the inner- and mid-shelf waters (20-123 m depth) of transects R18, R5, R13 and R19. By species, sardine accounted for 46% of this total back-scattered energy, followed by chub mackerel (17%), anchovy (16%), and Mediterranean horse mackerel (12%), with the remaining species showing relative contributions of acoustic energies lower than 10%.

GoC **anchovy** *Engraulis encrasicolus* (16% of the total NASC attributed to fish) was widely distributed in the surveyed area, although it showed very low acoustic densities in the easternmost and westernmost waters. High acoustic densities were mainly recorded between Ayamonte and the Bay of Cadiz (Figure 4.112).

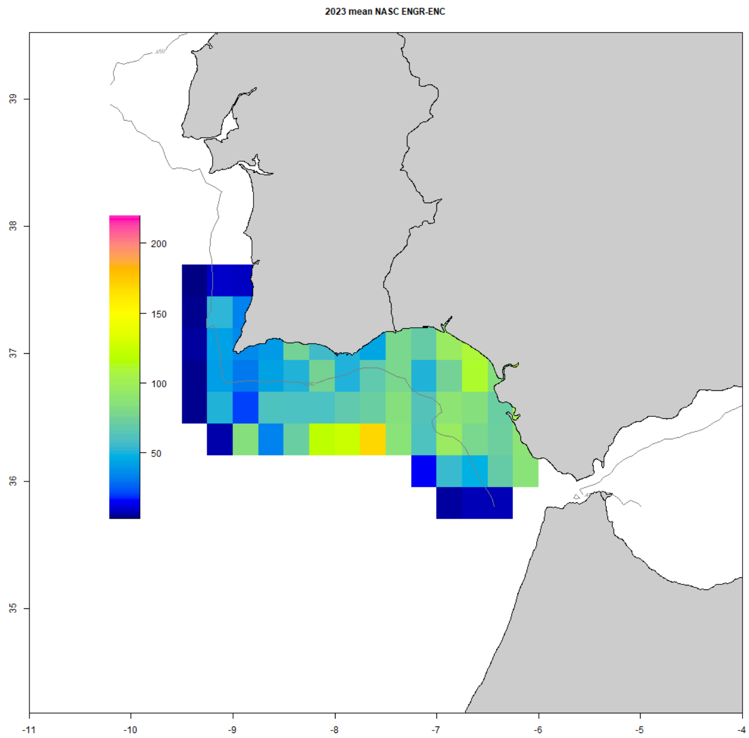


Figure 4.112 Anchovy (Engraulis encrasicolus) acoustic density (NASC, m2 nm-2) map derived from the ECOCADIZ 2023-07 Gulf of Cadiz summer acoustic survey, 0.25° map cell.

GoC **sardine** *Sardina pilchardus* comparatively showed a relatively high acoustic echo-integration in summer 2023 (46% of the total NASC attributed to pelagic fish species assemblage). Sardine was widely distributed all over the surveyed area, except between Faro and Ayamonte. High sardine densities were observed from dense mid-water schools in the Algarve coastal and inner shelf waters (20-60 m), and between Punta Umbria and Cape Trafalgar (20-40 m; Figure 4.113).

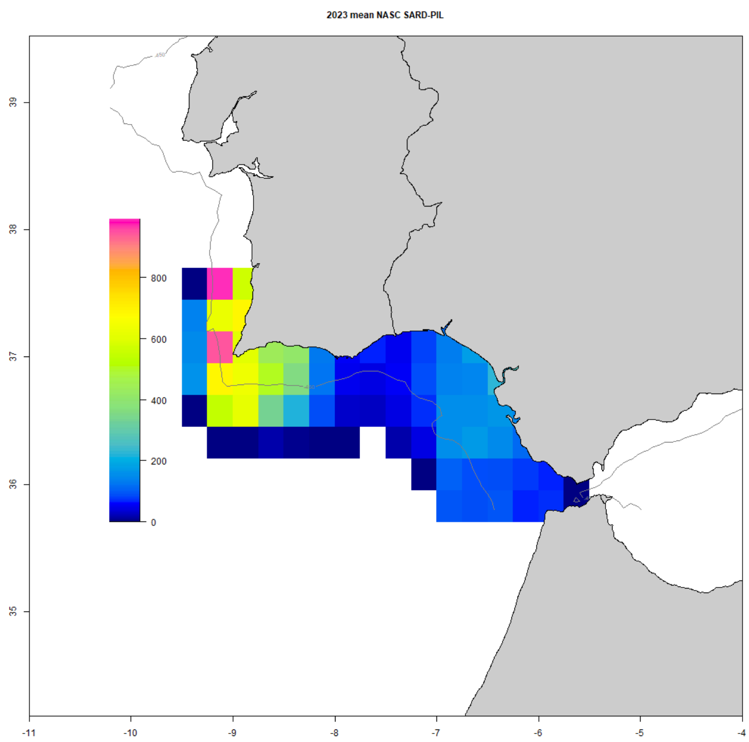


Figure 4.113 Sardine (Sardina pilchardus) acoustic density (NASC, m2 nm-2) map derived from the ECOCADIZ 2023-07 Gulf of Cadiz summer acoustic survey, 0.25° map cell.

Other adult small pelagic fish species acoustic density (NASC) distribution

Atlantic mackerel *Scomber scombrus* (<0.1% of the total NASC) showed two main density core areas, one in front of Faro and another between Punta Umbría and Chipiona, near the central zone of the surveyed area (Figure 4.114a).

Chub mackerel *S. colias* (17% of the total NASC) was mainly distributed over the Portuguese waters, recording higher acoustic densities between the Cape San Vicente and Cape Santa Maria area, whereas it was practically absent of Spanish waters (Figure 4.114b).

Horse mackerel *Trachurus trachurus* (7% of the total NASC) was observed mainly in Portuguese waters, with areas of high acoustic density being located between Cape San Vicente and Cape Santa Maria and a small area between Punta Umbria and Matalascañas in the Spanish waters (Figure 4.114c).

Mediterranean horse mackerel *T. mediterraneus* (12% of the total NASC) was observed in summer 2023 only in the easternmost waters of the Gulf of Cadiz, from the Bay of Cadiz to Cape Trafalgar. The species was absent from the most part of the Gulf (Figure 4.114d).

Blue jack mackerel *T. picturatus* (0.03% of the total NASC) was restricted almost exclusively to the Portuguese waters, showing the highest acoustic densities in Cape San Vicente shelf waters, while a small density area was observed just east of Cape Santa Maria (Figure 4.114e).

Bogue *Boops boops* (0.5% of the total NASC) was restricted to inner shelf waters (20-40 m), between Cape San Vicente and Cape Santa Maria. The species was absent of Spanish shelf waters (Figure 4.114f).

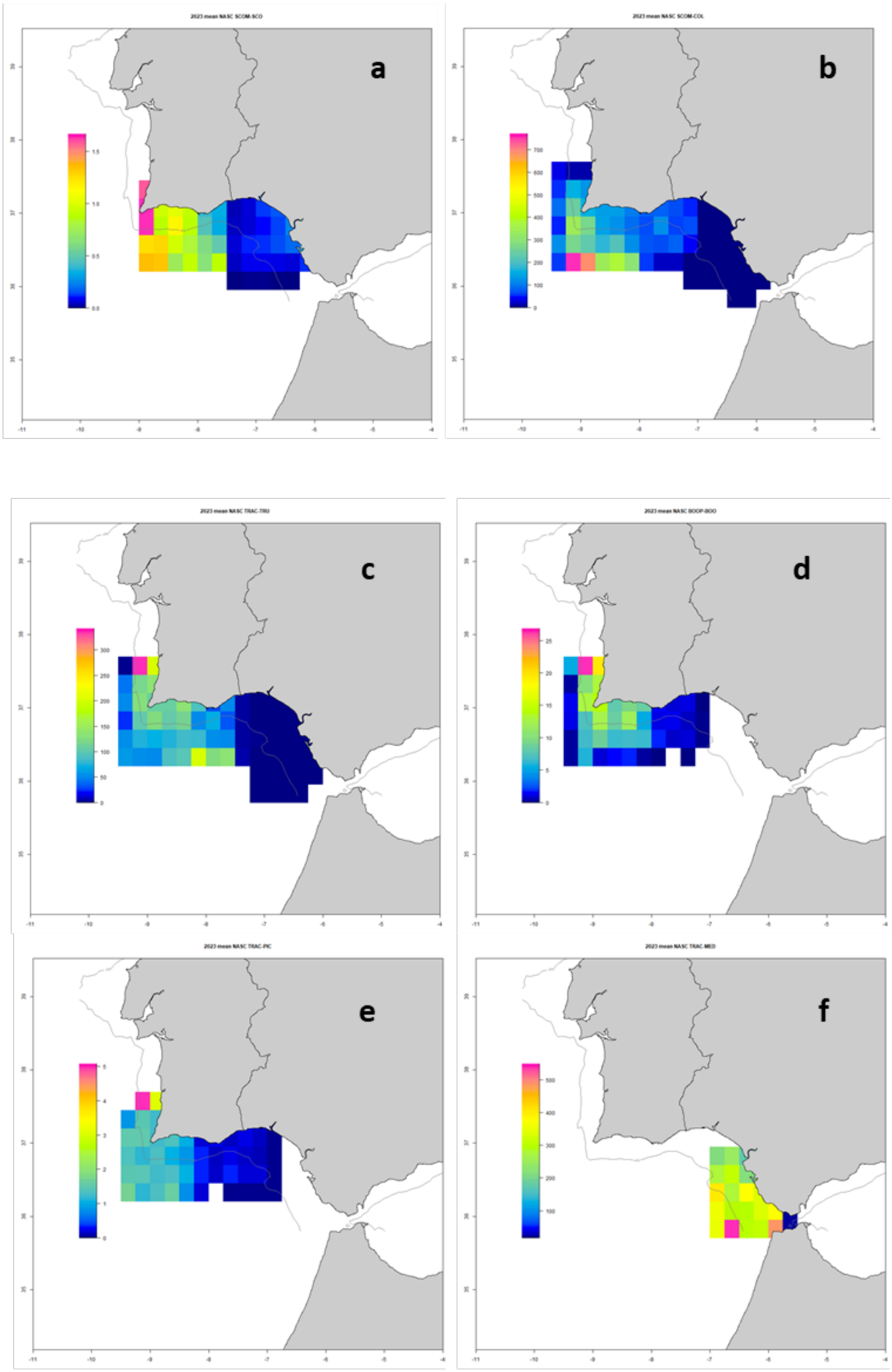


Figure 4.114 Atlantic mackerel (Scomber scombrus)(a), Chub mackerel (S. colias)(b), Horse mackerel (Trachurus trachurus)(c), Mediterranean horse mackerel (T. mediterraneus)(d), Blue jack mackerel (T. picturatus)(e) and Bogue (Boops boops)(f) acoustic density (NASC, m2 nm-2) maps derived from the ECOCADIZ 2023-07 Gulf of Cadiz summer acoustic survey, 0.25° map cell.

Transparent goby *Aphia minuta* (0.01% of total NASC) was only observed over the inner-shelf in front of Punta Umbria (Figure 4-115 a).

Boarfish *Capros aper* (0.8% of total NASC) was commonly observed over the shelf break of Algarve waters between Portimão and Faro with a small fraction of the population also detected in mid-shelf Spanish waters (40-60 m) in front of Punta Umbria (Figure 4-115 b).

Longspine snipefish *Macroramphosus scolopax* (0.2% of total NASC) was commonly observed over the shelf break of Algarve waters (Figure 4-115 c).

Pearlside *Maurolicus muelleri* (1% of total NASC) was commonly observed over the shelf break all over the GoC (Figure 4-115 d).

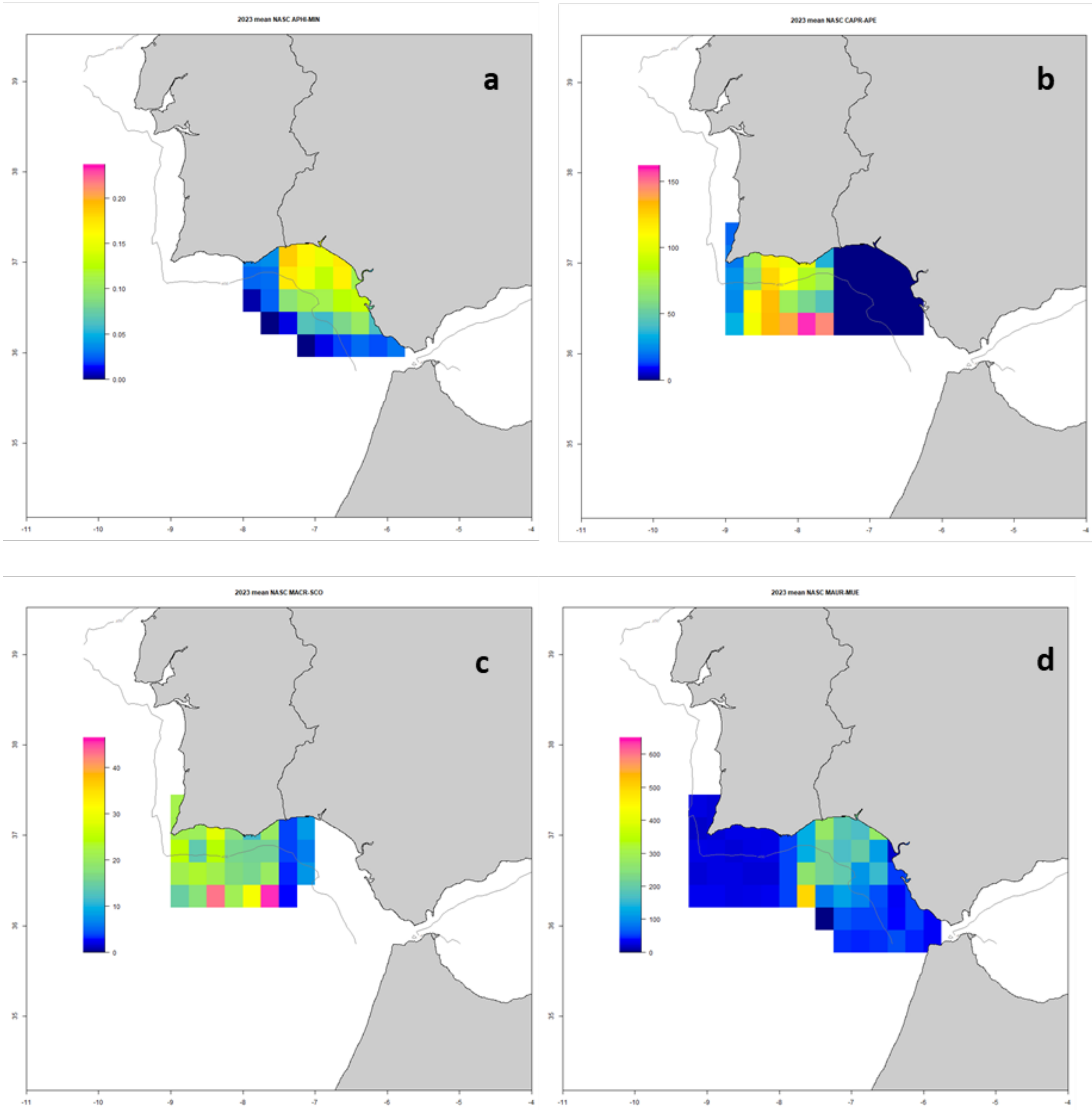


Figure 4.115 Transparent goby (Aphia minuta)(a), Boar fish (Capros aper)(b), Longspine snipefish (Macroramphosus scolopax)(c) and Pearlside (Maurolicus muelleri)(d) acoustic density (NASC, m2 nm-2) maps derived from the ECOCADIZ 2023-07 Gulf of Cadiz summer acoustic survey, 0.25^{o} map cell.

4.2.2.4 CUFES Egg distribution from Acoustic Surveys

For logistical reasons CUFES sampling was not previously carried out during the anchovy egg survey and neither during its acoustic counterpart.

4.2.2.5 ParioVET Egg distribution from DEPM Survey

The PairoVET anchovy egg spatial distribution from DEPM Survey in the Gulf of Cádiz (ICES 9aS Area) from 2005 to 2023 is shown in Figure 4.116.

The highest densities of anchovy eggs along the series were concentrates in the coastal area between the Bay of Cádiz and Cape Sta. Maria, mainly in Spanish waters. In 2023, exceptionally, a high density of anchovy eggs (Figure 4.117) was found in the Algarve (Portugal).

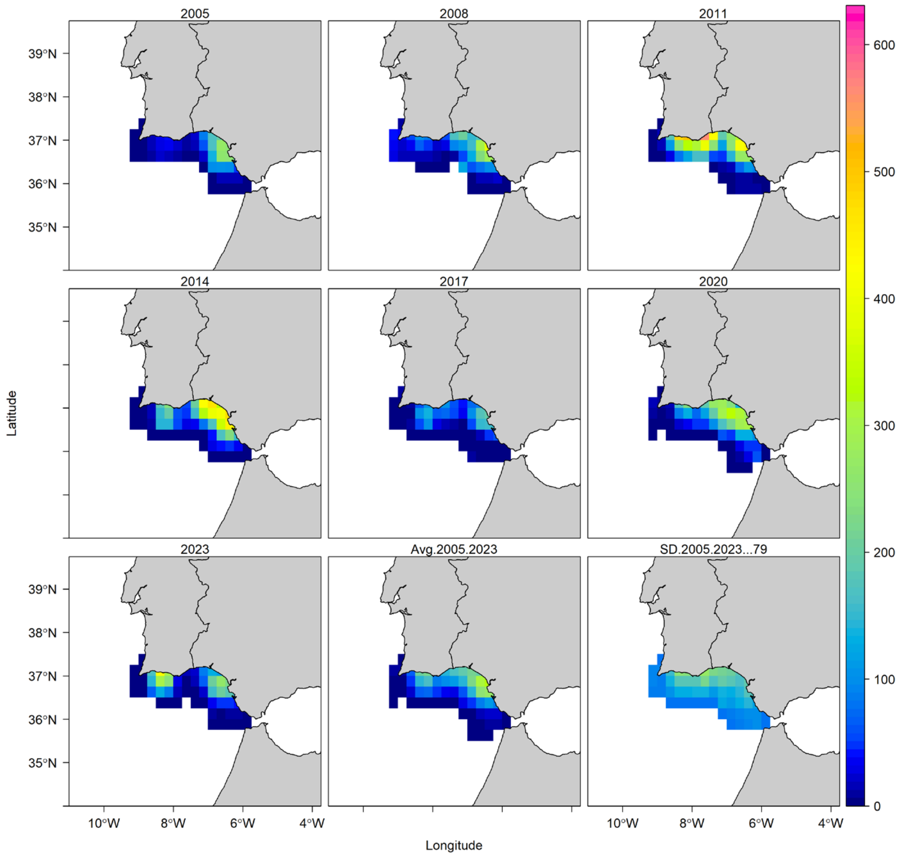


Figure 4.116 PairoVET Anchovy egg spatial distribution from DEPM Survey in the Gulf of Cádiz (ICES 9aS Area) from 2005 to 2023. The average value and standard deviation are shown too.

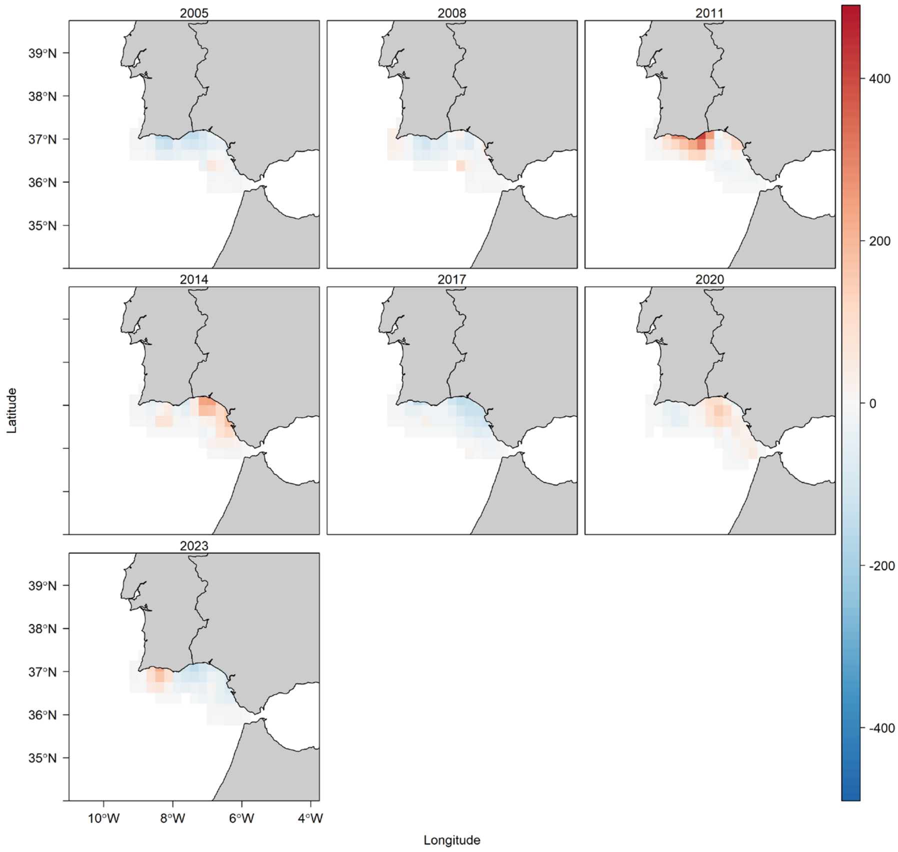


Figure 4.117 Anchovy egg density (egg/m²) anomaly maps derived from the DEPM Survey in the Gulf of Cádiz (ICES 9aS Area) from 2005 to 2023 (PairoVET sampling, 0.25° map)

4.2.3 Autumn Surveys

Five acoustic surveys took place in Autumn this year: *CSHAS*, *PELTIC*, *JUVENA*, *IBERAS* and *ECO-CADIZ-RECLUTAS*. The *JUVENA* survey was conducted from mid August to late September in the Bay of Biscay, *CSHAS* and *PELTIC* were conducted during October and early November in the Celtic Sea, and the *ECOCADIZ-RECLUTAS* was conducted in late September-mid October in the Portuguese and Spanish shelf waters off the Gulf of Cadiz.

4.2.3.1 Oceanography

Temperature and salinity were distributed differently in the different areas during the autumn campaigns. In the South, near-surface temperatures varied from 17 ºC (in the southern Portuguese region) to near 22 ºC off Cádiz. Similarly, salinity ranged between near 36 and 36.5, with the lowest values observed in the western area. Relatively colder, low-salinity waters dominate the entire area west of 7ºW, while warmer waters prevail in the eastern Gulf. These colder waters extend into the eastern shelf, dividing the warm water pool into two distinct pockets. An inner warm zone visibly extends westwards from the Guadalquivir River mouth into the Portuguese shelf beyond Cape St. Maria, demarcating the colder waters along the coast. Additionally, the offshore region also experiences warmer temperatures.

In the Western Portuguese waters, the temperature ranged between 18° and 20° C, being the temperature warmer in the central areas. Salinity showed a gradient of decrease from higher salinities, close to 36 in the south, to lower salinities, around 35 in the north.

In the Bay of Biscay, the temperature was highest in the southeastern part, with maximum temperatures close to 22.5° C, decreasing westwards to lows of around 21° C and northwards to temperatures of around 19° C. Salinity showed an east-west gradient, with values below 35 in the eastern area, associated with the plumes of the French rivers, and increasing to values of about 35.5 in the western area.

Finally, in the north, English Channel and Celtic Sea, temperatures were lowest in the westernmost area, with lows of around 14°C, rising to values above 18°C in the east. Salinity ranged from values around 35, with somewhat lower values in the west, except in the Bristol Channel, where it dropped sharply to values below 32.

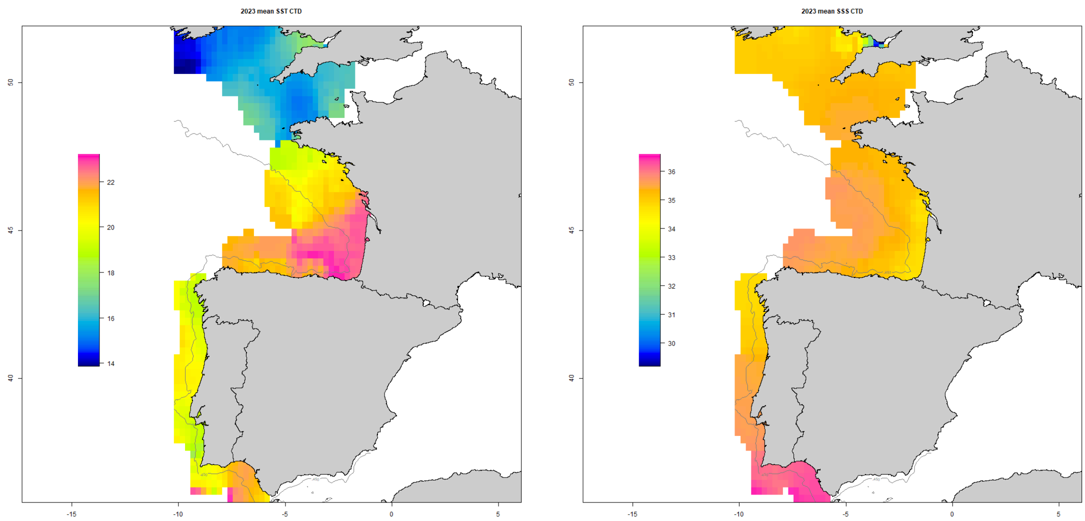


Figure 4.118 SST (left) and SSS (right) recorded during the autumn surveys. (CSHAS, PELTIC, JUVENA, IBERAS and ECOCADIZ-RECLUTAS).

4.2.3.2 Trawl Catch composition

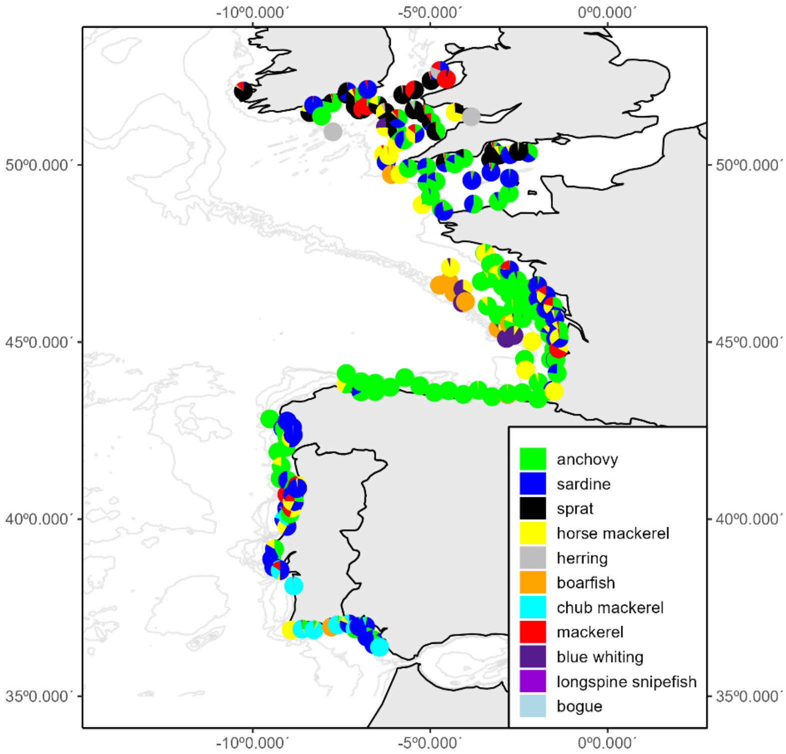


Figure 4.119 Trawl hauls catch composition during the five 2023 autumn acoustic surveys (CSHAS, PELTIC, JUVENA, IBERAS and ECOCADIZ-RECLUTAS).

A total of 204 trawls were performed by the 5 autumn surveys to ground-truth the acoustic echotraces and to obtain the age, length and weight distributions of the sampled species. The catch composition (Figure 4.119) of these trawls reflects the abundance and distribution of the main pelagic fish species related to the echotraces in the surveyed area, covering from 52° 8′ N to 36° 11′ N.

The Celtic Sea was sampled by 21 trawls showing a predominance of anchovy, sardine, herring, sprat and mackerel. PELTIC carried out 42 trawls which described a predominance of mackerel, sprat, sardine and herring in the Cardigan and Bristol Channel, with the additional presence of anchovy and horse mackerel in the latter. Clear predominance of horse mackerel and sardine was observed round the Scilly islands, with the presence of boarfish in the southwestern point of Cornwall. Anchovy was found widespread from Bristol Channel to the south of the survey, with highest densities in the Eddystone Bay. Anchovy biomass in the area was the highest on record. The largest coverage was of sardine, covering the entire sampling area, and sardine biomass was the highest recorded. This year, sprat biomass in the western Channel was the second highest in the time series since 2016.

In the Bay of Biscay, JUVENA performed 91 hauls, 57 of which were positive for anchovy, covering a great area of the BoB, reaching far North probably influenced by the presence of a surface scattering layer made of small salps. The anchovy found in the Cantabric Sea was pure juvenile and mixed with age 1 adults in the French platform. Sardine was mainly found in the inner part of the French continental shelf. Boarfish and blue whiting were present in the shelf break of the French area while mackerel and sprat were present along the French coast.

IBERAS completed 25 pelagic fishing stations and 12 purse seiner shots to identify on small anchovy, mainly in the northern part, a few thick sardine schools in 9aN and 9aCN, and chub mackerel in the southern part. The southernmost part of the autumn surveyed area was sampled by 13 fishing trawls from ECOCADIZ-R. The number of fishing hauls was somewhat lower than usual (usually ca. 20 hauls per survey) as a consequence of time constraints and the very low recorded acoustic densities. Horse mackerel (85% presence index), sardine (77%) and anchovy (77%) were the most frequent small pelagic species in the valid hauls, followed by chub mackerel (67%), Mediterranean horse mackerel (31%), bogue (31%) and Atlantic mackerel (31%).

Thirteen (13) fishing operations for echo-trace ground-truthing, all of them valid, were performed during the *ECOCADIZ-RECLUTAS 2023-10* survey. The number of fishing hauls was somewhat lower than usual (usually ca. 20 hauls per survey) as a consequence of time constraints and the very low recorded acoustic densities. The sampled depth range in these hauls oscillated between 35 and 138 m. A detailed description on the conduction of and results from these hauls is given in Ramos *et al*. (2023b WD in **Annex 3**). During the survey were captured 3 Chondrichthyan, 32 Osteichthyes, 3 Cephalopod, 2 Echinoderm, and several Cnidarian and Ascidian species. 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 horse mackerel (85% presence index), sardine *Sardina pilchardu*s (77%) and anchovy *Engraulis encrasicolus* (77%) were the most frequent small pelagic species in the valid hauls, followed by chub mackerel *Scomber colias* (67%), Mediterranean horse mackerel *Trachurus mediterraneus* (31%), bogue *Boops boops* (31%) and Atlantic mackerel *S. scombrus* (31%). No individuals of blue jack mackerel *T. picturatus* were observed. Boarfish *Capros aper*, longspine snipefish *Macroramphosus scolopax* and pearlside *Maurolicus muelleri* (8%) showed an incidental occurrence in the hauls performed in the surveyed area. During the survey were captured a total of 3 073 kg and 192 thousand fish. Forty-four per cent (44%) of this "total" of fished biomass corresponded to sardine, 28% to anchovy, 12% to chub mackerel, 5% to Mediterranean horse mackerel, 3% to boarfish, 2% to horse mackerel and contributions lower than 1% for the remaining species. The most abundant species in ground-truthing trawl hauls was anchovy (52%), followed by sardine (39%), boarfish (4%) and chub mackerel (2%), with each of the remaining species accounting for equal to or less than 1%.

4.2.3.3 SPF NASC distribution from Acoustic Surveys

Gulf of Cadiz (GoC) **sardine** showed a high acoustic echo-integration in *ECOCADIZ-RECLUTAS 2023-10* (34% of the total NASC attributed to pelagic fish species assemblage). High sardine densities were observed from dense mid-water schools in the coastal and inner shelf waters (40-57 m) found between Ayamonte and the Bay of Cadiz, with small densities also observed between Portimão and Faro (20-70 m; Figure 4.120). The sardine population in autumn 2023, contrary to the usually observed distribution pattern, was mostly restricted to Spanish waters.

During the IBERAS survey, sardine was detected mainly in the central part of the western Portuguese coast, in front of Aveiro and Figueira da Foz, as well as in the Galician Rias.

In the Bay of Biscay, sardine was mainly found during the JUVENA survey in the inner part of the French continental shelf, with some detections also in the western part of the Cantabrian Sea (Figure 4.120**)**. This distribution is similar to the distribution of sardine normally observed in this area and season (Figure 4.121 and Figure 4.122**)**. Further north, the density distribution of sardine was concentrated around the Cornish Peninsula and west in the English Channel. While more widespread and at higher densities, the distribution was typical for the area. Lower sardine densities were found along the southern Irish coast and the northernmost distribution of sardine appeared to be captured by the CSHAS and PELTIC surveys.

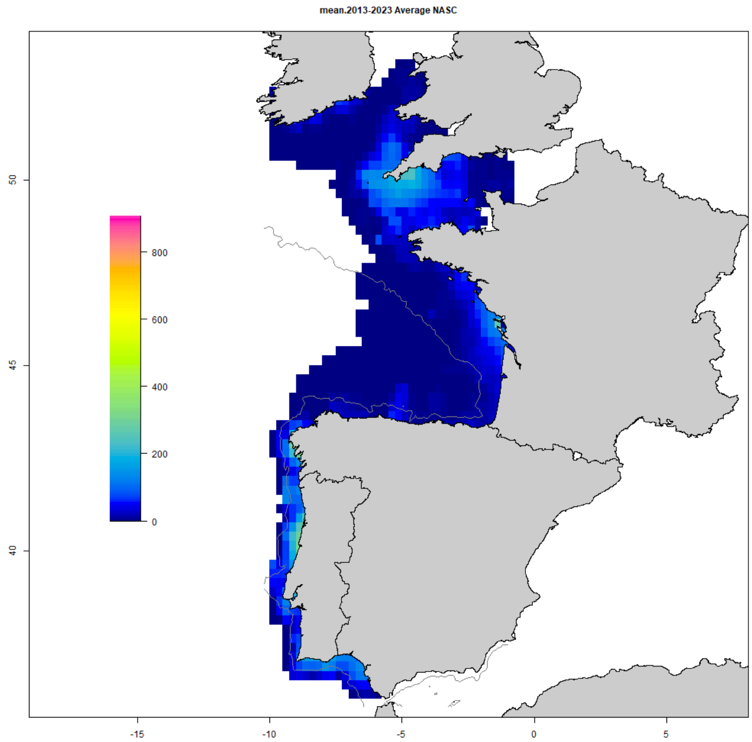


Figure 4.120 Adult Sardine (Sardina pilchardus) mean acoustic density (NASC, m2 nm-2) average map derived from the autumn acoustic surveys, 0.25^{o} map cell.

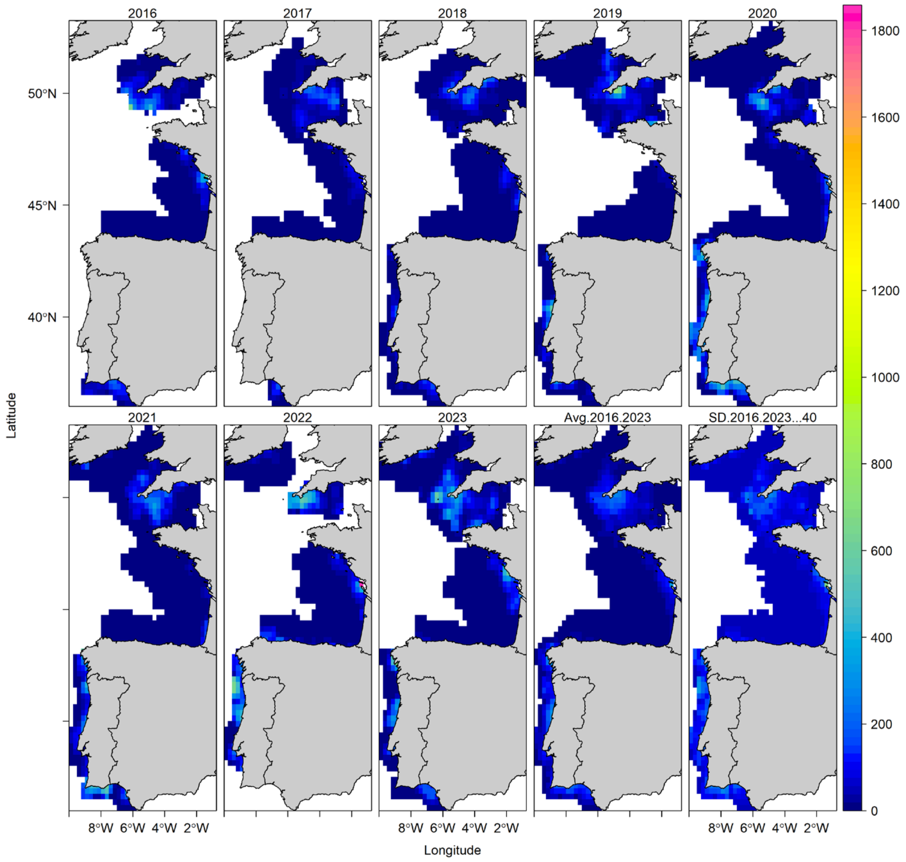


Figure 4.121 Adult sardine mean acoustic density (NASC, m².NM-²) maps derived from the autumn acoustic surveys, 0.25º map cell.

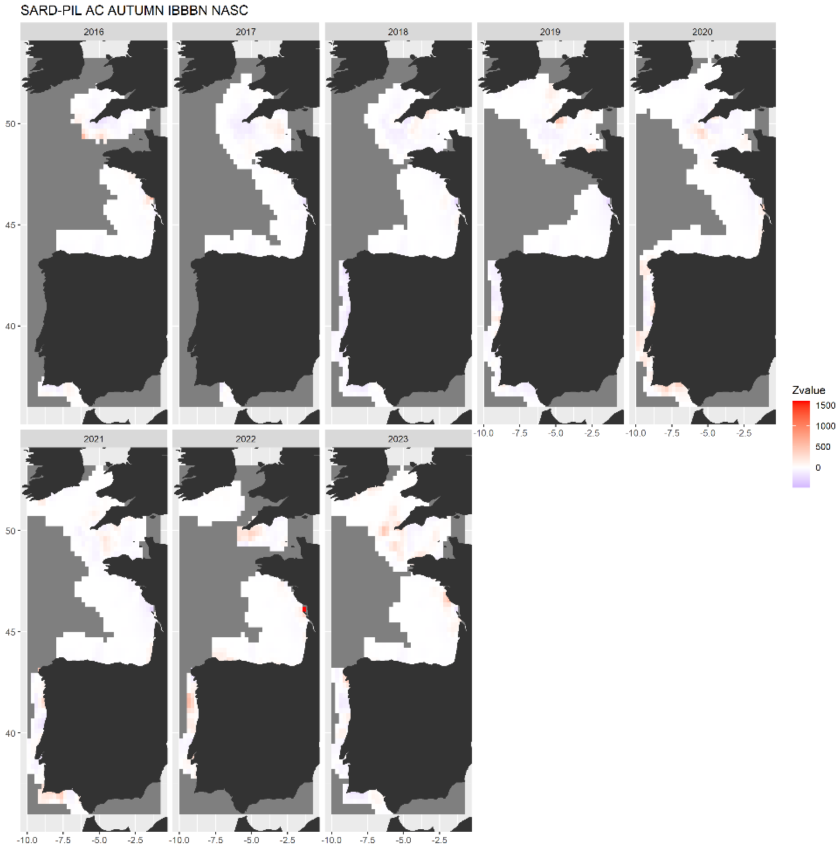


Figure 4.122 Adult sardine mean acoustic density (NASC, m².NM-²) anomaly maps derived from the autumn acoustic surveys, 0.25º map cell.

Anchovy (20% of the total NASC attributed to fish) was widely distributed in the GoC in autumn 2023, although higher densities were recorded between east of Cape Santa Maria and Bay of Cadiz (Figure 4.123). In the western Portuguese waters, anchovy was detected mainly on the shelf in front of Aveiro and Oporto, extending up to the southern Galician waters.

In the Bay of Biscay, adult anchovy was distributed along the French continental shelf, especially in the northern part, and in the western part of the Cantabrian Sea (Figure 4.123) following the typical distribution of this species for this area at this time of the year (Figure 4.124 and Figure 4.125). In the Celtic Sea, anchovy was more widely distributed and found in higher densities compared to the other years in the available timeseries (Figure 4.124 and Figure 4.125). Some lower densities of anchovy were again found south of Ireland although the northern most coverage yielded negligible numbers of anchovy.

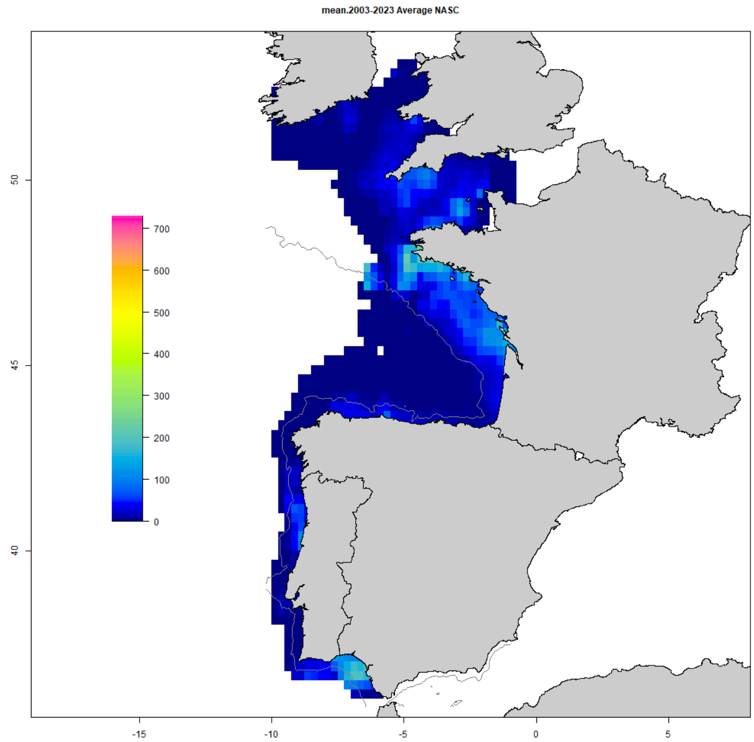


Figure 4.123 Adult Anchovy (Engraulis encrasicolus) mean acoustic density (NASC, m2 nm-2) average map derived from the autumn acoustic surveys, 0.25° map cell.

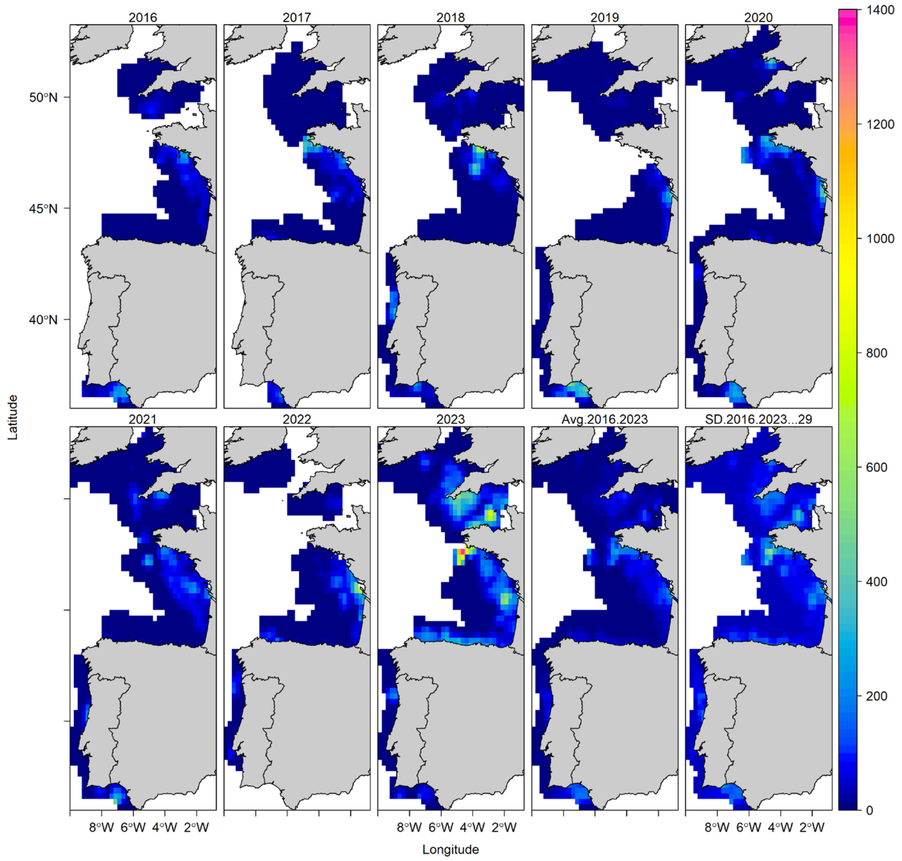


Figure 4.124 Adult anchovy mean acoustic density (NASC, m2 nm-2) map derived from the autumn acoustic surveys, 0.25° map cell.

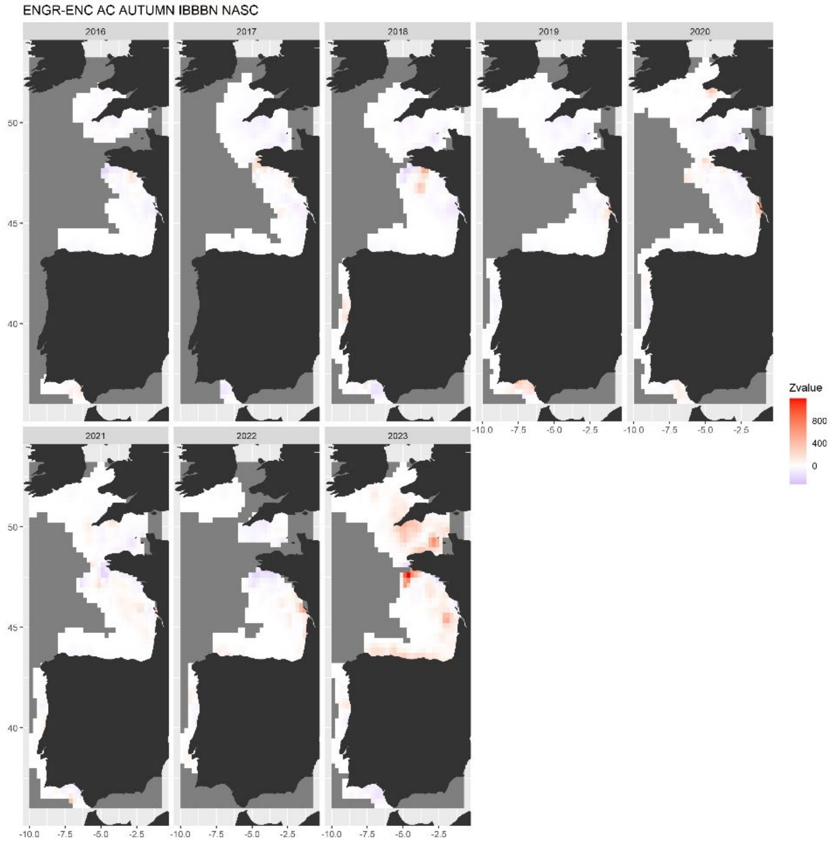


Figure 4.125 Adult anchovy mean acoustic density (NASC, m2 nm-2) anomaly map derived from the autumn acoustic surveys, 0.25^{o} map cell.

Atlantic mackerel was abundant in the Iberian coast with higher densities in the Aveiro surroundings, In the GoC (represented <0.01% of the total NASC in Ecocadiz-recultas) was barely observed in the GoC in autumn 2023, with no detectable high density areas given its low acoustic detection (Figure 4.126**a**). Atlantic mackerel were very scarce in the Bay of Biscay, with a concentrated distribution in coastal waters of the French shelf and the western Bay of Biscay.

Chub mackerel was present in the Atlantic side of the Ibearian peninsula, with higher densities found south of Lisbon. In the GoC (represented 14% of the total NASC in Ecocadiz-recultas) was mainly distributed between Punta Umbria and Cape San Vicente, recording the highest acoustic densities between the Cape San Vicente and Cape Santa Maria area, and between Faro and Punta Umbría (Figure 4.126**b**).

No acoustic record of **Blue jack mackerel** was recorded in the autumn surveys during the 2023 (Figure 4.126**c**).

Horse mackerel was commonly present in the Iberian peninsula coast.In GoC (represented 27% of the total NASC in Ecocadiz-reclutas) was observed between Cape San Vicente and Punta Umbria, with areas of higher acoustic densities located mainly in the western Algarve and just east of Faro (Figure 4.126**d**). An increase in horse mackerel was detected in the Bay of Biscay, spread over the northern part of the inner and outer French shelf.

Mediterranean horse mackerel (represented 8% of the total NASC in Ecocadiz-recultas) was observed from Cape Trafalgar to Vila Real de Santo Antonio in autumn 2023. The species was mainly distributed all over the Spanish waters, mainly over the inner-mid shelf (Figure 4.126 **e**).

Bogue was present in the Iberian Peninsula, with several hotspots (in the Galician area, south of Lisbon, and in the Gulf of Cadiz (GOC)). The higher higher densities were found in the GoC . In these area (represented 1% of the total NASC in Ecocadiz-reclutas) showed a scattered distribution throughout the Gulf, with higher acoustic densities located in inner shelf waters (25-50 m), between Punta Umbria and Ayamonte and in the easternmost part of the gulf of Cadiz (Figure 4.126**f**).

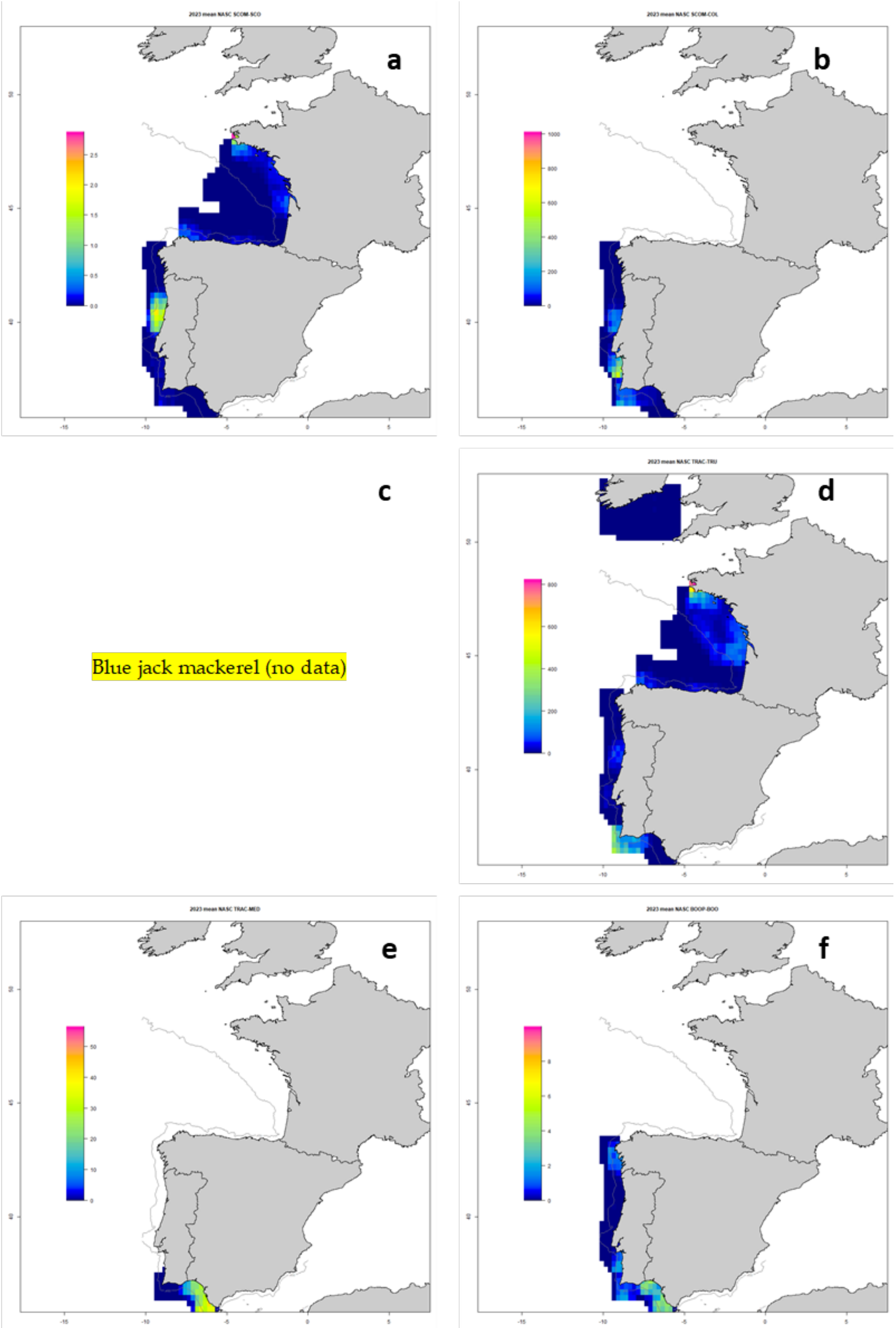


Figure 4.126 Atlantic mackerel (Scomber scombrus)(a), Chub mackerel (S. colias)(b), Blue jack mackerel (Trachurus picturatus)(c), Horse mackerel (T. trachurus)(d), Mediterranean horse mackerel (T. mediterraneus)(e), Bogue (Boops boops)(f) acoustic density (NASC, m2 nm-2) maps derived from the 2023 autumn acoustic surveys, 0.25° map cell.

Boarfish In GoC (represented <0.2% of total NASC in Ecocadiz-reclutas) was only located with very high acoustic density in front of Faro (Figure 4.127**a**). In the Bay of Biscay, the abundance of boarfish decreased compared to last year. It was found in the area around the shelf break in the northern part of the French shelf, extending across the shelf also in the area further north. In the Celtic Sea, boarfish was found around the Isles of Scilly. These are some of the deeper waters covered by the two surveys and it is likely that boarfish distribution extends further west beyond the area covered (Figure 4.127**a**).

Longspine snipefish was only present in the south of the autumn surveys coverage. In the GoC (represented <0.01% of total NASC in Ecocadiz-reclutas) was almost absent of the gulf of Cadiz given its low acoustic density (Figure 4.127**b**).

Pearlside (represented 3% of total NASC in Ecocadiz-reclutas) was commonly observed over the shelf break all over the gulf of Cadiz (Figure 4.127**c**). In the Bay of Biscay, it was mainly distributed in the Cantabrian area in oceanic waters in large abundances. It was also found in lower abundance in the oceanic zone off the French coast.

Herring During CSHAS herring distribution can be described in two groupings; the first being the offshore migratory component of the stock and the second as inshore juvenile herring. The offshore migratory stock component is composed of mature individuals and a single high density aggregation was located during the 2023 survey located approximately 30 nmi offshore. This aggregation was persistent in a particular area for almost 3 weeks prior to the survey and was surveyed as part of the CSHAS both acoustically and through trawl sampling through additional adaptive survey effort. The second stock component is made up of immature fish and is characterised by an inshore distribution with individuals occurring in low/medium density mixed species aggregations and. These fish have yet to recruit to the spawning stock and in general contribute variable proportions to the total survey estimate. Juvenile herring, mixed in with sprat, are also the main contributor along the UK coast, primarily in Cardigan Bay and, to a lesser extent, in the Bristol Channel, Small numbers are also found mixed ni with sprat in Lyme Bay, along the south coast of Devon (Figure 4.127**d**).

Sprat During CSHAS sprat were found distributed in moderately low number but over a wide area. The highest density aggregations were observed in the eastern survey area and in close inshore waters (<10nmi), which was corroborated also by PELTIC which found sprat to be widespread in Cardigan Bay and the Bristol Channel. In the English Channel, sprat was again found primarily in Lyme Bay with some of the highest densities in the ten year time-series (Figure 4.127 **e**). The sprat was virtually absent from Bay of Biscay this year.

Blue whiting was practically absent in the Gulf of Cadiz(Figure 4.127 **f**). In the Bay of Biscay, blue whiting was found distributed in a band around the northern French shelf-break in abundances higher than previous years.

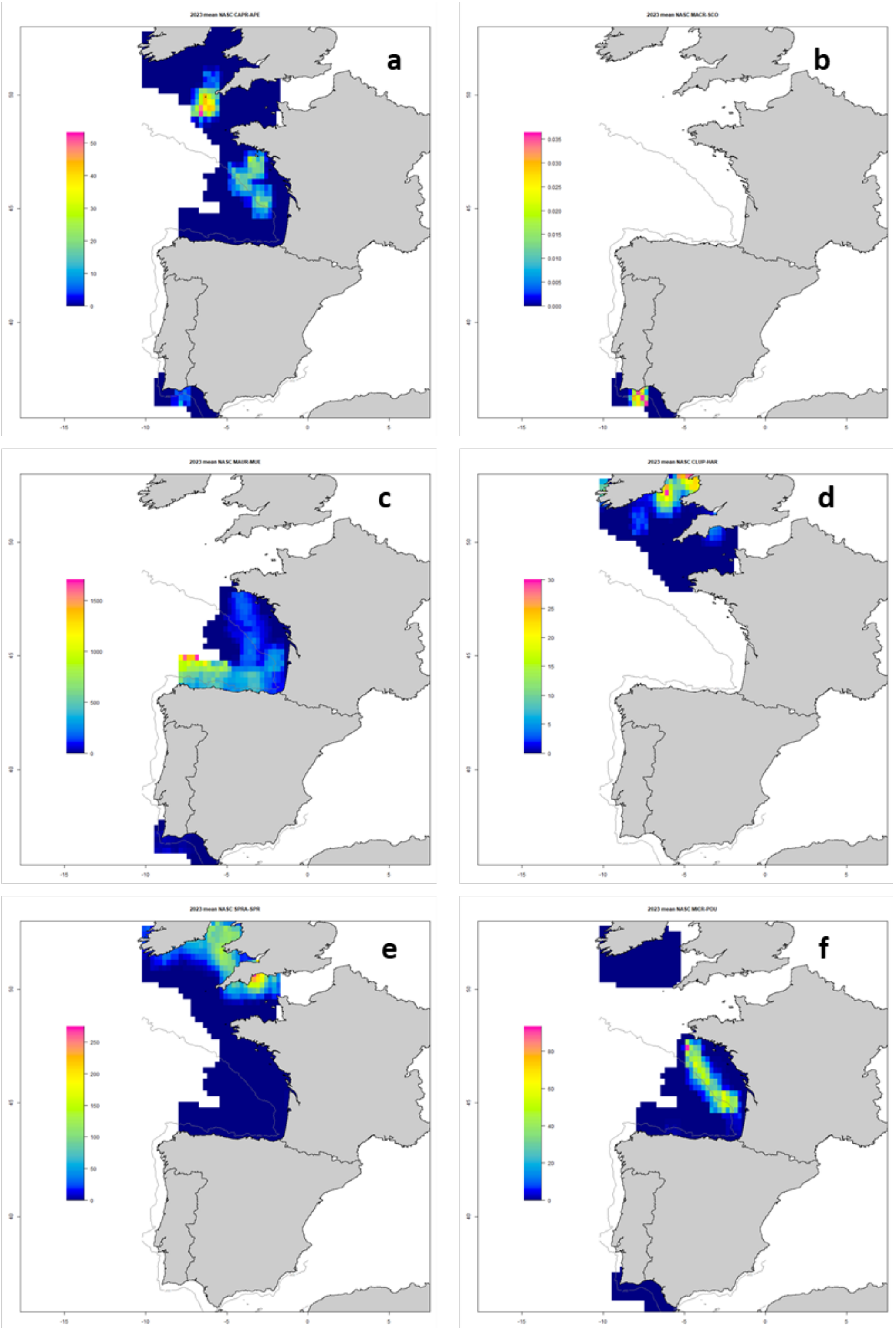


Figure 4.127 Boarfish (Capros aper)(a), Longspine snipefish (Marcroramphosus scolopax)(b), Pearlside (Maurolicus muelleri)(c), Herring (Clupea harengus)(d), Sprat (Sprattus sprattus)(e), Blue whiting (Micromesistius poutassou)(f) acoustic density (NASC, m2 nm-2) maps derived from the 2023 autumn acoustic surveys, 0.25º map cell.

4.2.4 SPF habitat modelling

4.2.4.1 Space time modelling of the monthly distribution of sardine in the Bay of Biscay

The Delmoges project aims at producing new ecological and fisheries knowledge, in order to reduce dolphin bycatch in the Bay of Biscay (BoB). Within this framework, the seasonal and inter-annual variability in the distribution of dolphins' main prey, small pelagic fish, was modelled, using a hierarchical model. The model integrates 3 types of data: presence-absence and biomass of fish from the WGACEGG-coordinated scientific surveys PELGAS and JUVENA, and presence of fish from fishing data (Vessel Monitoring System x landings data). The model applied to BoB sardine data has provided, for the first time, a quantitative description of the seasonal spatial dynamics of this species and associated fisheries. An Empirical Orthogonal Function (EOF) was applied to the model biomass prediction to characterize seasonal space time patterns in sardine distribution.

In springtime, sardine was on average distributed in coastal areas from Southern Biscay to the Loire's river mouth, and fluctuated from year to year with no obvious time trend (Figure 4.128).

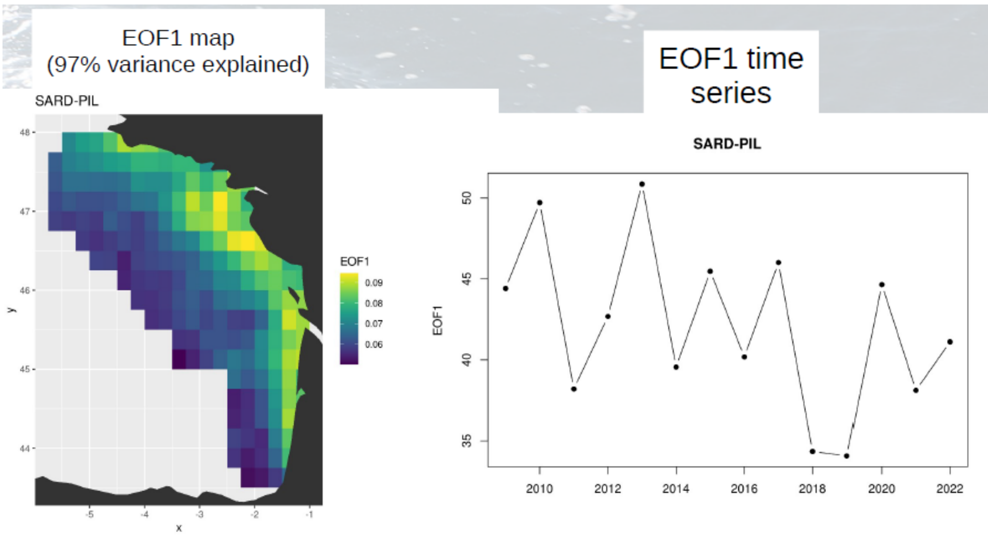


Figure 4.128 EOF1 map (left) and amplitude time series (right) derived from sardine biomass predictions in springtime.

In summer, the sardine main distributional pattern was shifted Northwards, in coastal areas from Gironde river mouth to Brittany, the intensity of this pattern has decreased over time (Figure 4.129).

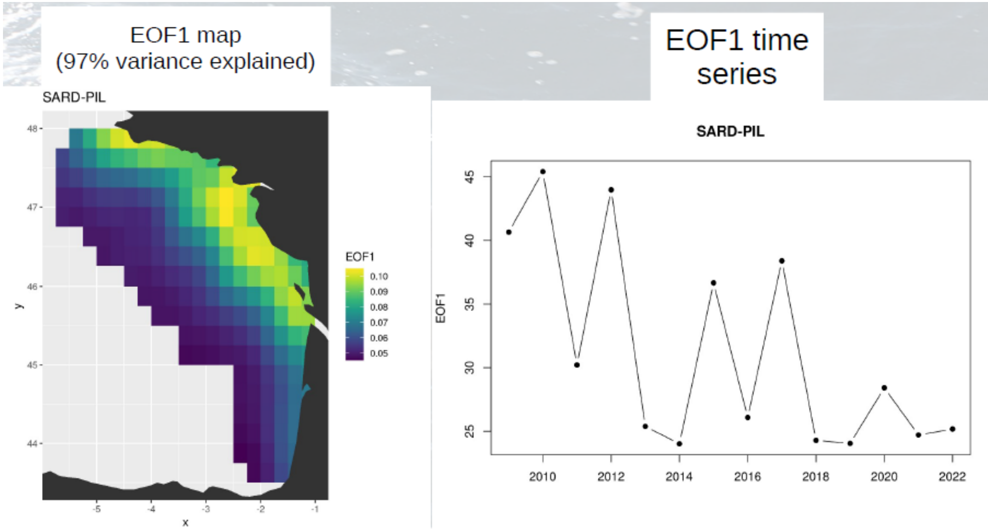


Figure 4.129 EOF1 map (left) and amplitude time series (right) derived from sardine biomass predictions in summer.

In fall, sardine seemed to migrate back to Southern coastal areas. The intensity of this average spatial pattern has also decreased over time (Figure 4.130).

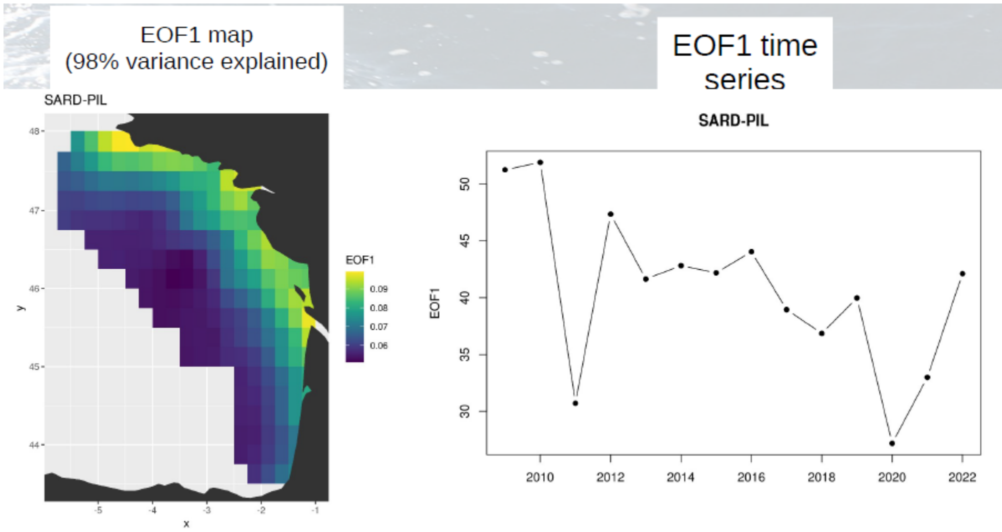


Figure 4.130 EOF1 map (left) and amplitude time series (right) derived from sardine biomass predictions in summer.

Fisheries were concentrated in the sardine's main coastal distribution areas, and was more intense in summer, then autumn, and less intense in spring. Details can be found in Hebert--Burggraeve (2023).

After integrating winter data, this model will be applied to anchovy, to predict the space time distribution of the main dolphin preys in the BoB at seasonal and inter-annual scales. These predictions will be used to study the co-occurrence between dolphins and their preys, and assess the potential effect of the predator-prey overlap on dolphin bycatch.

References

Hebert--Burggraeve, A., 2023. Une approche d'intégration de données avec des modèles hiérarchiques pour caractériser les variations spatio-temporelles de la distribution des petits poissons pélagiques dans le Golfe de Gascogne, A data-integration approach with hierarchical models to reveal spatiotemporal variations of small pelagic fish distribution in the Bay of Biscay. Mémoire de fin d'études d'ingénieur en « Sciences Halieutiques et Aquacoles » (Ressources et Ecosystèmes Aquatiques) de l'Institut Agro Rennes-Angers. https://archimer.ifremer.fr/doc/00855/96651/

4.3 Methodological developments for acoustic and DEPM biomass assessment

4.3.1 Methodological development for acoustic biomass assessment

4.3.1.1 Uncrewed vehicules

New monitoring technologies used to complement or increase the sampling effort in the Bay of Biscay were presented by IFREMER and AZTI.

Uncrewed Surface Vehicle (USV) for acoustic mapping of common dolphin and their small pelagic preys in inclement weather

Common dolphin bycatches have dramatically increased in the French Atlantic area (Bay of Biscay, BoB) over the last decade, especially in winter. This fishing mortality increase might be caused by a distributional shift of offshore dolphin sub-populations towards the heavily fished BoB continental shelf, in response to the recovery of the local anchovy population, one of the dolphins preferred food source. However, due to the lack of data on BoB small pelagic fish (SPF) distribution during the bycatch peak season, this hypothesis could not be tested. Within the framework of the DELMOGES research project, an integrated acoustic survey was conducted in winter 2022 in the main dolphin bycatch area in central BoB. The objective was to test if dolphin-SPF co-occured at this time of year, especially in areas where gillnetters were operating. As inclement weather would have jeopardised the quality of acoustic collected during a classical ship-borne acoustic survey in the BoB in winter, the survey was performed using the Exail USV Drix (Figure 4.131).

Figure 4.131 Exail's USV DriX in action during the DELMOGES survey. (c) Ifremer, S. Lesbats.

The USV was equipped with a Simrad EK80 echosounder (70 and 200kHz frequencies) to map fish schools, and with 2 hydrophones to detect dolphins. This 8m long USV could be rapidly deployed to take advantage of good weather windows. Its diesel engine, good seakeeping capacities and drop keel allowed to collect good quality data at sufficient speed to avoid detecting several times the same moving schools. To make SPF distribution maps, schools were extracted from EK80 narrowband data collected during daytime through echogram scrutinising. Dolphin density maps were produced by combining acoustic detections from the Drix with airborne sightings data collected synoptically in the same area. Map comparison showed that common dolphins and SPF distribution overlapped in coastal areas (<100m depth) where gillnetting activity was also intense. Unusual dense layers of SPF located very close to the seabed were also punctually detected. These hotspots of dolphin preys overlapped with the gillnets fishing area, confirming that the dolphin feeding behaviour may increase the bycatch risk. Perspectives for complementing classical ship-borne marine ecosystem acoustic monitoring with USV based surveys were discussed.

Since 2021, Azti has been collaborating with a Basque engineering company *Branka composite* on the development of two uncrewed vehicles: **USV ITSASDRONE** and **USV *Ranger 6.0***. ITSASDRONE (Figure 4.132) is a small catamaran equipped with an echosounder in a submerged gondola that was designed for long term missions (3 months or more) and works under automated remote control with radio or satellite communication, but also possible to control manually with a joystick. It is nearly 2 m long with a beam of 1.2 m and a draft of 50 cm. The hull material is carbon fibre and epoxy, it is propelled by 2 electric thrusters and reaches a maximum speed of 2-3 knots. It works with two rechargeable batteries (and is equipped with a Simrad WBT EK80 200 kHz echosounder and a weather station. Data is registered to local memory in *.raw* format.

Ranger 6.0 is an autonomous electric propulsion surface vehicle that requires a remote control unit installed on land to perform its navigational operations in autonomous mode. With a length of 5.9 m and beam of 2.0 m, the Ranger normally operates at a speed of 4-5 knots and can reach a maximum speed of 7-8 knots in certain situations. The autonomy in terms of energy is conditioned by the type of sensors the boat is equipped with and the operating speed (approximately 8 hours at medium speed).

Both ASVs have been used within the SafeWAVE European project that aims to improve the knowledge on the potential environmental impacts from Wave Energy projects by means of new technological monitoring technologies. Testing the viability in the use of the ITSASDRONE and Ranger 6.0 for this purpose was one of the objectives within this project. After the first measurements with ITSASDRONE around a floating laboratory within the BiMEP area in Armintza (Spain), good quality data was collected, however some limitations were detected such as limited electrical power and space, limited sample depths or sensitivity to weather conditions, making it a de facto coastal vehicle. Finally, due to the limited connectivity, the vehicle's navigation is blind, unable to avoid obstacles along the programmed route. All this means that the operation of the vehicle requires the almost permanent availability of a support vessel to deploy and withdraw it, depending on weather and sea conditions.

This vehicle will therefore be left for other types of measurements where less autonomy is required. At the moment, the idea is to use it to carry out avoidance experiments, where we would release the vehicle before the start of a trawl, so that we would have recorded the path of the trawl before the vessel passes. The goal is to check the distribution of fish before and after the disturbance caused by the vessel.

As for the Ranger 6.0, it is still in the process of obtaining the necessary permits for the launch. Once the procedures are completed, we will proceed to repeat the sampling previously done with ITSAS-DRONE.

Figure 4.132 ASV ITSASDRONE (left) and ASV Ranger 6.0 (right)

Automated Underwater Vehicle: Glider *"Xixili"*

Xixili is an autonomous sensing platform (Figure 4.133) designed to collect water column near real-time data profiles with very wide spatio-temporal coverage (thousands of km and weeks to months of endurance). Designed by French company *Alseamar*, it is driven by buoyancy changes, the vehicle silently glides up and down the water column while collecting physical, chemical, biological and/or acoustic data, depending on the sensor configuration.

It requires no supervising boat at surface during its mission, but a full-time onshore pilot is mandatory. The glider has a body size of 0.25 m x 2 m + 1 m of a foldable antenna, it weights 59 kg in air and is designed for both shallow and deepwater operations, from subsurface down to 1000 m depth. It presents several navigation modes: survey, virtual mooring, drifting and bottoming and is able to face high density gradients and strong currents (providing high speed and maneuverability). It can reach up to 1 kn maximum speed and cover 1,700 km (110 days) with CTD, DO and fluorimeter.

In 2022 it was first used to monitor the migration of anchovy juveniles in the Cantabrian Sea. The changes in horizontal and vertical distribution were monitored along the sampling time.
The idea was to have a transect of the Cantabrian Sea acoustically monitored simultaneously to the JUVENA survey and then continue the acoustic sampling for several weeks to try to observe the change of regime from "summer" to "winter" and the typical migration towards the coast happening when the first winter storms arrive.

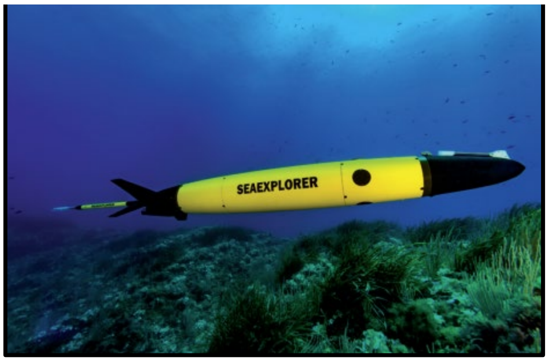


Figure 4.133 AUV Xixili

4.3.1.2 Effect of ping rate on the acoustic abundances

In trawl-acoustic surveys, the distance between consecutive transmissions or "pings" determines the along-transect resolution. An increase in either ping interval or vessel speed increases the inter-ping distance, hence decreasing the effective resolution. In this study, we analysed whether a loss in along-transect resolution affects the mean acoustic backscattering energy, leading to uncertainty and/or bias in abundance estimates (Figure 4.134). To this end, we echo-integrated a real acoustic survey, followed by the application of a systematic resampling scheme to simulate a decrease in pinging resolution. For each transect, the mean NASC calculated at each resolution was compared with the mean NASC at the original resolution. Transects were characterised according to their heterogeneity and spatial autocorrelation to investigate their effect on the relationship between abundance error and sampling resolution.

A portion of transects of a real acoustic survey (JUVENA 2010) were recorded with a split-beam echosounder Simrad EK80 with a 38 kHz transducer working in CW mode. Acoustic data were recorded with an average ping distance of 2.5 m, vessel speed of 10 knots (5 m/s), and pulse duration of 1 ms. The acoustic data were echointegrated by cells at the maximum along-transect resolution (1 ping x ~ 50 m). The survey data was divided into segments or transects that were considered independent samples. It followed a sequence of resamples on the echointegrated data to simulate the increase of ping distance.

Systematic (or sequential) resampling was carried out with resampling locations homogeneously distributed at constant intervals. The simulated ping distances were gradually increased from 2.5 m to 75 m. For each ping distance, the resampling was repeated 3000 times. In each transect, the mean NASC across the replicates was calculated for each simulated ping distance and compared to the original mean NASC values. Then, uncertainty and bias were estimated for each ping distance. To help explaining the variation in abundance errors with sampling resolution, mean heterogeneity and spatial autocorrelation were calculated for each transect as the most influential ancillary variables. Heterogeneity was measured with the Gini index and spatial autocorrelation was measured using geostatistical techniques.

Uncertainty was seen to increase with decreasing resolution, with higher heterogeneity and lower spatial autocorrelation accelerating the rise in imprecision. Although the mean bias across replicates was zero, the asymmetry of the bias distributions increased with decreasing resolution, leading to an increasing probability and magnitude of underestimation. We have built a web-based interactive application of these predictions, showing the result of a fitted GAM, predicting uncertainty and bias for different ping rates, at different heterogeneity of acoustic data, allowing also to change the percentage of underestimation (https://aztigps.shinyapps.io/PingRateStudio/). The analysis was recently published in Scientific Reports: https://www.nature.com/articles/s41598-023-40960-6.

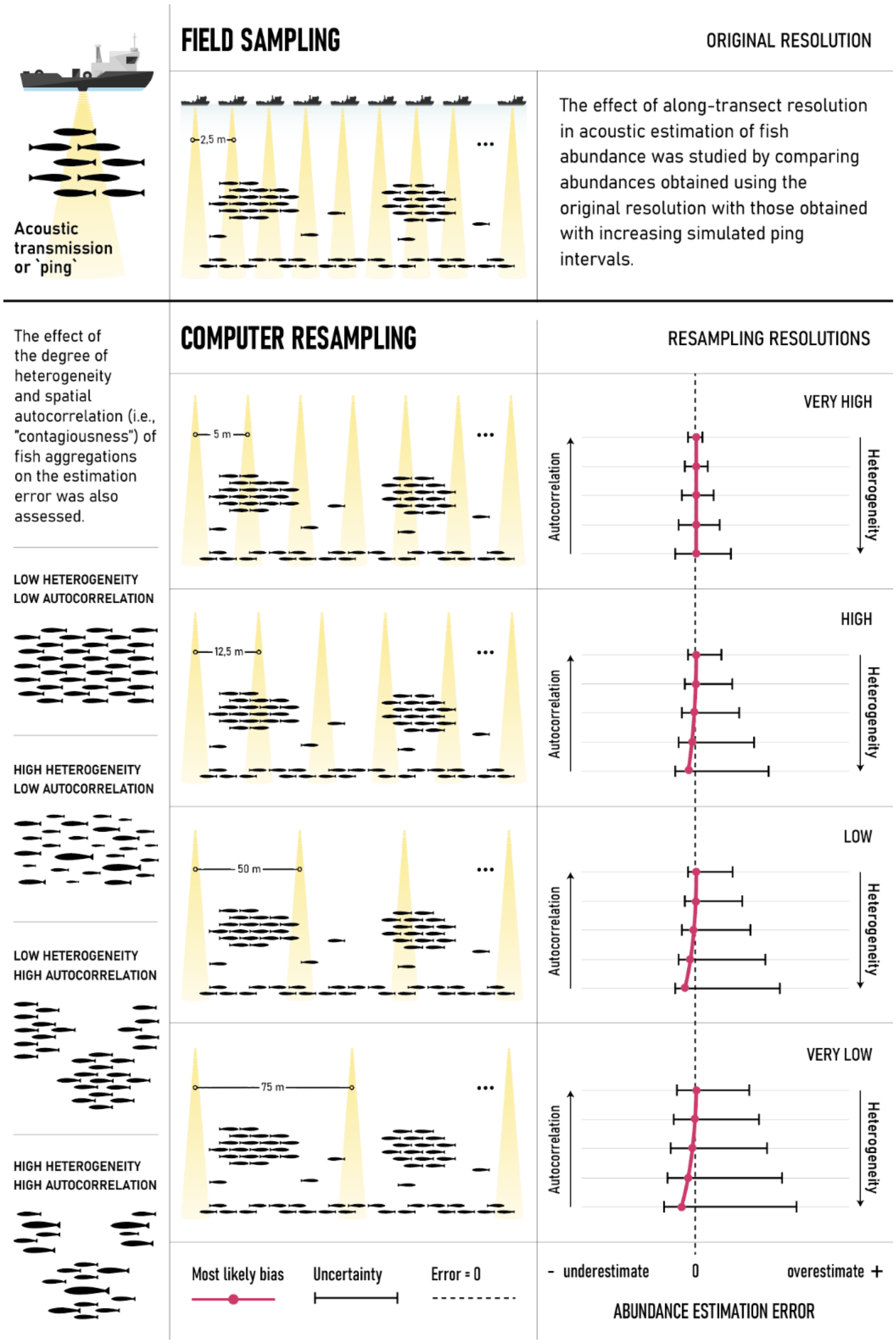


Figure 4.134 General schematics and main summarized results of the study.

4.3.1.3 Weakly-supervised classification of acoustic echo-traces in a multispecific pelagic enviroment

Acoustic surveys are dependent on trawling for species and size. Acoustic backscattering is usually integrated across depth layers and/or echo-traces, and the partitioning of echo-integrals is accomplished by directly assigning neighbouring catch proportions. This approach attributes identical species proportions to all echo-traces (i.e., the images of the detected schools in the echograms) in the vicinity of a given trawl haul (Figure 4.135 a). Consequently, the specific composition of each echo-trace remains unknown. In addition, the delineation of boundaries between the areas of the echograms attributed to the different fishing operations is determined visually, based on the knowledge of acoustic experts, using criteria that may not be consistent between different technicians. In contrast, if echo-integration is performed per echo-trace, the morphological, energetic, and positional traits of the aggregations can be extracted and utilized by machine learning tools to automatically identify each of the echo-traces using a classification model. A classification model enables the assignment of different species to each echo-trace in the echogram (Figure 4.135 b), thereby enhancing the spatial resolution of the echo-integral partition into different species.

Automatic classifiers have the potential to improve the reliability and reproducibility of trawl-acoustic methodology by assigning species composition to individual echo-traces. Furthermore, they can increase the vertical resolution of species allocation and provide valuable insights into the behaviour of gregarious species. However, their implementation within highly diverse communities remains a challenging task. In this study, a novel methodology was proposed to classify the schools of small pelagic species into nine different classes based on trawl information. The model utilised catch proportions as an approximation of the probability that each school belongs to a particular species. Given the challenge of determining the true composition of each school in a multi-species catch, the model's accuracy at school-level was exclusively estimated for those derived from single-species catches or previously identified by experts, yielding an accuracy of 71.40 %. The error for all schools was assessed at haul-level by comparing the species proportion in the catch with the predicted species proportion for that fishing event (error at haul-level 20.01 %). Additionally, a novel confidence metric was introduced for each school assignment. The application of this automatic classification model can enhance the knowledge about schooling behaviour while considering the reliability of each prediction.

The methodology proposed in this study for automatic school classification within multispecific ecosystems constitutes an original advancement over earlier methods. Despite recent progress in machine-learning classification models, achieving precise school-level classification in diverse scenarios remains a persistent challenge. Therefore, our work contributes to acoustic target classification by demonstrating that school-level classification in a diverse pelagic ecosystem is feasible combining probabilistic and weakly-supervised methodologies, yielding high performance. Additionally, the introduction of a novel confidence metric constitutes a significant step forward in the reliability of acoustic backscattering energy partitioning into different species, consequently improving the accuracy of acoustic-survey estimates. However, further investigation is required. Future research should explore new techniques to reduce the uncertainty associated with schools from multispecific trawl catches. The probabilistic model developed in this study will enable the analysis of specific structural and aggregation patterns in an objective and reproducible manner, while considering the reliability of the predictions. This integration has the potential to promote a comprehensive ecosystem-based approach for studying small pelagic species in the Bay of Biscay.

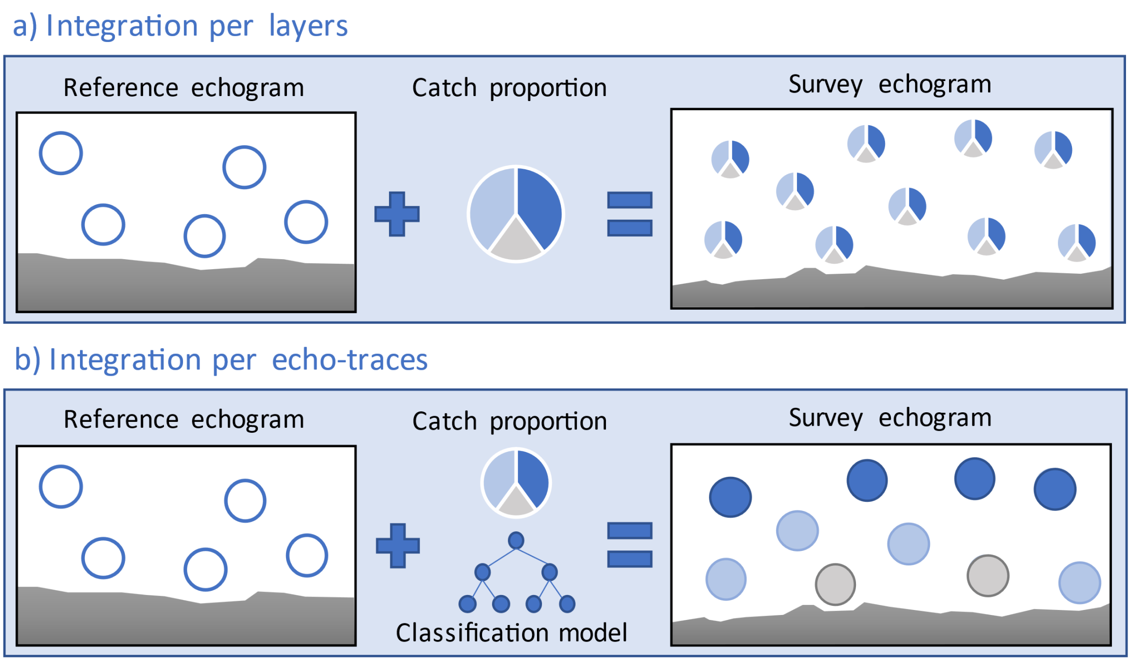


Figure 4.135 Two distinct approaches for assigning catch species proportions to echo-traces in a trawl-acoustic survey. In the echo-integration per layer method (a), species proportions of a reference catch are directly allocated to all echo-traces within the survey echogram. In the echo-trace integration method employed in this study (b) the species proportion of the reference echogram is incorporated into a classification model along with other reference catches. Subsequently, the model assigns different species to each of the echo-traces based on their distinctive aggregation patterns.

4.3.1.4 Improved sampling of surface schools

Anchovy biomass detected near sea surface by vertical echosounders during the PELGAS survey in springtime has been increasing since 2019. This raised the question of how much fish biomass was not accounted for by acoustic method in the surface acoustic blind zone (0-10m depth) of vertical echosounders. This section presents new methodologies for improved sampling and biomass assessment of surface schools.

4.3.1.4.1 Estimating surface school biomass based on lateral echosounder data collected during the PELGAS survey

A methodology for acoustic biomass estimation of small pelagic fish (SPF) located near-sea surface based on lateral echosounder data was proposed and applied to PELGAS data collected in the Bay of Biscay in spring 2019 and 2023. SPF biomass was estimated in the vertical echosounder blind zone and compared to biomass estimates from vertical 38kHz echosounder, in an attempt to assess the bias in acoustic estimate caused by SPF shallow vertical distribution. Details can be found in Doray et al. (2023).

Biomass indices per ESU from lateral echosounder has been calculated for 2 years: 2019 and 2023. Comparisons between biomass estimates from lateral and vertical echosounders are shown in the table below.

Survey	Species	Biomass vertical	Biomass lateral	Lat. over vert.	Lat. + vert.
PELGAS2019	ENGR-ENC	167 134	6 588	0.04	173 722

Survey	Species	Biomass vertical	Biomass lateral	Lat. over vert.	Lat. + vert.
PELGAS2023	ENGR-ENC	75 987	15 100	0.20	91 087
PELGAS2023	SARD-PIL	204 352	14 936	0.07	219 289

Fish biomass from lateral echosounder was twice higher in 2023 relatively to 2019. This confirms that fish distribution was particularly shallow in 2023.

Ratio of fish biomass from lateral and vertical echosounders was small in 2019 (4%), but significant in 2023 (20%) for anchovy.

Almost no sardine were found near sea surface in 2019. In 2023, the amount of sardine detected near sea surface by the lateral echosounder was 7% of the sardine biomass derived from vertical echosounder data.

In a nutshell, acoustic data from lateral echosounder processed with MOVIES3D and EchoR revealed that significant small pelagic fish biomass could be found near sea-surface (0-10m depth) in the Bay of Biscay in springtime. The methodology used in this study can provide estimates of this extra biomass so far not accounted for in acoustic biomass estimates.

Several aspects of the methodology should be improved (Target Strength …), and biomass estimates are probably biased low, but their precision is satisfactory for target species, and they provide a first assessment of fish biomass located in vertical echosounder blindzone in the Bay of Biscay in springtime. Biomass assessed with the lateral echosounder in the surface layer can represent up to 20% of the biomass estimated with a vertical echosounder in the case of anchovy.

References

Doray Mathieu, Duhamel Erwan (2023). **PELGAS2023: acoustic biomass estimation of small pelagic fish near sea surface in the Bay of Biscay**. ICES WGACEGG 2023 WD. https://doi.org/10.13155/97276

4.3.1.4.2 Improved monitoring of surface aggregations in Juvena survey

In the Juvena campaign, a large part of the juvenile anchovy population is located in the shallowest layers of the column, down to depths of about 40 m. In order to minimize possible bias due to loss of the first layers, several measures are taking place.

Reduce transducer depth

At least one transducer is placed on each vessel at a depth of 2.5 m, so that the echo-integration is performed from about 5-6 m depth.

Lateral monitoring using multibeam sonars

An additional monitoring methodology, involving the use of lateral sonar, is being developed to obtain information on the amount of anchovy in the first layer (between the surface and ~10 m). A Simrad CS90 multibeam sonar is fitted on the Emma Bardán and a Simrad MS70 multibeam sonar is fitted on the Angeles Alvariño. Since year 2021, these sonars are routinely used to monitor the vertical distribution of juvenile anchovy and other species in the first layers of the column. The goal is to be able to produce a correction for the abundance indices based on the abundance measured in these first layers of the water column.

In order to use the data collected with these multibeam sonars quantitatively, some protocols are being developed for calibration, data collection and data processing.

Calibration

Two types of calibrations are being conducted for both sonars: on axis gain calibration and beam overlap calibration. Gain calibration is performed following the standard target methodology using tungsten carbide spheres of 38.1 mm for the Simrad MS70 (of 70-120 kHz) sonar and of 64 mm for the Simrad CS90 (of 70-90 kHz). The MS70 software provides the possibility to perform gain calibration following standard procedures. A set of 7 m long horizontal poles are used to calibrate any beam of the MS70. In the case of the CS90, the default software does not provide on axis gain calibration possibility and an external program designed by the IMR acoustic team in Bergen, Norway has to be used to calibrate it. A first software is needed for assure that the sphere is located at the center of the beam that is being calibrated. Then a second program calculates the on-axis gain correction value. In addition to this, to calibrate CS90, long poles must be used to avoid collecting data inside the 12 m nearfield of the transducer.

The beam overlap estimation is based on the study performed in Boyra et al., 2022 using mutibeam sonars in commercial purse seiners. However, the calibration technique has been considerably simplified with respect to the procedure followed in that study. In the new calibration procedure, the degree of overlap between contiguous beams is calculated using the sphere normally used for gain calibration. The procedure can be applied with the vessel at the harbour, hence substantially simplifying the logistics and minimizing the time required for the operation.

Acoustic monitoring.

Lateral sonar data is acquired in both vessels with a range of 250 m during the transects. As the sonars record larger volumes at the surface, they are useful to better delimitate positive areas, studying potential avoiding behavior of the surface aggregations as well as estimating and correcting the potential underestimation bias in the index.

The data processing is conducted using two different LSSS modules: one developed for generic multibeam sonars (PROFOS) and one specific for the MS70 (PROMUS). The output of the PROFOS can be linked with the vertically estimated abundances, using the StoX software. All these pieces of software were developed by IMR, Bergen, Norway.

Validation of the sonar monitoring

As a way to validate the methodology of estimating fish abundance in the first meters of the water column (specifically to assure that the vertically and horizontally obtained indices are in the same scale) some additional experiments are being conducted. The idea is to try to obtain vertical distribution of fish in areas with near-surface aggregations using vertical echosounders located at the surface. These vertical distributions collected with vertically-oriented echosounders will be compared with the near-surface abundances obtained by lateral transducers to try to convert the latters into absolute measurements (or at least, comparable to vertically obtained ones).

To obtain vertical distribution of near-surface aggregations several tools are being used: (1) a WBAT with a 70 and 120 kHz split-beam transducers; (2) a prototype of the Zunibal Precatch echosounder buoy, with three single beam Airmar transducers of 50, 120 and 200 kHz (Figure 4.136); and (3) an uncrewed surface vehicle (Itsasdrone), a catamaran with a Simrad Ek80 WBT mini with a split-beam transducer of 200 kHz. (Figure 4.137)

The three systems involve the use of transducers vertically oriented downwards from depths a few centimeters depth, but each has its advantages and disadvantages. The WBAT and the Itsasdrone have scientific calibrated and programmable echosounders able to provide vertical high quality data for vertical distribution near the surface. The itsasdrone has the additional advantage of being able to monitor segments of transects of a few hundreds of meters, comparable with the echograms recorded by the vessel. But they have the disadvantage of the difficulty of retrieving in case of bad weather. The echosounder buoys on the other hand, are easier to deploy and retrieve, but provide lesser quality single beam acoustic data.

Some of the experiments conducted in Juvena 2023 involved comparing echosounder buoy and WBAT data on surface aggregations of juvenile anchovy (Figure 4.138).

Figure 4.136 Operation of the collection of the pair of precatch and drifting buoys.

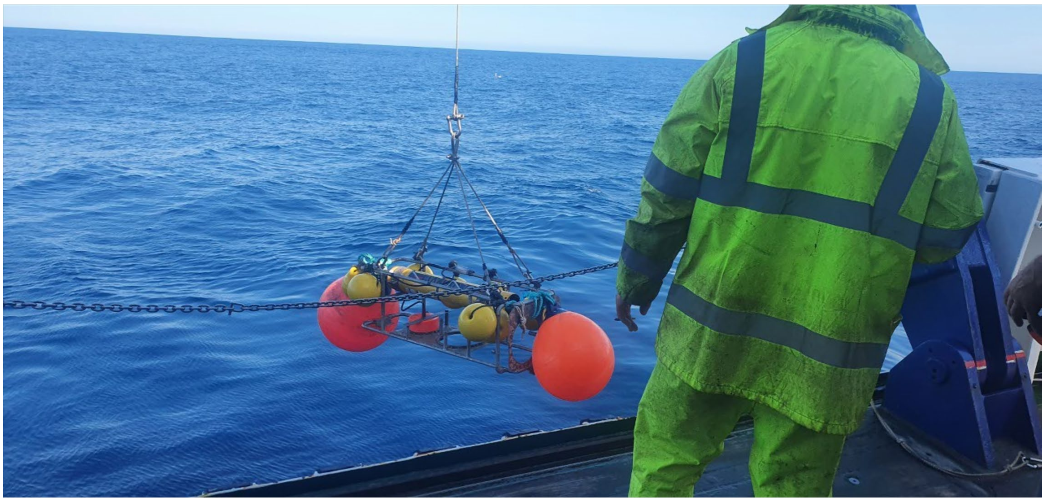
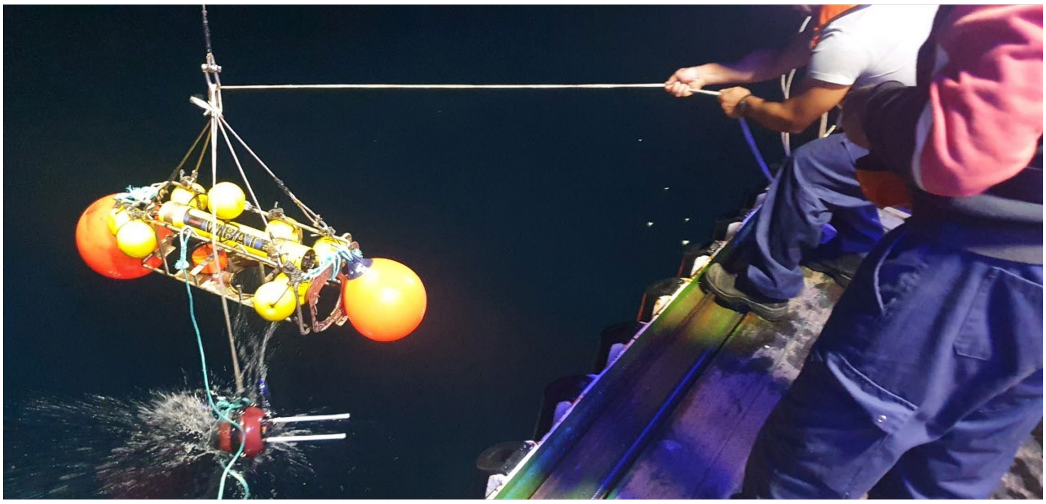



Figure 4.137 WBAT launched individually for the function test (top). WBAT launched together with the PRECATCH buoy in the night intercalibration exercise (bottom).

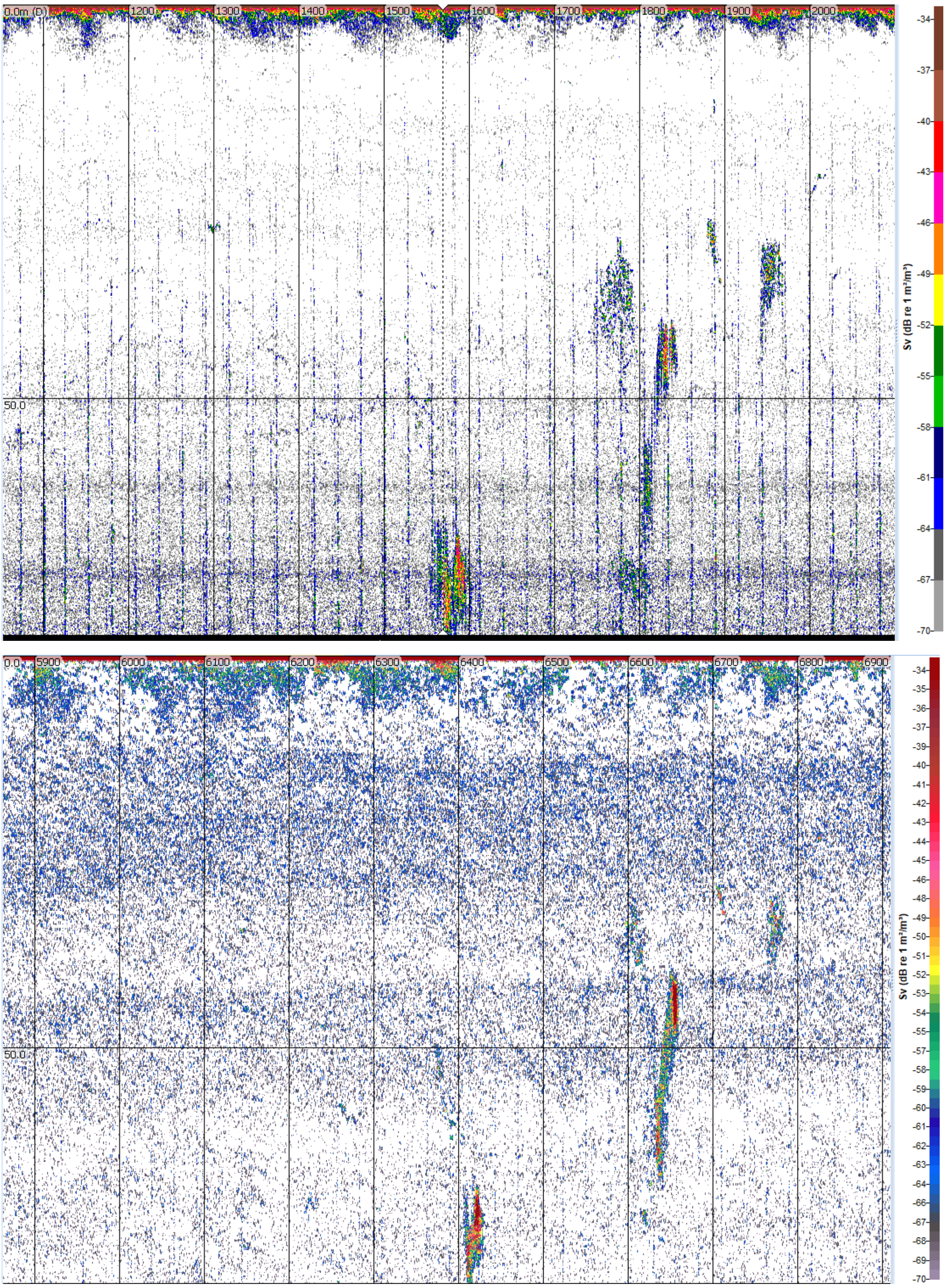


Figure 4.138 Example of a comparison between the echogram of the Precatch recordings (above) and the WBAT (below) on nocturnal anchovy aggregations.

4.3.1.5 Improvement of error estimation of Juvena abundance indices

This year, the JUVENA campaign implemented the calculation of uncertainty in acoustic estimates described in the general protocol of the acoustic campaigns coordinated within WGACEGG. When carrying out this implementation, we noticed that the description of the methodology in the document where it is reflected (Doray et al 2021) is not detailed enough for its application. Therefore, an extended version of the description and equations needed to perform the calculations is proposed below, together with a summary of the changes made. This extended version of the methodology is to be reviewed and validated by the rest of the group during 2024 and is proposed as a new version of the methodology in the next update of the TIMES protocol (Doray et al 2021) when it is carried out. In addition, it is suggested that further effort is applied to try to implement them in all acoustic surveys in WGACEGG as simple, common estimation of uncertainty.

4.3.1.5.1 Summary of proposed changes in the protocol

Inconsistencies:

The subindex *i* stands for both "species" and "by numbers (individuals)"

The subindex *1* is sometimes used to mean "by numbers (individuals)", probably to avoid confusion with the subindex *i* for "species".

The subindex *k* stands for both "hauls" and "by weight (kilos)"

The subindex *k* meaning "by weight" is sometimes replaced by the subindex *w*

The proportion by numbers is sometimes referred to as w_i and sometimes as z_i

The species allocation factor is sometimes referred to as X_i and sometimes as Z_i

Solution proposal:

Use only the subindex *w* to mean "by weight" (this way there is no confusion with the subindex *k*)

Remove the use of the subindices *i* or *1* to mean "by numbers (individuals)". By default, without subindex, it will mean "by numbers"; in order to mean "by weight" we will add the subindex *w* followed by a "—" sign, as in the following example:

X_i (allocation factor by numbers of species *i*).

X_{i-w} (allocation factor by weight of species *i*).

Use w_i rather than z_i to mean proportions by numbers.

Use X_i rather than Z_i to refer to the species allocation factor.

Other changes:

Correction of Eq. 10.

Add two new equations (Eq. 11 and 12) with the calculation of abundance per species with the explicit calculation of the abundance of species by strata (Q_{ij}). This has been done to be able to provide later the explicit calculation of the variance of X_{ij}. For consistency, this should be completed with the subindex *d* for ecotypes.

Extra explanations are provided for the variance of $\overline{X_{ij}}$, including additional explicit equations (Eq. 15, 16 and 17) for var(X_{ij}) and var(w_{ij}) based on the formula for the variance of a weighted average.

4.3.1.5.2 Changed and added equations

In this section, the number of equations refer to the number of equation in the TIMES document as it was published (Doray et al 2021). The proposed new equations have been numbered accordingly so that they fit correlatively in the document.

Equation 10 had a typo, and was corrected to the following:

$$X_i = X_{i-k}/\langle W\rangle \qquad (10)$$

Equation 7 was rewritten making explicit the reference to the stratum *j*. The abundance (number of individuals) of the species *i* in the stratum *j* is:

$$Q_{ij} = X_{ij} \times E_{mj} \times A_j = \frac{w_{ij}}{\sum_i w_{ij}\sigma_{ij}} E_{mj} \times A_j = \frac{w_{ij}}{\langle\sigma\rangle_j} E_{mj} \times A_j \qquad (11)$$

Where w_{ij} is the proportion of species *i* in the stratum and $\langle\sigma\rangle_j$ the mean linearized target strength of all the species in the stratum. w_{ij} is calculated as the average of the proportions of species in the hauls of the stratum w_{ijk} weighted to the energy in the vicinity of each haul E^v_{jk} as follows:

$$w_{ij} = \frac{\sum_k \left(E^v_{jk} w_{ijk}\right)}{\sum_k E^v_{jk}} = \frac{\sum_k \left(E^v_{jk} \frac{q_{ijk}}{q_{jk}}\right)}{\sum_k E^v_{jk}} \qquad (12)$$

Where q_{ijk} is the number of individuals of species *i* in haul *k* and $q_{jk} = \sum_i q_{ijk}$ is the number of individuals of all species in haul *k*.

New detail was given to the expressions of $var\left(\overline{E_{d,j}}\right)$ and $var\left(\overline{X_{d,i,j}}\right)$:

$var\left(\overline{E_{d,j}}\right) = var\left(E_{d,j}\right) w_{E-j}$, where $w_{E-j} = \frac{1}{N_j}$, N_j being the number of EDSUs in region *j*; and:

$var\left(\overline{X_{d,i,j}}\right) = var\left(X_{d,i,j}\right) w_{X_{d,i,j}}$, where: $w_{X_{d,i,j}} = \sum_k \left(\frac{E_{kd}}{\sum_k E_{kd}}\right)^2$ is the weight of the *X* factor of species *I* in region *j* and echotype *d*, computed over trawl hauls *k*, as the mean fish backscatter value E_{kd} around the hauls. According to this definition, $w_{X_{d,i,j}}$ is a weighting factor that can have values ranging from $1/N_k$ (when the energy of al the hauls is the same) to 1 (when there is large variability between the energy of the different hauls).

As the mean backscattering energy is obtained by a simple average, the calculation of $var\left(E_{d,j}\right)$ is straightforward. However, as $w_{i,j}$ is obtained as a weighted average (see Eq. 12), the calculation of $var\left(X_{d,i,j}\right)$ is a little bit more complicated and is therefore explicitly shown below. As $\langle\sigma\rangle_j$ is constant, the variance of $X_{i,j}$ is reduced to the variance of w_{ij}:

$$var\left(X_{i,j}\right) = var\left(\frac{w_{ij}}{\sum_i w_{ij}\sigma_{ij}}\right) = \frac{var\left(w_{i,j}\right)}{\left(\sum_i w_{ij}\sigma_{ij}\right)^2} = \frac{var\left(w_{i,j}\right)}{\langle\sigma\rangle_j^{\,2}} \qquad (15)$$

The variance of w_{ij} is estimated as the variance of a weighted average:

$$var\left(w_{i,j}\right) = \frac{\sum_k E^v_{jk}\left(w_{ijk} - \langle w\rangle_{ij}\right)^2}{\left\langle E^v_{jk}\right\rangle (n_k - 1)} = \frac{\sum_k E^v_{jk}\left(w_{ijk} - \langle w\rangle_{ij}\right)^2}{\frac{(n_k-1)}{n_k}\sum_k E^v_{jk}} \qquad (16)$$

Then, the variance of $X_{i,j}$ is:

$$var(X_{i,j}) = \frac{\sum_k E^v_{jk}(w_{ijk} - \langle w \rangle_{ij})^2}{\langle E^v_{jk} \rangle (n_k - 1) \langle \sigma \rangle_j^{\,2}}$$

(17)

4.3.1.6 Effect of inter-transect distance on acoustic estimates

In 2022 the inter-transect distance of the Juvena survey was increased from 15 nmi to 17.5 nmi., the intertransect distance used the first years of the survey. This was done after a long time concern about insufficient survey time for conducting the survey with guaranties of convering the full potential area of distribution of juvenile anchovy. Particularly, in year 2019, it was not possible to cover the northern part of the French shelf, thus causing potential bias in that year's abundance estimation.

The effect of increase of inter-transect distance is expected to have both advantages and disadvantages for the abundance estimation error. In general it is believed that it should decrease potential bias at the cost of increasing the uncertainty of the indices. A direct consequence of increasing the intertransect distance is the increase of the available time for fishing and the time available to cover the area, minimising the possibility of not being able to cover the whole area due to bad weather.

The effect of an increase in the inter-transect distance on the acoustic estimates is being calculated. Two techniques are to be applied: an empirical approach and a geostatistical approach.

4.3.1.6.1 Empirical approach

Based on empirical works developed in the eighties of last century (Kimura and Lemberg, 1981; Aglen, 1983, 1989; Francis, 1985), it was shown that the precision of acoustic surveys depended on the degree of coverage (DC) of the survey, defined as follows:

$$DC = \frac{Dist}{\sqrt{Area}}$$

The uncertainty of the abundance estimations, measured as a coefficient of variation (CV), was shown to depend on the DC as follows:

$$CV = \frac{1}{\sqrt{DC}}$$

The effect of the increase in Inter Transect Distance ITD on the Juvena index was calculated using this empirical rule as a first approach (Table 4.20). The CV was estimated to increase in 1.5%, from 17.5% to 19%.

Table 4.20 Impact of the Inter-transect distance (ITD) on the CV of Juvena survey.

L	ITD	CovArea	Lsq	DegreeCov	Cvmin	Cvmax	Cvmean
6150	5	30750	175	35.1	6.80%	13.50%	10.10%
3075	10	30750	175	17.5	9.60%	19.10%	14.30%
2050	15	30750	175	11.7	11.70%	23.40%	17.50%
1757	18	30750	175	10	12.60%	25.30%	19.00%
1538	20	30750	175	8.8	13.50%	27.00%	20.30%

1230	25	30750	175	7	15.10%	30.20%	22.70%
1025	30	30750	175	5.8	16.50%	33.10%	24.80%

4.3.1.6.2 Geostatistical approach

In order to apply the geostatistical approach, we will follow the methodology described in the Handbook of Geostatistics in R for Fisheries and Marine Ecology (Petitgas *et al.*, 2017) the experimental variogram of the juvenile anchovy biomass per EDSU will be obtained using the R package RGeostats (Renard *et al.*, 2023). The technique will involve global estimation in 1D for acoustic surveys and precision for different sampling efforts. The approach applies to acoustic surveys with regularly spaced parallel transects. The code uses 1D data files obtained by summing for each transect the fish biomass densities along the transects. The experimental and modelled variograms will be computed for these data. Then, from them, the geostatistical estimation variance will be computed for different defined inter-transect distances.

4.3.1.6.3 References

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4.3.2 Methodological developments for DEPM biomass assessment

4.3.2.1 Bayesian approach for egg production and mortality estimation

The daily egg production (P_0) is obtained from the exponential decay mortality model (Picquelle and Stauffer 1985) fitted as a Generalized Linear Model (GLM, McCullagh and Nelder, 1989) to the egg daily cohorts (Stratoudakis *et al*. 2006). Most usual frequentist approaches for fitting this GLM can occasionally lead to implausible mortality (Z) estimates. Thus, an alternative Bayesian approach is proposed, where estimates of mortality are restricted to the proper domain through a prior distribution based on literature. This Bayesian approach has been applied to the sardine and anchovy in the Bay of Biscay case studies using the data collected during BIOMAN surveys (Santos *et al*, 2023).

As in frequentist approaches, assuming that the number of eggs in daily cohort *j* in station *i* ($N_{i,j}$) follow a negative binomial distribution $N_{i,j} NB\left(E\left[N_{i,j}\right], \phi\right)$ where ϕ is the shape parameter, the model is written as a generalised linear model (GLM, McCullagh and Nelder 1989; ICES 2004, Bernal *et al*. 2011a) with logarithmic link function as follows:

$$log\left(E\left[N_{i,j}\right]\right) = log(R_i) + log(P_0) - Za_{i,j} \ ,$$

where the logarithm of the effective sea surface area sampled (log (R_i)) is an offset (i.e., its coefficient is not estimated) that accounts for differences in the sea surface area sampled and the logarithm of the daily egg production log(P_0), the hourly mortality Z rates and the shape Assuming that each estimate of Z comes from a normal distribution, a mixture of normal distributions was generated, excluding negative values. parameter of the negative binomial distribution are the parameters to be estimated. Data were weighted by the area represented by each station in the estimation process.

In order to define the prior distribution for the mortality parameter, estimates of hourly mortality rate and corresponding standard errors from several case studies were collected from the literature. For the anchovy the following case studies were included: 1) Argentina (*Engraulis anchoita*, Pájaro *et al*. 2009) , 2) Patagonia (*Engraulis anchoita*, Pájaro *et al*. 2009), 3) Cadiz (*Engraulis encrasicolus*, Jiménez *et al*. 2018), 4) California (*Engraulis mordax*, Lo 1997), 5) Chile (*Engraulis ringens* Cubillos *et al*. 2007), 6) Peru (*Engraulis ringens* , Lo 1997) and 7) South Africa (*Engraulis capensis*, Shelton *et al*. 1993). For the sardine the following case studies were included: 1) Iberian sardine (*Sardina pilchardus*, Angélico *et al*. 2018), 2) Californian sardine (*Sardinops sagax*, Dorval *et al*. 2016) and 3) Australian sardine (*Sardinops sagax*, Ward *et al*. 2011). The statistical distribution that best fitted these mixtures were Gamma distributions, with $\alpha = 1.46$ and $\beta = 62.48$ for the anchovy case study (Figure 4.139) and $\alpha = 2.15$ and $\beta = 112.56$ for the sardine case study (Figure 2), thus:

$$Z Gamma(\alpha, \beta)$$

The prior distributions for the other two unknown parameters in the GLM, namely the intercept, log(P_0), and the shape parameter of the negative binomial distribution, ϕ, were defined following the default proposal made in the "bmrs" (Bürkner *et al*. 2017) R package, which was used for parameter estimation based on MCMC methods:

$$\phi Gamma(0.01,0.01)$$

$$log(P_0) Student_{t(3,location,scale)},$$

Following this approach for each of the anchovy and sardine datasets, corresponding to each year (from 1989 to 2022 for anchovy and from 1999 to 2023 for sardine) of the BIOMAN survey series, posterior distributions for the parameters of interest, P_0 and Z, were obtained ensuring that the mortality estimated within the model were in the proper domain. Obtained P_0 and P_{tot} estimates with the proposed Bayesian approach agree with the estimates from the previous frequentist approaches (Figure 4.140 and Figure 4.141).

A sensitivity analysis to the priors for the mortality parameter was carried out comparing the selected Gamma prior distribution based on literature to other alternatives, obtaining that posterior distributions were very similar in all cases.

More details on the anchovy case study are provided in Citores *et al*. *in press*.

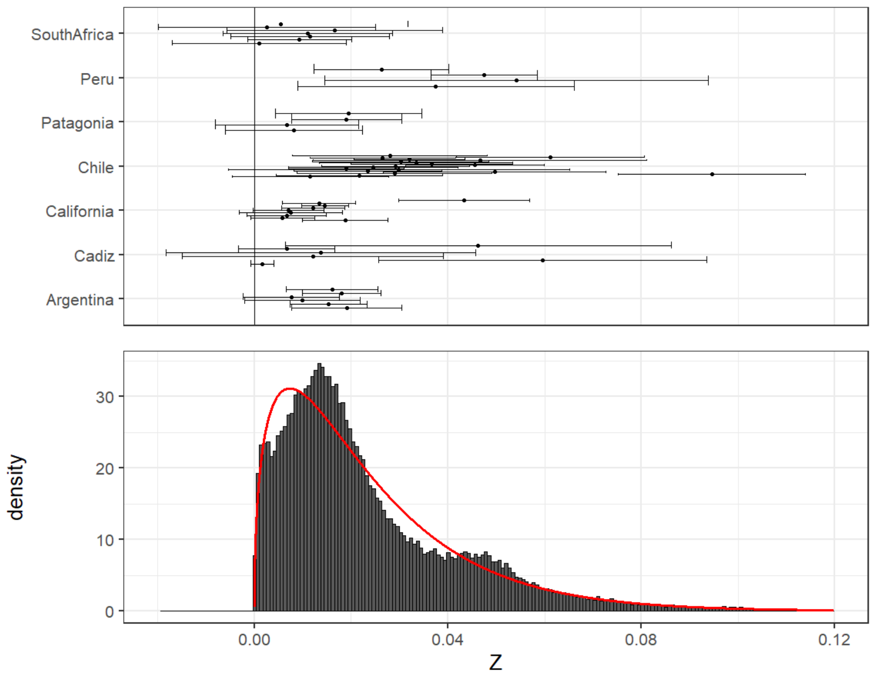

Figure 4.139 Hourly mortality (Z) point estimates (points) and 95% confidence intervals (horizontal lines) for each year provided by each anchovy case study (upper panel). Density of the empirical mixture distribution in black, and density of the fitted Gamma (1.46, 64.48) distribution in red (lower panel).

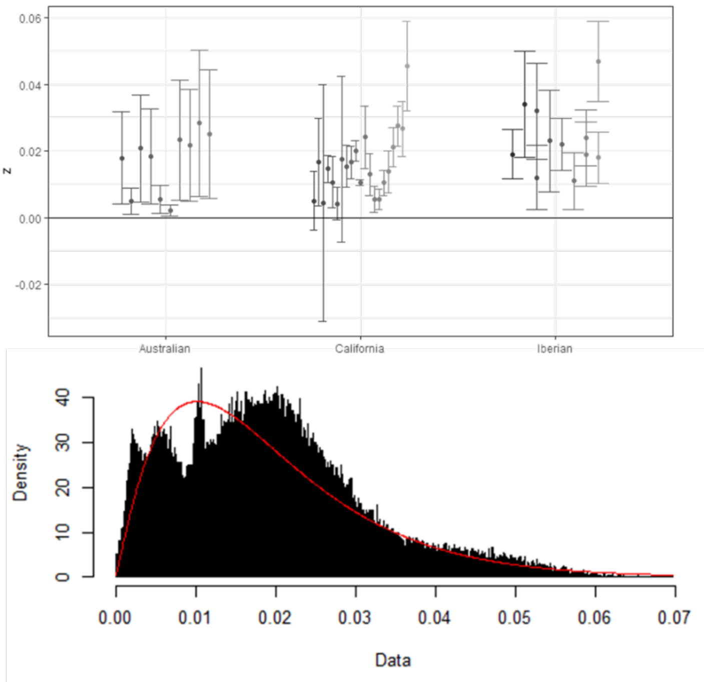

Figure 4.140 Hourly mortality (Z) point estimates (points) and 95% confidence intervals (horizontal lines) for each year provided by each sardine case study (upper panel). Density of the empirical mixture distribution in black, and density of the fitted Gamma (1.46, 64.48) distribution in red (lower panel).

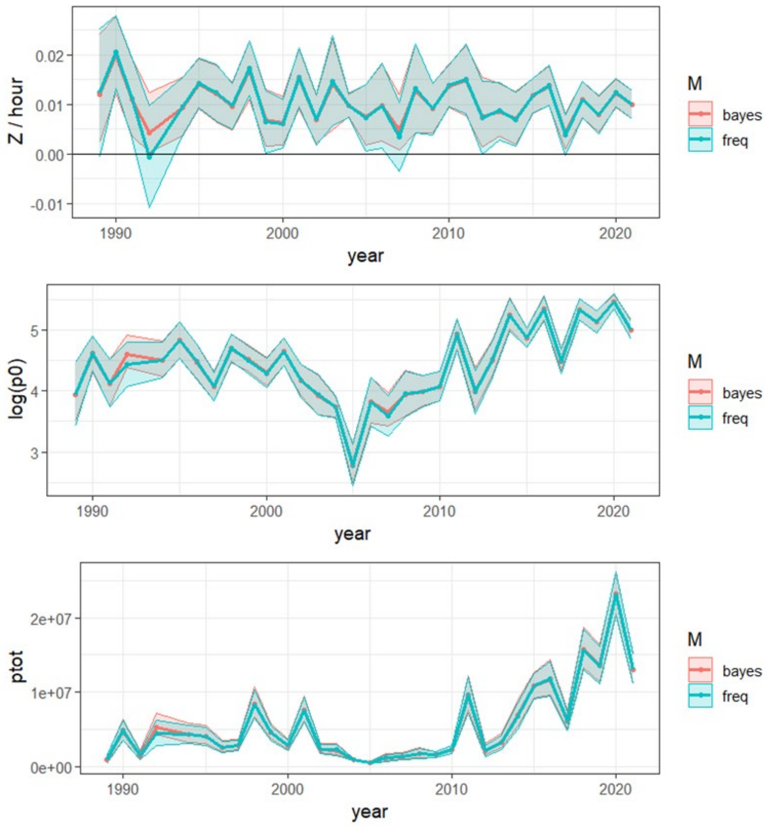

Figure 4.141 Point estimates (joined points) and 95% confidence intervals (shaded ribbons) for estimated parameters Z, P0 and Ptot for all years and all covered area for the anchovy case study. Colours represent two different approaches: the Bayesian approach in red and the frequentist approach in blue. Frequentist confidence intervals are computed as mean+- 1.96se.

4.4 Comparison between acoustic and DEPM fish biomass indices

Understanding discrepancies in particular years between acoustic and Daily Egg Production Method (DEPM) estimates is essential to better understand potential bias impacting both estimates and study the possibility of developing a weighting per year assessing the coherence between survey estimates. (ICES, 2017; Petitgas et al., 2009; Doray and Huret, 2020).

Results of the comparison of acoustic and DEPM indices produced by WGACEGG surveys for anchovy and sardine in the Bay of Biscay (BoB) since 2000 were presented, in an attempt to identify and discuss potential bias. Acoustic biomass estimates and egg indices might also be combined to derive fecundity proxies (Doray et al. 2020). Time series of a hybrid, acoustic-egg daily fecundity (DF) index based on acoustic PELGAS survey data were compared to the DF estimates from biological samples obtained during DEPM BIOMAN survey, used originally to estimate a biomass index by the DEPM.

Material and methods, detailed results and proposed workplan can be found in the accompanying Working Document (Doray et al. 2023).

4.4.1 Anchovy 8abc biomass indices time series

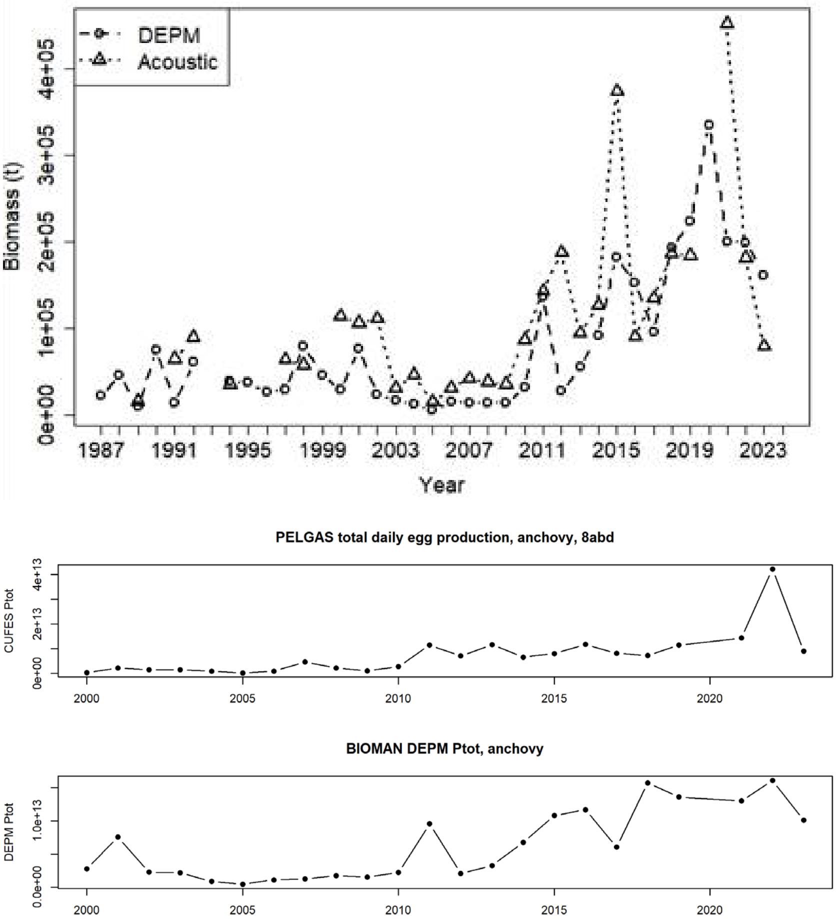

Figure 4.142 Time series of acoustic biomass and CUFES Ptot from Acoustic survey (PELGAS) in 8ab, and DEPM biomass and Ptot estimates from DEPM survey (BIOMAN) in 8abc for anchovy.

Acoustic and DEPM indices time series for anchovy derived from PELGAS and BIOMAN surveys respectively, displayed similar trends, except for peaks in acoustic biomass in 2015 and 2021 and in CUFES Ptot from PELGAS in 2022 (Figure 4.142).

4.4.2 Anchovy DEPM (in 8abc) and acoustic (in 8ab) biomass comparison

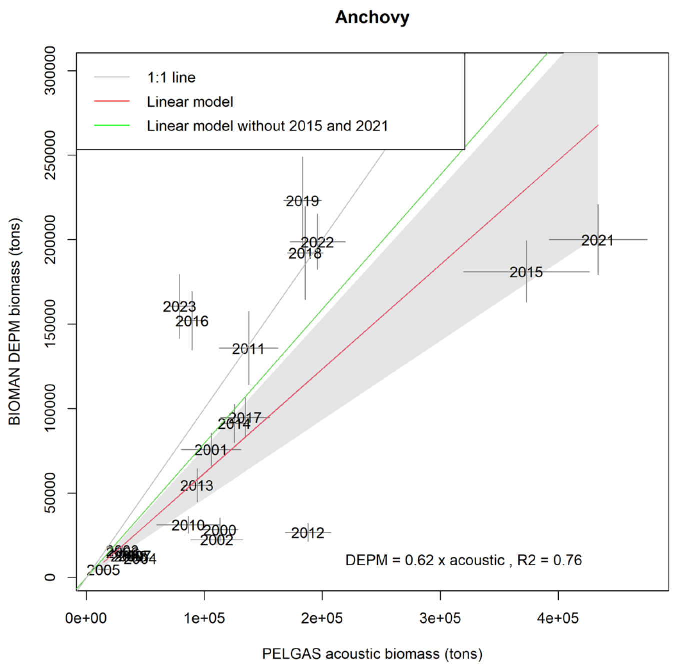

Figure 4.143 PELGAS acoustic biomass estimate versus BIOMAN DEPM biomass estimate for anchovy, with linear model fit (95% confidence interval in grey).

PELGAS anchovy acoustic biomass estimate in ICES area 8ab and BIOMAN DEPM biomass estimate in ICES area 8abc displayed a strong positive correlation, (No intercept Linear model (LM) R2 = 0.76). The DEPM biomass was about 40% lower than the acoustic one, on average, based on the no intercept LM. The no intercept LM between both indices was however dragged towards outlying 2015 and 2021 point estimates. (Figure 4.143) Correcting the 2023 acoustic estimate for biomass in vertical echosounder blind zone did not move the 2023 point estimate into the LM uncertainty polygon (Doray et al. 2023a). The residuals of the no intercept LM between acoustic and DEPM biomass were not normally distributed, namely due to the presence of outliers. They were not autocorrelated over the whole time series, but a significant time trend was found in residuals. DEPM biomass has been significantly higher than acoustic biomass since 2018 (Doray et al. 2023a). This may be due to the fact that since 2018 anchovy has reappeared in the Cantabrian Sea, which had disappeared since 2000, an area that the Acoustic survey does not sample while the DEPM survey does.

4.4.3 Potential biases in anchovy indices

In 2019 and 2023, BIOMAN DEPM biomass were significantly higher than PELGAS acoustic biomass indices (Doray et al. 2023a). Egg-based indices were equal in 2019 and different in 2023 (PELGAS CUFES Ptot higher than DEPM Ptot, Doray et al. 2023a). PELGAS CUFES Ptot were significantly higher than PELGAS acoustic biomass indices in 2019 and 2023 (Doray et al. 2023a). One of the main potential sources of bias in the acoustic biomass estimate was the presence of schools not detected in the acoustic blind zone of the vertical echosounder near sea surface. Bias was assessed to be low in 2019 (4%, Doray et al. 2020), and significant in 2023 (20%, Doray and Duhamel, 2023). In 2019, an alternative hypothesis to explain the discrepancy between acoustic and DEPM biomass would be that fish fecundity might have been underestimated in some areas in the DEPM estimate (Doray et al. 2023). However, the differences are small and may be due to the different method and natural variability.

In 2015, BIOMAN DEPM biomass was significantly lower than PELGAS acoustic biomass (Figure 4.143). Egg-based indices from PELGAS and BIOMAN did not agree, as PELGAS CUFES Ptot was significantly lower than BIOMAN DEPM Ptot (Doray et al. 2023). PELGAS CUFES Ptot was however significantly lower than PELGAS acoustic biomass (Doray et al. 2023). Some hypothesis to explain the discrepancies between biomass indices are focus on the Gironde area as was characterized by very high NASC values and the presence of potentially immature females. These hypotheses are: i) the inclusion of riverine anchovy in the acoustic biomass estimate, as very high anchovy NASC were detected near the Gironde Mouth ii) a misidentification of anchovy with other species e.g., sardine or sprat, due to the difficulties to capture fish with pelagic trawls in shallow water areas to identify the high fish aggregations detected by acoustics in that area, iii) the application of a TS-length relationship independent of the depth, in near-surface layers can increase the apparent biomass due to the observed increase of TS with depth for physostomous species, such as anchovy (Ona, 2003; Zhao et al., 2008) which could be relevant in the shallow waters of the Gironde area, iv) the possible presence of immature anchovies in the Gironde area, which could not have been accounted by the DEPM method. This last hypothesis was already checked; In this year 2015 although there were some anchovies that *a visu* appeared to be immature, after their histological analysis it was confirmed that they were spawning although with a batch fecundity (F) extremely low. This low batch fecundity was accounted for the DEPM biomass estimates.

These possible causes will have to be checked if they have not been checked already or other causes will have to be sought to resolve the 2015 differences, if possible.

In 2021, BIOMAN DEPM biomass was significantly lower than PELGAS acoustic biomass (Figure 4.143). Egg-based indices from PELGAS and BIOMAN agreed well, as PELGAS CUFES Ptot was not significantly different from BIOMAN DEPM Ptot (Doray et al. 2023). PELGAS CUFES Ptot was significantly lower than PELGAS acoustic biomass (Doray et al. 2023). As no obvious bias could be identified in the acoustic biomass estimate, and neither in the DEPM biomass estimate because the presence of immature anchovies in the BoB were not detect, that was one of the possible causes, this difference remains to be investigated.

4.4.4 Sardine 8ab biomass indices time series.

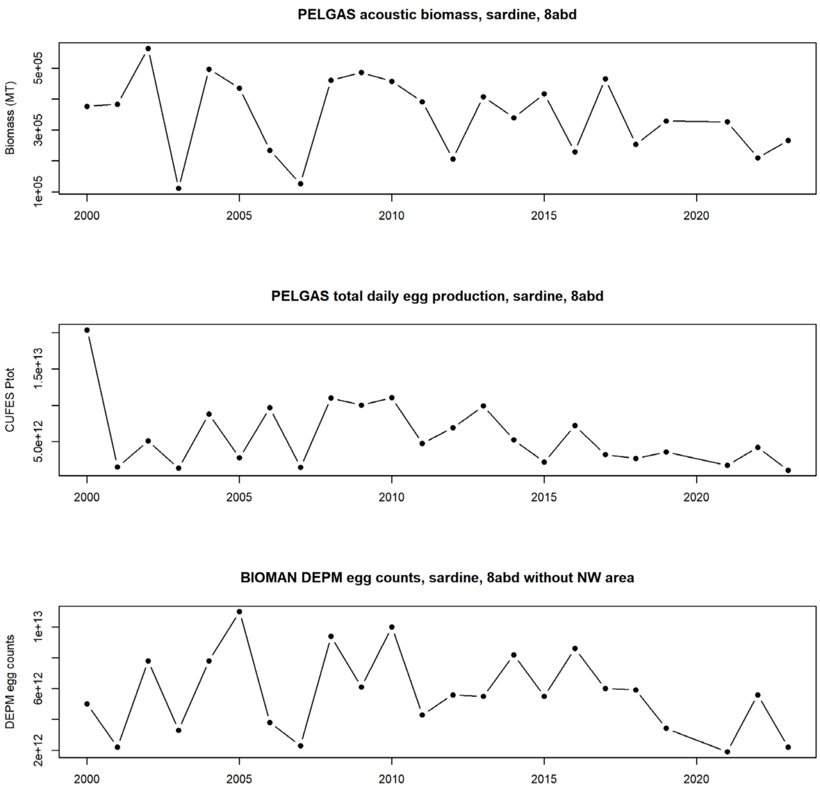

Figure 4.144 Time series of PELGAS acoustic biomass and CUFES Ptot from acoustic survey, and egg abundances from BIOMAN DEPM survey for sardine.

Time trends in egg abundance indices differ from those observed in the acoustic-trawl biomass index since 2017 (Figure 4.144). The sardine population biomass has been stable since 2017, according to the acoustic biomass estimate, whereas egg-based indices from acoustic and DEPM surveys suggest a decrease.

4.4.5 Sardine 8ab, DEPM egg count and acoustic biomass comparison.

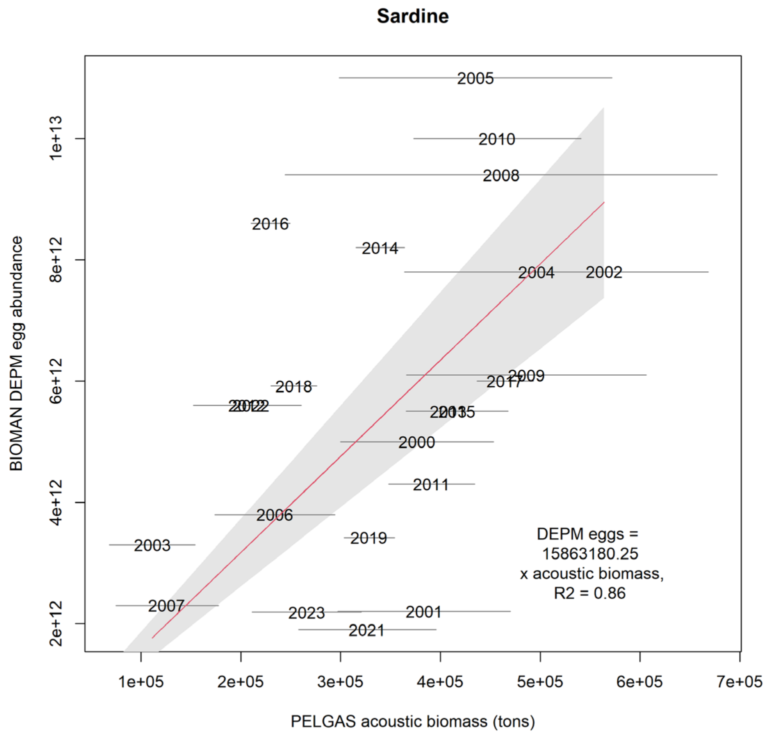

Figure 4.145 PELGAS acoustic biomass estimate versus egg abundances from BIOMAN DEPM survey for sardine, with linear model fit (95% confidence interval in grey).

PELGAS sardine acoustic biomass estimate and egg abundances from BIOMAN DEPM survey displayed a strong positive correlation, (No intercept Linear model R2 = 0.86, Figure 4.145). The residuals of the no intercept LM between DEPM egg abundances and acoustic biomass were not normally distributed, namely due to the presence of outliers. They were not autocorrelated over the whole time series but showed signs towards relatively lower egg estimates since 2019, though not significant (Doray et al. 2023).

4.4.6 Potential biases in sardine indices

The comparison between sardine biomass proxies is less precise, due to the absence of confidence interval around egg abundances from DEPM surveys. However, P_{tot} estimates with their CV from DEPM BIOMAN survey for sardines are available and could be used for future comparisons.

The negative bias in egg abundance residuals in recent years versus the no intercept linear model fitting to PELGAS acoustic biomass index is likely due to the fact that the BIOMAN index used for this exercise was calculated while excluding a substantial part of the sardine core distribution area in NW Bay of Biscay. Nevertheless, estimates including the NW part are available for future comparison.

In 2021, BIOMAN DEPM egg abundances was significantly lower than PELGAS acoustic biomass (Figure 4.145). Egg-based indices did not agree between surveys, as PELGAS CUFES Ptot was significantly higher than BIOMAN DEPM egg abundances (Doray et al. 2023). PELGAS CUFES Ptot was however significantly lower than PELGAS acoustic biomass (Doray et al. 2023). As no obvious bias could be identified in the acoustic biomass estimate, the main hypothesis remaining to explain the discrepancies between indices is the presence of a significant amount of immature sardine in some areas of the BoB, which could not have been accounted for egg abundances estimates.

4.4.7 Daily fecundity indices

Mean weights time series derived from acoustic PELGAS survey data displayed decreasing trends for both species (Doray et al. 2023). Anchovy RFS estimates (derived from a model) followed an increasing trend, whereas sardine ones decreased, yielding overall increasing and decreasing hybrid acoustic:egg fecundity indices for anchovy and sardine, respectively (Doray et al. 2023). Biometry-based fecundity estimates for anchovy from the DEPM BIOMAN survey do not show any trend since 2010 (Santos *et al*. 2023).

Contrasting trends found between increasing PELGAS mean DF proxy and no trend since 2010 in BIOMAN DF estimates for anchovy should be investigated.

Biometry samples from which BIOMAN DF estimate were derived could be not representative of the whole population / areas where eggs were collected. The effect of spatial heterogeneity on global DEPM DF estimates should be further investigated. Collecting biometry samples based on a spatially stratified sampling scheme for DF estimation in DEPM method could be a way forward, as well extended gonad sampling during PELGAS survey to improve DEPM DF spatial representativity. Conversely, the effect of potential biases in yearly CUFES and acoustic estimates on the DF proxy derived from PELGAS data should be investigated.

Time trends were moreover found in residuals of acoustic vs. DEPM models. Those systematic bias may be caused by changes in fish fecundity not accounted for in the DEPM method and/or changes in survey coverage or species distribution. The acoustic:egg hybrid DF index derived from PELGAS data provides new insights on the evolution of anchovy and sardine fecundity in the BoB in springtime. This DF index could be useful to benchmark DEPM DF estimates and for ecological studies.

Several, more or less elaborated, acoustic and egg indices were compared, based on LM results. The effect of LM selection should be further explored: use of linear model, with(out) biased indices and/or outliers, robust regression models, other models… etc. After solving those methodological issues, it will be discussed whether to perform a systematic bias analysis of all years lying outside of the models confidence intervals or just to try to explain the differences in the years with the largest discrepancy as 2015 and 2021 and further assess the survey indices quality.

4.4.8 Conclusions

An overall strong correlation base on the no intercept LM ($R2>0.6$) was found between all acoustic and DEPM indices, indicating a good general agreement biomass proxies. Outliers and time trends in residuals were however also found. They should be studied to identify potential bias in indices. For that purpose, gridded maps and global indices should be further compared to identify bias in observation and / or scaling components.

A workplan was proposed by Ifremer to further study potential bias in acoustic and DEPM indices. The completion of this workplan requires to make available up-to-date eggs and NASC gridmaps and indices before the group, to identify potential bias and inform stock assessment groups. AZTI required agreement on the workplan developed by Ifremer before implementing it before the WGACEGG 2024 meeting.

4.4.9 References

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4.5 Suitability of CUFES data for anchovy and sardine egg production estimates in areas 8 and 9

Ifremer developed an analytical methodology to enable the estimation of Egg Production (EP) for anchovy and sardine using the egg data obtained using the CUFES sampler (Petitgas et al., 2006, 2009, Goarant et al. 2007). The method considered historic information on egg density and vertical distribution in different hydrographic scenarios and the development and parameterization of a 1D vertical model that is applied, together with CTD and wind data, to obtain "vertical eggs profiles" and finally vertical integrated egg abundance estimates to be used for EP calculations.

In 2022, the same approach was tested for data collected during the Iberian DEPM sardine surveys in 2008 (PT-DEPM-PIL, SAREVA) and the preliminary results presented at the SPF conference in November (Angélico, MM; P. Díaz, PB Oliveira; E. Tel & M. Huret. *Egg Production estimation for Atlantic Iberian sardine using CUFES sampling. Implementation of a biophysical model to assess the egg vertical density distribution.)*. In the IPMA-IEO approach once the egg densities are estimated the following EP calculations are carried out using an adapted version of the standard DEPM-EP estimation method used for data obtained with the PairoVET sampler. The results obtained to present were discussed during the 2023 meeting, in a dedicated sub-session, and several steps were planned to explore further the application of the methodology for the sardine Iberian region and investigate details that may still need to be improved/adapted. It was also planned to test the utilization of data from other historic surveys.

4.6 Coordination and standardisation of the surveys

4.6.1 Survey Schedule 2024

Survey planning for 2024 is summarized in the table 4-21.

Table 4.21 Overview of 2023 surveys under the auspice of WGACEGG.

Country (Institute)	Survey	Vessel	Areas	Dates	Survey type
Spain (IEO)	PRE-PELACUS	R/V Miguel Oliver	27.8c	6-17/2	Acoustic
Portugal (IPMA)	PELAGO	R/V Miguel Oliver	27.9a south, west	1-24/03	Acoustic
Spain (IEO)	PELACUS	R/V Miguel Oliver	27.9a north, 8c	26/03-27/04	Acoustic
France (Ifremer)	PELGAS	R/V Thalassa	27.8abd	27/04-28/05	Acoustic
Spain (AZTI)	BIOMAN	R/V Vizconde de Eza R/V Enma Bardán	27.8abcd	30/04-24/05 02-31/05	DEPM
Ireland (Marine Institute)	WESPAS	R/V Celtic Explorer	27.6 a, 7b,c	08/06-20/07	Acoustic
Spain (AZTI)	JUVENA	R/V Ángeles Alvariño	27.8abcd	15/08-30/09	Acoustic
Spain-Portugal (IEO-IPMA)	IBERAS	R/V Ramón Margalef	27.9a west	13-27/09	Acoustic
UK (Cefas)	PELTIC	R/V Cefas Endeavour	27.7 e, f, g	29/09-02/11	Acoustic
Spain (IEO)	ECOCÁDIZ-RECLUTAS	R/V Ramón Margalef	27.9a south	1-14/10	Acoustic
Ireland (Marine Institute)	CSHAS	R/V Tom Crean	27.7 j, g, a south	9-29/10	Acoustic

Acoustic-trawl surveys

The PRE-PELACUS survey is expected to take place in February to detect shifts in the spawning areas of the Atlantic mackerel and the sardine in the Eastern Cantabrian Sea. In addition, alteration of the aggegration patterns will be investigated.

Spring acoustic-trawl surveys will be carried out following the standard methodologies defined by the WGACEGG and coordinated between IPMA, IEO and Ifremer. IPMA will survey the southern region from Cadiz to the northern border between Portugal and Galicia (PELAGO); IEO will operate off western Galicia and the Cantabrian Sea (PELACUS) and Ifremer (PELGAS) will cover the French shelf of the Bay of Biscay.

In summer, the ECOCADIZ acoustic-trawl survey, routinely conducted by IEO in the Spanish and Portuguese waters of the Gulf of Cadiz, will be temporaly suspended until further notice. The WESPAS acoustic-trawl survey will be carried out by the Marine Institute, starting in the south and working progressively northwards covering shelf seas from the Celtic Sea, west coast of Ireland and the Porcupine Bank finishing north of the Hebrides.

In autumn 2024, the PELTIC acoustic-trawl survey will be conducted by CEFAS off the Southwest of Britain (Division 7e,f), covering also French waters. Multidisciplinary methodologies, coordinated through two relevant survey working groups (WGACEGG and WGIPS), will be implemented. The CSHAS acoustic-trawl survey will be carried out by the Marine Institute and will focus on the mid and northern latitudes of the Celtic Sea.

The JUVENA survey will be coordinated between AZTI and IEO, as a result of an agreement between both institutes in 2014. AZTI leads on the assessment studies of the JUVENA series and IEO on the ecological studies. In 2024, it is planned to continue this collaboration. The survey will sample the continental shelf and shelf break of the Bay of Biscay.

IPMA and IEO are expected to collaborate in the common autumn acoustic-trawl survey IBERAS-JUVESAR, covering the Atlantic waters from Sao Vicente Cape to Fisterra Cape. In the Gulf of Cadiz, IEO has initially planned to conduct the ECOCADIZ-RECLUTAS autumn acoustic-trawl survey (juvenile anchovy and sardine survey) in early October, earlier tan the usual dates (mid to late October), and as a continuation of the IBERAS-JUVESAR survey.

DEPM surveys

The next triennial Iberian Sardine DEPM survey will take place in 2026. The region from the Gulf of Cadiz to the northern border between Portugal and Spain will be surveyed by IPMA (PT-DEMP-PIL); IEO will cover the north and northwest Spanish waters (SAREVA).

The annual anchovy DEPM survey in the Bay of Biscay (BIOMAN) will take place in May, conducted by AZTI and covering the usual spawning grounds at ICES 8abcd.

The next DEPM survey to estimate the SSB of Anchovy in the Gulf of Cadiz (BOCADEVA triennial survey) will take place by IEO in summer 2026.

4.6.2 Update on WGACEGG Series of ICES Survey Protocols

The resolution for publication of the Techniques in Marine Environmental Sciences (TIMES) draft report on WGACEGG-DEPM survey protocols has been completed and the updated version of the manuscript, organized to comply with the new TIMES- ICES survey protocols guidelines, was submitted to ICES and is currently undergoing peer review. It is expected that a final version of the document can be ready for publication during the first quarter of 2024.

4.7 Mesozooplankton monitoring

The surveys coordinated within the framework of WGACEGG underwent several developments over time to became more complete and address diverse components of the pelagic ecosystem. At present, all surveys (depending on the specificities of each survey and RV utilized) include monitoring of different variables for many ecosystem components including zooplankton and hydrodynamics. Moreover, these surveys are already contributing with essential information for ecosystem assessment and monitoring directed at the MSFD requests. Plankton (zooplankton, phytoplankton) is at the base of the marine trophic webs and it is very relevant in the small pelagic fish diets, changes in its composition and sizes may affect directly some species but also influence directly or indirectly the whole ecosystem. Moreover, as most plankton groups have short life cycles and are very sensitive to physical and chemical factors and its variations, due to natural or human forcing, plankton derived indicators are very good for monitoring the good environmental status and to study fluctuations and trends in the ecosystems.

Owing to its recognized importance, zooplankton monitoring has been implemented in all WGACEGG surveys and the Group considered a ToR to address its analyses and developments (ToR J). The Group considers that it would be a major advantage and a great complement to the data and analyses already produced from the surveys, that information on zooplankton communities could be available, for all the areas monitored, in a spatial scale compatible with the other variables already gathered.

During the 2023 meeting, the Group reiterated the relevance of zooplankton monitoring and discussed the current, and diverse, zooplankton survey and analyses protocols and its potential limitations and desirable improvements and possible standardizations. In 2024, the Group will host a Zooplankton Session dedicated specifically to address aspects related to sampling and analyses methodologies in particular the use of image recognition techniques to characterise the distribution of (surface) mesozooplankton communities. It will also be discussed the development of zooplankton indicators, that could be used across the monitored regions, together with the other variables compiled, to improve monitoring and progress in the assessment and sustainable management of the ecosystems.

4.8 Changes/Edits/Additions to ToRs

No changes to the ToRs were proposed during the meeting.

4.9 Collaborate with groups wishing to utilize available timeseries from WGACEGG coordinated surveys

WGHANSA members joined the survey presentations on 13th and 14th of November, at the start of the WGACEGG meeting.

4.10 Cooperation with Advisory structures

WGACEGG has evaluated and provided echo-integration and/or Daily Egg Production Method (DEPM) estimates for sardine, anchovy horse mackerel, boarfish, herring, and sprat in ICES sub- Areas 6, 7, 8 and 9 to WGHANSA, WGWIDE and HAWG assessment groups (details below).

WGACEGG has provided the WGHANSA stock assessment group with the sardine and anchovy indices listed in section 4.

WGACEGG has provided the WGWIDE stock assessment group with horse mackerel, boar fish, mackerel and blue whiting distribution and numbers-at-age in 9a and 8c derived from the PELACUS survey.

WGACEGG has provided to the HAWG with the sprat and herring indices listed in section 4.

Annex 1: List of participants

Name	Institute	Country (of institution)	Email
Adriana Villamor(*)(**)	ICES	Denmark	adriana.villamor@ices.dk
Aitor Lekanda(*)	AZTI	Spain	alekanda@azti.es
Ana Moreno	IPMA	Portugal	amoreno@ipma.pt
Anxo Lago(*)	IPMA	Portugal	anxo.lago@ipma.pt
Beatriz Sobradillo(*)	AZTI	Spain	bsobradillo@azti.es
Beñat Iglesias(*)(**)	AZTI	Spain	biglesias@azti.es
Carlos Pinto(*)(**)	ICES	Denmark	carlos.pinto@ices.dk
Ciaran O' Donnell	MI	Ireland	Ciaran.odonnell@marine.ie
Elsa Cuende(*)(**)	AZTI	Spain	ecuende@azti.es
Erwan Duhamel(*)(**)	IFREMER	France	Erwan.Duhamel@ifremer.fr
Fernando Ramos	IEO	Spain	fernando.ramos@ieo.csic.es
Guillermo Boyra (Chair)	AZTI	Spain	gboyra@azti.es
Hannah Holah (*)(**)	(Chair WGELFADG)	Scotland	Hanah.Holah@gov.scot
Hector Peña(*)(**)	IMR	Norway	hector.pena@hi.no
Hjialte Parner (**)	ICES	Denmark	hjalte@ices.dk
Isabel Riveiro(**)	IEO	Spain	isabel.riveiro@ieo.csic.es
Jeroen Van der Kooij	CEFAS	United Kingdom	jeroen.vanderkooij@cefas.co.uk
Jose Antonio Canseco	IEO	Spain	jantonio.canseco@ieo.csic.es
Laura Wise(*)(**)	IPMA	Portugal	lwise@ipma.pt
Leire Citores(*)(**)	AZTI	Spain	lcitores@azti.es
Leire Ibaibarriaga(**)	AZTI	Spain	libaibarriaga@azti.es
Maite Louzao(*)(**)	AZTI	Spain	mlouzao@azti.es
Maria Makri(*)(**)	ICES	Denmark	maria.makri@ices.dk
Maria Manuel Angelico	IPMA	Portugal	mmangelico@ipma.pt
Maria Santos	AZTI	Spain	msantos@azti.es
Martin Huret	IFREMER	France	martin.huret@ifremer.fr
Mathieu Doray	IFREMER	France	Mathieu.Doray@ifremer.fr
Pablo Carrera	IEO	Spain	pablo.carrera@ieo.csic.es
Paulo Oliveira (*)(**)	IPMA	Portugal	pboliveira@ipma.pt
Paz Diaz (Chair)	IEO	Spain	paz.diaz@ieo.csic.es
Pierre Petitgas(**)	IFREMER	France	pierre.petitgas@ifremer.fr
Rosario Dominguez-Petit	IEO	Spain	rosario.dominguez@ieo.csic.es
Silvia Rodriguez Climent	IEO	Spain	silvia.rodriguez.climent@ieo.csic.es
Ursula Krampe(*)(**)	EC	Belgium	Ursula.Krample@ec.europa.eu

(*) Chair-invited participants

(**) Partial time

Annex 2: Survey Summary Sheets

PT-DEPM23-PIL

Nation:	Portugal	**Institute**	IPMA, Instituto Português do Mar e da Atmosfera
Survey:	PT-DEPM23-PIL	**Dates:**	*10/04/2023-01/05/2023*
Vessel:	RV Vizconde de Eza	**Survey area**	ICES 9a S, W
Target species and	Sardina Pilchardus Pil.27.8c9a	**Results to join with other survey**	SAREVA0423
Survey coordination Group	*ICES WGACEGG*	**Data submitted for assessment (WG)**	WGHANSA. SSB Pil.27.8c9a maturity and size at age
Survey responsible	Maria Manuel Angélico, Cristina Nunes		

Survey description:	Objectives: • estimation of SSB for sardine triennially and DEPM parameters (egg mortality, spawning area, daily egg production, total egg production, mean female weight, sex ratio, batch fecundity and spawning fraction • collection of hydrological data • estimation of sardine maturity and mean weights at age for the Atlantic Iberian stock (pil 27.9a8c) The DEPM surveys comprise ichthyoplankton, fish and hydrographic sampling. Plankton samples are collected, along a grid of parallel transects perpendicular to the coast, for spawning area estimation and daily egg production calculation. Concurrently, fishing hauls are carried out for estimation of daily fecundity (sex ratio, female weight, batch fecundity and spawning fraction) for the mature sardines in the population. Survey design, laboratory and estimation analyses are described in detail in the TIMES survey manual (in press) and Massé *et al.* 2018 Changes in the survey design: In 2023 due to logistic issues (reduced number of vessel days) the initial grid of stations for PairoVET was altered. The number of transects and distance between PairoVET stations along the transects was reduced. From the planned 8x3 nm (transects x stations) it was changed to 10x4nm. Fish samples were collected by a hired purse-seiner apart from 3 samples obtained in Cadiz with the RV.
Gear details:	PairoVET 150 µm mesh size net, CUFES 335 µm mesh size net , CTD RBR, TSG SBE45 (temperature, salinity, fluorescence)
Notes from	. See survey description
Number of working days/adverse weather days or other	15 working days

Other notes, any unusual observations (eg. rare	

Survey outputs (main and extra info)	Main outputs see survey results summary table Extra info: Egg abundance of other species, birds and mammals census
Overall evaluation on survey and data quality for assessment (green, yellow, red)	
Index revisions:	

Survey summary table - Eggs

Institute	IPMA	IPMA
Survey area	9a South	9a West
SURVEY EGGS		
R/V	Vizconde de Eza	Vizconde de Eza
Date	19-24/2	10-19/2
Transects	17	28
PairoVET stations	125	257
Positive stations (%)	34 (27)	72 (28)
Tot. Eggs	1686	3356
Max eggs/m2	4156	4727
Temp (ºC) min/mean/max	15.7/16.2/16.8	13/14.4/15.8
Max age	58.2	65.6
CUFES stations	141	294
Positive CUFES stations (%)	ongoing work	ongoing work
Tot. Eggs CUFES	ongoing work	ongoing work
Max eggs/m3	ongoing work	ongoing work
Hydrographic stations	125	257

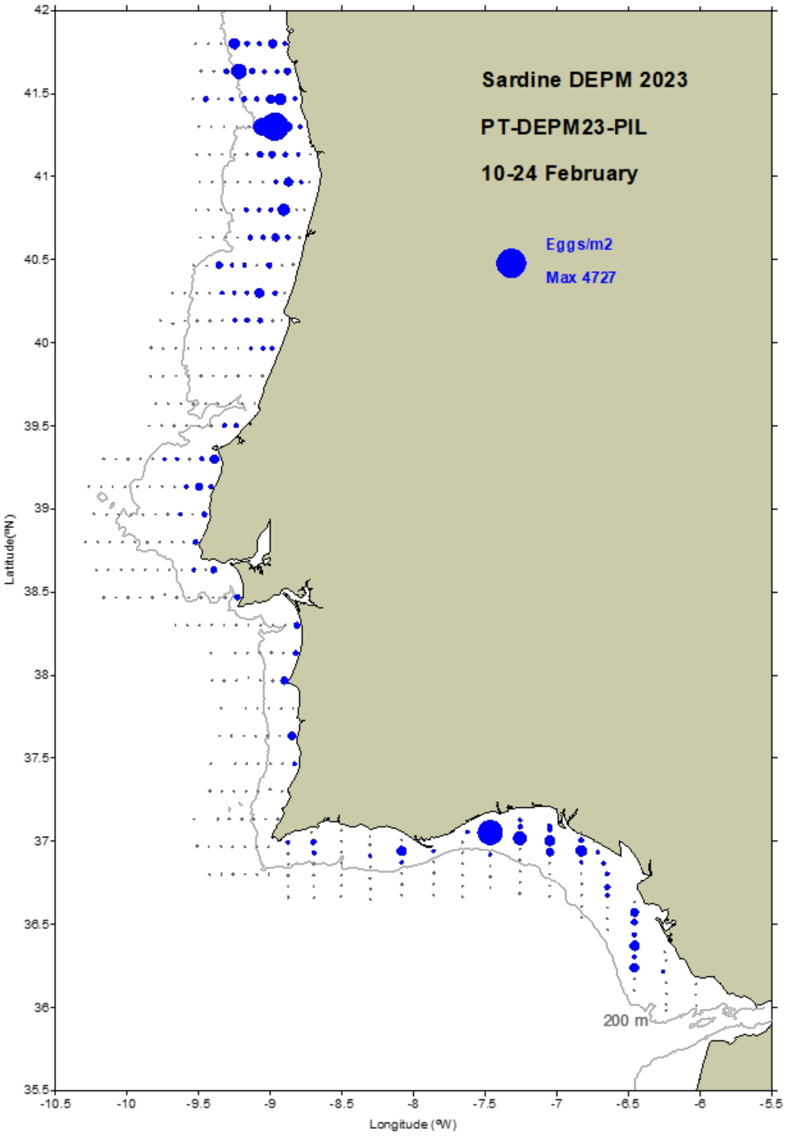
Survey summary table - Adults

Institute	IPMA	IPMA	TOTAL
Area	9a South	9a West	
R/V	Vizconde de EZa		
Number Hauls R/V	4	-	4
Number Hauls C/V	8	23	31
Number R/V (+) trawls	3	-	3
Date	19-25/02	10-19/02	10-25/02
Bottom (m)	13 – 72	15 – 99	13 – 99
Time range (hh:mm)	01:30 – 22:40	01:00 – 23:00	01:00 – 23:00
Total sardine sampled	729	1422	2151
Length range (cm)	9.5 – 22.6	10.8 – 22.2	9.5 – 22.6
Weight range (g)	5.0 – 89.92	9.03 – 88.9	5.0 – 89.92
Female for histology	327	634	1021
Hydrated females	21	11	32
Otoliths	653	1286	1939

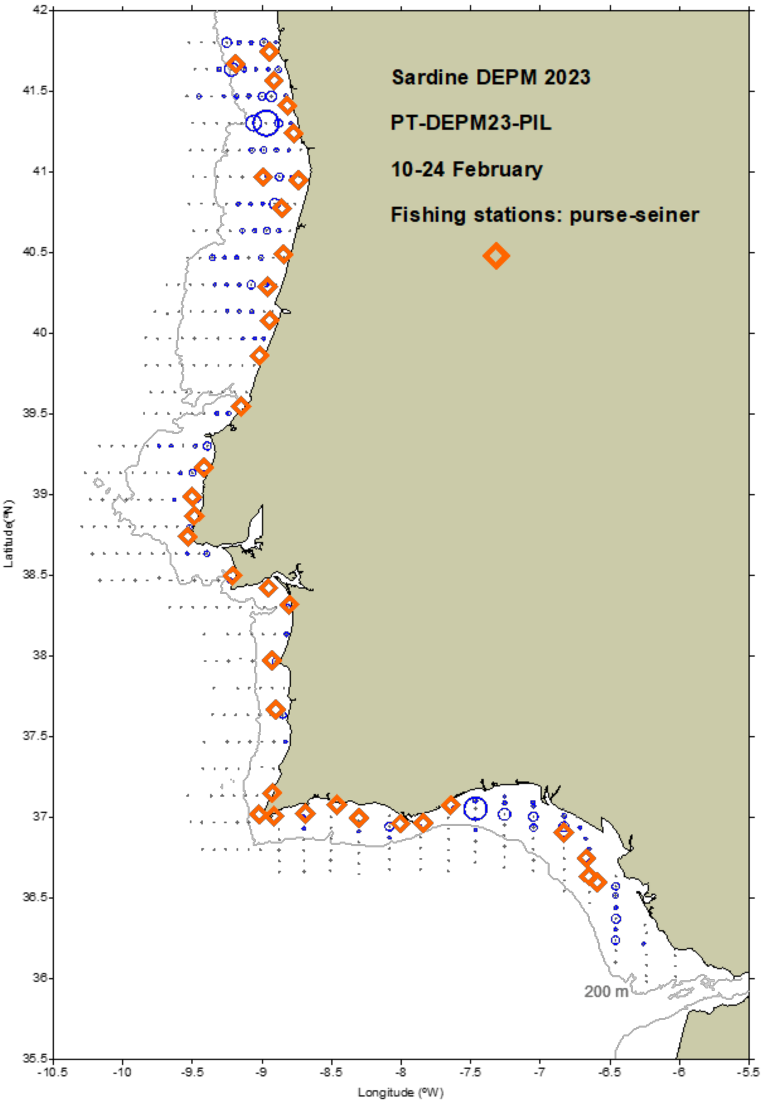
Survey results summary table

Institute	IPMA	IPMA	Total
Area	**9a South**	**9a West**	
Survey area (Km^2)	18144	36396	54540
Positive area (Km^2)	5114	10656	15770
Z (hour^{-1}) (CV%)	-0.029 (7.6)	-0.02 (6.0)	
P0 (egg/m^2/day (CV%)	319.08 (18)	276.46 (12)	
P0 tot (eggs/day) (x10^{12}) (CV%)	1.63 (18)	2.95 (12)	4.58
Female Weight (g)	43.39 (15)	36.7 (10)	
Batch Fecundity	18172 (15)	15388 (10)	
Sex Ratio	1.422 (12)	0.556 (4)	
Spawning Fraction	0.041 (41)	0.044 (18)	
Spawning Biomass (tons) (CV%)	226326 (51)	287593 (26)	513919

Survey map of egg abundance distribution



Survey map of of egg abundance distribution plus fishing hauls locations



PELAGO23

Survey Summary Table WGACEGG 2023	
Name of the survey (abbreviation):	PELAGO23 acoustic survey in the Atlantic Iberian Waters of ICES area 9a (River Minho – Cape Trafalgar)
Target Species:	Anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*) and chub mackerel (*Scomber colias*).
Survey dates:	15th March 2023 – 4th April 2023.

Summary:

https://www.researchgate.net/publication/377527634_PELAGO23_acoustic_survey_in_the_Atlantic_Iberian_Waters_of_ICES_area_9a_River_Minho_-_Cape_Trafalgar

PELAGO23 survey was carried out on board R/V Miguel Oliver (Secretaría General de Pesca, Spain), between the 15th of March 2023 and the 4th of April 2023, for a total of 21 working days. In this survey, a total of 1960 nautical miles were tracked, 1085 nm over 71 sampling transects; 40 pelagic fishing hauls (3 null) and 28 purse-seine fishing operations were undertaken in the Portuguese continental shelf and the Bay of Cadiz, in Spain. The estimated total sardine biomass was 436 thousand tons, representing a decrease of 46% in relation to the PELAGO22 survey (808 thousand tons). The estimated total abundance was 13 710 million sardines, a number that represents a decrease of about 27.5% in relation to the previous year (18 907 million sardines). Whereas the subdivision 9aCN exhibited the higher biomass and the subdivision 9aSC had the lowest. The low value of biomass in subdivision 9aSC is of particular importance because it is one of the main recruitment areas for the Iberian stock along with 9aCN. In fact, both areas concentrated the main proportion of 1-year-old sardines, mainly the northern area. The subdivision 9aCS showed the most acute reduction in both abundance and biomass, a decrease of 81.8% and 86.7% respectively when compared to records of 2022. The subdivision 9aSA showed similar values in abundance to those reported in 2022 (an increase of less than 6%), while biomass had a quite significant decrease (minus 28.8%).

The estimated total anchovy biomass was around 97 thousand tons, representing a decrease of 19.8% in relation to the PELAGO22 survey (121 thousand tons). The estimated total abundance was 6 590 million individuals, a number that represents an increase of 14.5%, compared to the previous year (5 636 million individuals). The western component of the Iberian anchovy stock (9aCN+9aCS), showed an approximate 37% decrease in both abundance and biomass. However, the western component contained the most of the biomass and somewhat less than half the total abundance. In the southern component (9aSA+9aSC) there was an increase in both abundance an biomass. Further, individuals belonging to short length class sizes were more common in the southern component (mode about 11 cm), while larger and heavier specimens were more frequently observed in the western component. The estimated biomass of chub mackerel in PELAGO23 was 36 thousand tones and the abundance 432 million individuals, increasing 3.3 times the value of biomass (11.1 thousand tons in 2022) and abundance by a factor of four (162 million individuals in the previous year survey). The main proportion of the stock was located at north and east of Cape S. Vicente, subdivisions 9aCS and 9aSA respectively. The smallest class sizes were observed in subdivision 9aSA and the largest specimens corresponded to subdivision 9aSC.

Sardine exhibited dominance in the community almost anywhere. Sardine and anchovy co-occurred along the coast at several depths. Abundance and biomass of other pelagic species (HOM, BOG, MAC, BOC, and HMM) were estimated for the first time.

	Description
Survey design	The survey area, over the shelf until the 200 m isobath, was covered following a parallel grid with a mean distance between transects of 8 nautical miles, tracking about 1960 nautical miles (71 radials). The average speed of the acoustic screening was 10 knots and the acoustic signals were integrated over one nautical mile intervals. Acoustic screening was performed from sunrise to sunset with the scientific eco-sound Simrad EK80 (18-38–

	70-120-200 kHz), covering the continental shelf of Portugal and the Bay of Cadiz, in Spain.
Index Calculation method	The echo-integration of the acoustic signal was performed with a frequency of 38 kHz, while the remaining frequencies were used to assist in the echogram scrutiny process. The acoustic data was recorded in Echoview, which was also used to integrate the fish acoustic energy. The echogram bottom was manually corrected prior to the acoustic energy extraction. Fishing operations were used to split the acoustic energy by species and by length within each species, to collect weight-at-length, age, and other biological data. Biological sampling of sardine, anchovy, horse mackerel, mackerel and chub-mackerel was performed in each fishing station, whenever the species was captured. Age data was used to produce Age Length Keys (ALK) for sardine, anchovy and chub mackerel. The abundance by age group and area was estimated from the combination of the ALK and the estimates of abundance at length from the echo-integration in each area. Fishing was carried out according to the echogram information.
Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys.
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	NA, weather was not an issue to compromise the survey
Extinction (shadowing)	Not observed during the survey.
Blind zone	Hull mounted transducers at 5.7 m depth, downward facing. Upper integration limit set at 10 m depth. In this survey aggregations of sardine and/or anchovy were not observed near the surface.
Dead zone	A 0.5 m offset is added to the bottom line detected by the transducers.
Allocation of backscatter to species	Expert echogram scrutiny is performed at the EDSU scale using Echoview software. Direct allocation to the species, based on the expert judgment, was applied in cases of clearly identifiable individual schools. The remaining allocation was based in the species composition of the closer trawl hauls which were considered a good approximation of the real species composition.
Target strength	Species-specific b20 values are listed in Table 2.12 in Doray *et al*. (2021). Anchovy and sardine: -72.6; chub mackerel: -68.7. Doray, M., Boyra, G., and van der Kooij, J. (Eds.). 2021.
Calibration	Acoustic equipment was calibrated by IEO team before the PELAGO survey (Bueu, Ria de Pontevedra, Galicia), following the ICES standard procedures (Demer *et al*., 2015; see also Foote *et al*., 1987).
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*

Stock containment	The target species relevant for stock assessment (PIL and ANE) were covered within the survey area at the time of sampling. The stock of anchovy exhibited two differentiated, uncoupled dynamics, one in the western waters, another in southern waters. Sardine was well contained within the survey area. The western component of the southern anchovy stock and the Iberian sardine stock extend their distribution into the north of the survey area, subdivision 9aN, and 9aN+8abd, respectively. The timing of the survey is well coordinated with the PELACUS survey to enlarge the sampling northwards and to the Cantabric, pursuing a comprehensive containment of the PIL and ANE stocks.
Stock ID and mixing issues	Potential mixing of the sardine stock with the north-western stock on the African coast. The existence of genetically unrelated stocks of anchovy in southern and western parts of the surveyed area is undergoing clarification.
Measures of uncertainty (CV)	Acoustic data are checked using taylor-made routines before biomass estimation. Biomass per echotype and species, internal consistency checks (mean weight, total abundance vs. sum of at length abundances, comparison of mean weights calculated with different methodologies).
Biological sampling	Biological sampling of sardine, anchovy, horse mackerel, mackerel and chub-mackerel was performed in each fishing station, whenever the species was captured. Subsamples of 100 individuals per haul and species to collect weight-at-length, age, and other biological data.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

PELACUS0423

Survey Summary Table WGACEGG 2023	
Name of the survey (abbreviation):	PELACUS0423
Target Species:	Acoustic assessment of Iberoatlantic stock of Sardine (*Sardina pilchardus*), Anchovy (*Engraulis encrasicolus*) and Horse mackerel (*Trachurus trachurus*)
Survey dates:	1st leg: 8th – 18st April 2023 2nd leg: 19th -30th April 2023
Summary:	

PELACUS0423 was carried out on board R/V Vizconde de Eza this year due to electrical issues associated with the vessel usually used (R/V Miguel Oliver). First leg from 8th to 18th April and second leg from the 19th to 30th April 2023. Calibration of the acoustic equipment took place on the 18th September in las Rias Baixas (Galicia). The survey´s main objective is the acoustic biomass estimates by echointegration of the main pelagic species: sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), horse mackerel (*Trachurus trachurus*), mackerel (*Scomber scombrus*), blue whiting (*Micromesistius poutassou*), bogue (*Boops boops),* boarfish (*Capros aper*), chub mackerel (*Scomber colias*) distributed in the Spanish Cantabrian and North West (NW) waters.

Weather conditions were rough in the first leg. There were also Covid-19 cases at the end of the first leg (13/03) which forced several readjustments to continue with the second leg. The second leg had good weather conditions and was Covid-19 free.

During the survey 34 pelagic trawl hauls were performed with the research vessel. The main species present in most of the fishing stations was sardine (85% of the total NASC allocated), anchovy (74% of the total NASC allocated to both sardine and anchovy)) and blue whiting (8% of the total NASC allocated). Horse mackerel, sardine and blue whiting were divided in two categories (juveniles and adults).

As a main result, biomass estimates for adult sardine (individuals >16cm) achieved 525 thousand metric tonnes that corresponded to 7.7 $*10^9$ fish. Sardine was mostly found in the 9aN this year. The most representative age group, which accounted for 48% of the total biomass was age 4. This means that those individuals would be the ones born in 2019. Age 4 was in fact the predominant age in areas 9aN (52%) and 8cEw (36%); whereas age 1 was predominant in areas 8cW (46%), 8cEe (79%) and 8b (95%).

Biomass estimates for adult anchovy (individuals >12 cm) in subdivision 9a was 3.2 $*10^3$ tonnes, corresponding to $168*10^6$ fish. The vast majority of anchovy this year was found in the eastern part (8cE). In 8c area a total of 39.7 thousand tonnes were estimated. In 9aN Age 1 accounted for the 71% of the total biomass, corresponding to 77% in number.

	Description
Survey design	The survey covered 8cW, 9aN, 9a CN and the northern of 9aCS (e.g. western coast of the Iberian Peninsula, since Fisterra Cape until Sines Cape) on a survey design consisting in parallel tracks 6 nmi apart, with random start, and covering from 20-15 m depth up to 100 m. This zone coincides with the main potential distribution area of sardine recruitment of the

	Iberoatlantic stock. Moreover, in the main recruitment area (e.g. middle part of 9aCN) sampling intensity has been increasing up to 4 nmi among transects.
Index Calculation method	Acoustic equipment consisted of a Simrad EK-80 scientific echosounder, operating at 18, 38, 70, 120 and 200 kHz, working in CW mode. The elementary sampling distance unit (EDSU) was fixed at 1 nm. Acoustic data were obtained only during daytime at a survey speed of 8-10 knots, although, some tracks were also steamed at night. Data were then stored in raw format and post-processed using SonarDataEchoview software (Myriax Ltd.) (Higginbottom et al, 2000). All echograms were first scrutinized, the bottom line incorporated, and background noise was also removed according to De Robertis and Higginbottom (2007). Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002), although echograms from 18, 70, 120 and 200 kHz frequencies were used to visually discriminate between fish and other scatter producing objects such as plankton or bubbles, and to distinguish different fish species according to the frequency response. The 18, 70, 120 and 200 kHz frequencies were used to create a mask allowing a better discrimination between swimbladder fish species and other organisms. The threshold used to scrutinize the echograms was –70 dB. The integration values were expressed as nautical area scattering coefficient (NASC) units or sA values (m2 nm-2) (MacLennan et al., 2002).
Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys.
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	NA, good weather dominated the survey.
Extinction (shadowing)	Not observed during the survey.
Blind zone	Drop-keel mounted transducers at 6.5 m depth, downward facing. Upper integration limit set at 10 m depth.
Dead zone	A 0.5 m offset is added to the bottom line detected by the transducers.
Allocation of backscatter to species	When possible, direct allocation was done, accounting for the shape of the schools and also the relative frequency response (Korneliussen and Ona, 2003, De Robertis et al, 2010). For all school candidates, several of variables were extracted, among them the NASC (s_A, m^2 /nmi^2) together with the proportioned region to cell (ESDU, 1 nmi) NASC and the s_V mean and s_V max and geographic position and time. PRC_NASC values were summed for each ESDU and distances were referenced to a single starting point for each transect. Results for 38 and 120 kHz were compared. Besides, the frequency response for each valid school (i.e. those with length and s_V which allows them be properly measured) was calculated as the ratio s_A(fi)/s_A(38), being fi the s_A values for 18, 70, 120 and 200 kHz.

Target strength	Species-specific b_{20} values are listed in Table 2.12 in Doray *et al.* (2021). Anchovy and Sardine: -72.6 Doray, M., Boyra, G., and van der Kooij, J. (Eds.). 2021. ICES Survey Protocols – Manual for acoustic surveys coordinated under the ICES Working Group on Acoustic and Egg Surveys for Small Pelagic Fish (WGACEGG). 1st Edition. ICES Techniques in Marine Environmental Sciences Vol. 64. 100 pp. https://doi. org/10.17895/ices.pub.7462
Calibration	All frequencies were calibrated according to the standard procedures (ICES-CRR326) during the first two days, following the ICES standard procedures (Demer *et al*., 2015; see also Foote *et al*., 1987). Demer, D.A., Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., *et al*. 2015. Calibration of acoustic instruments. *ICES Coop. Res. Rep*, 326, 133 pp. Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan, E.J. Simmonds, 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. *ICES Coop. Res. Rep*., 144, 57 pp.
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	The main distribution area of sardine was located in 9aN close to the mouth of Ria de Muros and in 9aCN between Porto and Figueira da Foz, being similar that observed in previous years. For the anchovy, the main distribution area was in 8cEe between Laredo and San Sebastián (Donosti).
Stock ID and mixing issues	Presence of fixed commercial fishing gears or irregular and rocky bottoms: it was not possible to perform hauls in some areas. Potential mixing between anchovy, sardine and chub mackerel in some specific areas can be a reality, so the energy allocation to the species considering the closest trawl haul(s) (relative species composition) may underestimating one specie over another.
Measures of uncertainty (CV)	Acoustic data are checked using taylor-made routines before biomass estimation. Biomass per echotype and species, internal consistency checks (mean weight, total abundance vs. sum of at length abundances, comparison of mean weights calculated with different methodologies)
Biological sampling	Biological sampling of sardine and anchovy was performed in each fishing station, whenever the species was captured. Subsamples of 100 individuals per haul and species to collect weight-at-length, age, and other biological data.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*

Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be anwered by Assessment Working Group*

SAREVA 0423

Nation:	SPAIN	**Institute**	C.N IEO, CSIC. CENTER OF VIGO. SPAIN
Survey:	SAREVA 0423	**Dates:**	Eggs samples: 10-30/04/2023 Adult samples: collected in the acoustic-trawl survey PELACUS 0423 (8-30/04)
Vessel:	R/V VIZCONDE DE EZA	**Survey area**	ICES 8.c and 9.a North
Target species and stock	Sardina Pilchardus Pil.27.8c9a	**Results to join with other survey (code)**	PIL-DEPM-PT
Survey coordination Group	ICES WGACEGG	**Data submitted for assessment (WG)**	Pil.27.8c9a SSB, maturity and mean weights at age → WGHANSA
Survey responsible	Paz Díaz Conde: paz.diaz@ieo.csic.es Rosario Domínguez Petit: rosario.dominguez@ieo.csic.es		

Survey description:	Cruise Report Link: SAREVA 0423 Survey Report Objectives o Contribute to the assessment: - estimation of SSB for sardine triennially and DEPM parameters (egg mortality, spawning area, daily egg production, total egg production, mean female weight, sex ratio, batch fecundity and spawning fraction (joint data analyses from SAREVA and PIL-DEPM-PT surveys; results submitted to WGHANSA as input for assessment) - estimation of sardine maturity and mean weights at age for the Atlantic Iberian stock (pil 27.9a8c) (results submitted to WGHANSA as input for assessment) o Ecosystem approach: - collection of hydrological data (vertical profiles and continuous surface recording) - collection of extra information, fish eggs and larvae, fish communities, biological/physiological fish data The SAREVA DEPM survey encompass the collection of ichthyoplankton, fish, and hydrographic data. Plankton samples were systematically gathered along a grid of parallel transects perpendicular to the coast to estimate spawning area and calculate daily and total egg production. Simultaneously, fishing hauls were conducted to assess the daily fecundity of mature sardines in the population, including factors such as sex ratio, female weight, batch fecundity, and spawning fraction. Survey design, as well as methods for laboratory and estimation analyses are described in detail in the TIMES survey manual (in press) and Massé *et al.* 2018. The rise in total egg production in the northern region based on SAREVA 0423, compared to 2021, is attributed to a notable increase in egg production density (measured in eggs per day per square meter). Concerning the mean weight of females observed across the series, females from the northern stratum (SAREVA; 9a N and 8c) consistently exhibit a higher weight compared to their counterparts in the other two strata (9.a South and 9.a West). In terms of temporal trends, there has been an overall decrease in mean weight, particularly notable in the northern stratum in 2014 with a significant drop of approximately -50%. However, data for 2023 reveals a gradual recovery in the mean weight within this stratum, a positive trend that commenced in 2017. It is noteworthy that batch fecundity displays analogous patterns to the average weight of females in the study area, given the direct relationship between these two variables. The DEPM-based SSB estimate for the study area in 2023, at 126 874 tons, represents the third-highest value in the time series. However, it remains below the estimates recorded in 2005 and 2008, which were 206 668 tons and 179 983 tons, respectively.
Gear details:	PairoVET 150 µm mesh size net, CUFES 335 µm mesh size net, CTD SBE-25 (temperature, salininy, fluorescence) and TSG SBE-45, Turner fluorometer.
Notes from survey:	**See Survey Summary Table**
Number of working days/adverse weather days or other constraints	- 22 working days/4 days of adverse weather. - Reduction of 2 vessel days (due to logistic problems in the Portuguese DEPM survey) and reduction of the number of transects and stations from the traditional 8x3 nm grid (transects x stations) to a 10x4 nm grid to cover the Galician coast. It was possible to carry out sampling according to the usual grid from 7.5ºW to the east.
Other notes, any unusual observations	*Other notes:*
Survey outputs (main and extra info)	- Main outputs see **Survey results summary table** - Extra info: Egg abundance of *Engraulis encrasicolus, Trachurus trachurus, Scomber scombrus, Maurolicus muelleri* from PairoVET and CUFES samples

Overall evaluation on survey and data quality for	Green
Index revisions:	

Survey summary table

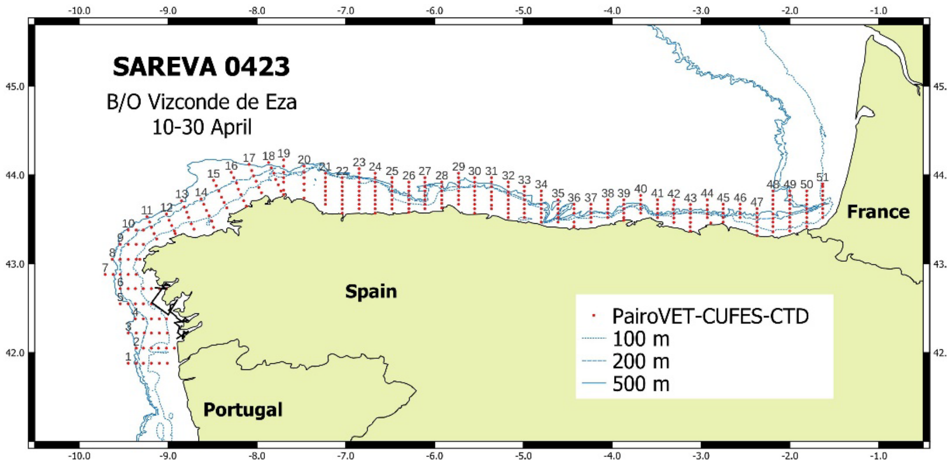
Study area	**ICES 9.a North + 8.c**
EGGS SAMPLING	
Dates	10-30 April
Transects (planned/achieved)	51/51
PairoVET stations (planned/achieved)	389
Positive stations (with eggs of target sp)	127
Tot. Eggs	1590
Max eggs/m2	4257
Temp (°C) min/mean/max	13.09/ 14.25/15.97
CUFES stations	341
Positive CUFES stations	139
Tot. Eggs CUFES	9421
Max eggs/m3	93.6
CTDF stations	341
ADULTS SAMPLING	
Number Hauls R/V	34
Number R/V (+) trawls	23
Date	8-30 April
Depth range (m)	31-203
Total individuals target species sampled	1424
Length range (cm)	13.9-25.0
Weight range (g)	16.6-118
Females for histology	571
Hydrated females	60
Otoliths	561

Survey results summary table

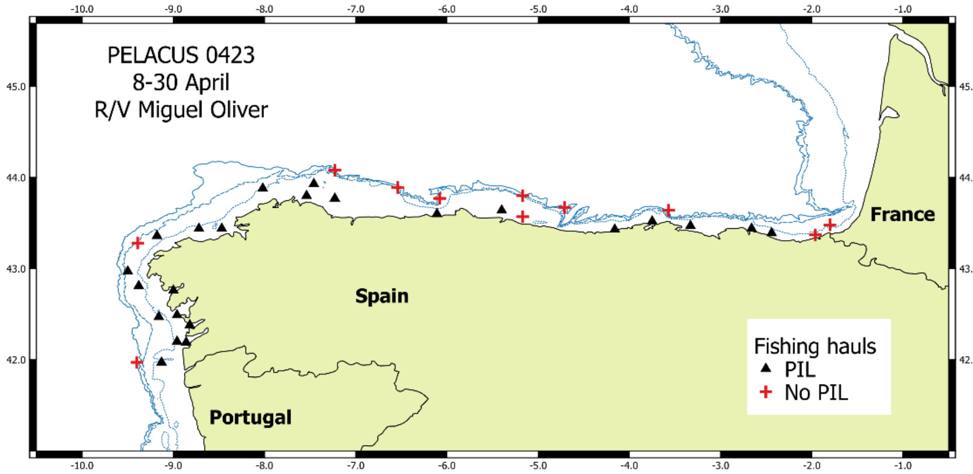
Study area	ICES 9.a North + 8.c
Survey area (Km^2)	41673
Positive area (Km^2)	15615
Z ($hour^{-1}$)(CV%)	-0.021 (5.7)
P0 (eggs/m2/day)(CV%)	151.65 (11)
P0 tot (eggs/day) ($x10^{12}$) (CV%)	2.37 (11)
Female Weight (g) (CV%)	58.31 (6.3)
Batch Fecundity (CV%)	23718 (6)

Sex Ratio (CV%)	0.516 (6.4)
Spawning Fraction (CV%)	0.089 (13.7)
Daily Fecundity (eggs/day.g female)	18.68
Spawning Biomass (tons) (CV%)	**126874 (21)**

Survey map of plankton stations



Survey map of fishing stations



PT-DEPM23-PIL & SAREVA 0423

Nation:	Portugal, Spain	**Institute**	IPMA, IEO
Survey:	PT-DEPM23-PIL, SAREVA0423	**Dates:**	PT-DEPM23-PIL: 10-24 Feb SAREVA0423: 10-30 Apr
Vessel:	RV Vizconde de Eza	**Survey area**	PT-DEPM23-PIL: 9aS,9aW SAREVA0423: 9aN, 8c
Target species and stock	PIL 27.9a8c	**Results to join with other survey (code)**	PT-DEPM23-PIL, SAREVA0423
Survey coordination Group	WGACEGG	**Data submitted for assessment (WG)**	13 Nov 2023, WGHANSA
Survey responsible	MM Angélico, CNunes (IPMA); Paz Díaz (IEO,CSIC), Rosario Domínguez (IEO, CSIC)		

Survey description:	Objectives: • estimation of SSB for sardine triennially and DEPM parameters (egg mortality, spawning area, daily egg production, total egg production, mean female weight, sex ratio, batch fecundity and spawning fraction • collection of hydrological data • estimation of sardine maturity and mean weights at age for the Atlantic Iberian stock (pil 27.9a8c) The DEPM surveys comprise ichthyoplankton, fish and hydrographic sampling. Plankton samples are collected, along a grid of parallel transects perpendicular to the coast, for spawning area estimation and daily egg production calculation. Concurrently, fishing hauls are carried out for estimation of daily fecundity (sex ratio, female weight, batch fecundity and spawning fraction) for the mature sardines in the population. Survey design, laboratory and estimation analyses are described in detail in the TIMES survey manual (in press) and Massé *et al.* 2018 Changes in the survey design: In 2023 due to logistic issues (reduced number of vessel days) the initial grid of stations for PairoVET was altered. The number of transects and distance between PairoVET stations along the transects was reduced. From the planned 8x3 nm (transects x stations) it was changed to 10x4nm. However, during the SAREVA survey it was possible to carry out sampling according to the usual grid from 7.5ºW to the east, only the Galician coast was covered with the adjusted grid. Fish samples for IPMA survey were collected by a hired purse-seiner apart from 3 samples obtained in Cadiz with the RV. Fish samples for IEO DEPM survey were collected during PELACUS acoustics survey, which took place in the same area simultaneously.
Gear details:	PairoVET, 150 µm mesh size nets; CUFES, 335 µm mesh size net; CTDs (RBR, SBE-25), TSG (SBE45; Turner)
Notes from survey:	See survey summary table below
Number of working days/adverse weather days or other constraints	PT-DEPM23-PIL: 15 days SAREVA0423: 22 days (4 days adverse weather)

Other notes, any unusual observations (eg. rare species)	
Survey outputs (main and extra info)	See results summary table below
Overall evaluation on survey and data quality for assessment (green,	
Index revisions:	

Survey summary table

Institute	**IPMA**	**IPMA**	**IEO**
Survey area *(stratum)*	**9a South**	**9a West**	**9.a North + 8.c**
SURVEY EGGS			
Dates	19-24/2	10-19/2	10-30 April
Transects	17	28	51
PairoVET stations	125	257	389
Positive stations (with eggs of target sp)	34 (27)	72 (28)	127
Tot. Eggs	1686	3356	1590
Max eggs/m2	4156	4726	4257
Temp (ºC) min/mean/max	15.7/16.2/16.8	13/14.4/15.8	13.09/ 14.25/15.97
CUFES stations	141	294	341
Positive CUFES stations	Ongoing work	Ongoing work	139
Tot. Eggs CUFES	Ongoing work	Ongoing work	9421
Max eggs/m3	Ongoing work	Ongoing work	93.6
CTDF stations	125	257	341
SURVEY ADULTS			
Number Hauls R/V	4	-	34
Number Hauls C/V	10	21	-
Number R/V (+) trawls	1	-	23
Date	18-25/02	10-17/02	8-30 April
Depth range (m)	13 – 72	15 – 99	31-203
Time range (hh:mm)	01:30 – 23:00	01:00 – 19:35	6:10-15:40 GMT
Total individuals target species sampled	929	1298	1424
Length range (cm)	9.5 – 22.6	10.8 – 22.2	13.9-25.0
Weight range (g)	5.0 – 89.92	9.03 – 88.9	16.6-118
Females for histology	387	634	571
Hydrated females	21	11	60
Otoliths	653	1286	561

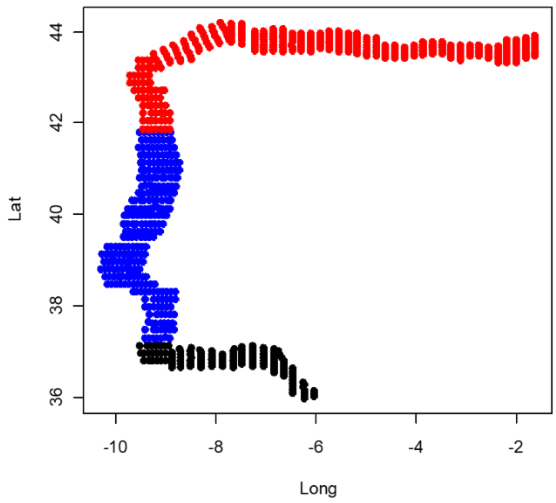
Survey results summary table

Institute	**IPMA**	**IPMA**	**IEO**	**TOTAL**
Survey área ***(stratum)***	9.a South	9.a West	9.a North & 8.c	

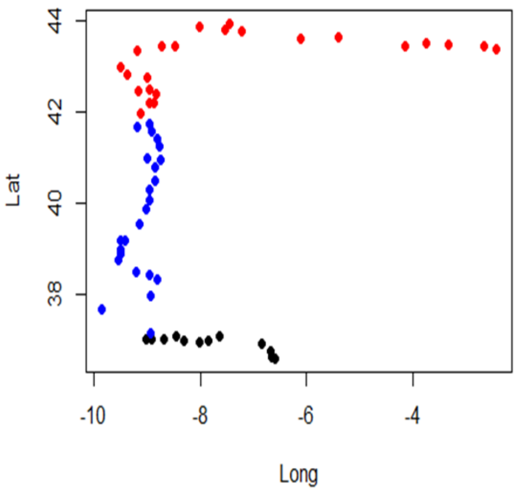
Survey area (Km²)	18144	36396	41673	96213
Positive area (Km²)	5114	10656	15615	31385
Z (hour^{-1})(CV%)	-0.029 (7.6)	-0.02 (6.0)	-0.021 (5.7)	
P0 (eggs/m2/day)(CV%)	319.08 (18)	276.46 (12)	151.65 (11)	747.19 (8)
P0 tot (eggs/day) (x10^{12}) (CV%)	1.63 (18)	2.95 (12)	2.37 (11)	6.96 (8)
Female Weight (g)	43.39 (15)	36.7 (10)	58.31 (6)	
Batch Fecundity	18172 (15)	15388 (10)	23718 (6)	
Sex Ratio	0.422 (12)	0.556 (4)	0.516 (6)	
Spawning Fraction	0.041 (41)	0.044 (18)	0.089 (14)	
Spawning Biomass (tons) (CV%)	**226326 (51)**	**287593 (26)**	**126874 (21)**	**640793 (22)**

Survey maps

Survey map of plankton stations (South-black, West-blue and North-red strata)



Survey map of fishing stations (South-black, West-blue and North-red strata)



PELGAS 2023

Survey Summary table WGACEGG 2023	
Name of the survey (abbreviation):	PELGAS (FR)
Target Species:	Anchovy, sardine, small pelagic fish
Survey dates:	29 April – 30 May, 2022
Summary:	**Cruise Report Link:** https://doi.org/10.13155/97276
The objectives of the survey were carried out successfully and as planned. Good weather conditions dominated during the whole survey. Comprehensive pelagic trawling was carried out (N=95), comparable to 2022. Acoustic sampling effort (1825 n.m. linear transect) and geographical survey coverage were comparable to 2022. Survey effort, timing and area coverage were comparable to previous years and the same vessel and sampling equipment (transducers and trawl) were used.	

	Description
Survey design	Stratified systematic parallel design with fixed starting point.
Index Calculation method	Methodology described in Doray, M., Van Der Kooij, J., Boyra, G. (Eds.), 2021. ICES Survey Protocols - Manual for acoustic surveys coordinated under the ICES Working Group on Acoustic and Egg Surveys for Small Pelagic Fish (WGACEGG). https://doi.org/10.17895/ICES.PUB.7462 Implemented with EchoR R package V1.4.5
Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective TIMES should outline how these are evaluated:*
Bubble sweep down	The weather has been very clement during the whole survey, no significant bubble sweep down occured.
Extinction (shadowing)	None
Blind zone	The use of a lateral-beaming echosounder sampling the 0-15m depth layer allowed to control for the presence of in the vertical echosounders blind zone. It showed that the small pelagic fish distribution was exceptionnaly shallow in

	2023, especially in the case of anchovy. It was estimated, based on lateral echosounder data, that acoustic biomass estimates were biased low by about 20% for anchovy, and by 7% for sardine, due to the presence of fish schools in the acoustic blind zone of the vertical echosounders used for biomass assessment.
Dead zone	A 70 cm offset was applied above seabed to avoid integrating seafloor backscatter in the water column. Target species were generally distributed above this deadzone.
Allocation of backscatter to species	Directed trawling for verification purposes
Target strength	Cf. https://doi.org/10.17895/ICES.PUB.7462
Calibration	All survey frequencies calibrated and results within recommended tolerances
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	Anchovy (8ab): Yes Sardine (8ab): Yes Sprat (8ab): Yes Blue whiting: No Atlantic mackerel: No Chub mackerel: No Boarfish and horse mackerel: good geographical alignment on the northern (IRL: WESPAS) and southern (SP: PELACUS) boundaries but temporal mis-match (~1 month).
Stock ID and mixing issues	None
Measures of uncertainty (CV)	*CV on abundance* Boarfish: 0.26 Anchovy 0.21 Hake 20 Blue whiting 1.30 Sardine 0.28 Atlantic mackerel 3.30 Sprat 0.73 Med. horse mackerel: 7.28 Horse mackerel: 1.23 Chub mackerel NA

	*Calculation carried out using EchoR package version 1.4.6
Biological sampling	Good sampling carried out for all species.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

BIOMAN 2023

Nation:	SPAIN	**Institute**	AZTI. CENTER OF PASAIA. SPAIN
Survey:	BIOMAN 2023	**Dates:**	03/05/2023-26/05/2023
Vessel:	R/V VIZCONDE DE EZA	**Survey area**	ICES 8abcd
Target species and stock	Engraulis encrasicolus & Sardina Pilchardus Anc & Pil.27.8	**Results to join with other survey (code)**	
Survey coordination Group	ICES WGACEGG	**Data submitted for assessment (WG)**	Anc.27.8→ Total biomass & % B age 1 Pil.27.8abd → SSB and egg Abundance
Survey responsible	Maria Santos Mocoroa: msantos@azti.es		

Survey description:	**Link to the working document: DOI: 10.13140/RG.2.2.10327.24485** Objectives o Contribute to the assessment: - estimation of Biomass for anchovy annually by the DEPM; as well as numbers at age, % at age, biomass at age, weight at age and length at age; Total biomass and B at age 1 submitted to WGHANSA as inputs for assessment of anchovy in 8abcd. - Estimation of SSB for sardine 2011,2014,2017 and since 2020 annually by the DEPM in 8abcd and 8abd. Egg abundance and SSB triennially submitted to WGHANSA as inputs for assessment of sardine in 8abd. o Ecosystem approach: - Characterization of the Hydrography - Zooplankton and ichthyoplankton analysis - eDNA analysis - Top predators (m. mammals & sea birds) distribution and abundance - Fishing activities distribution and abundance - Marine debris and microplastics distribution and abundance Methodology: In 1987 a study was done for the egg sampling design. Since then, the strategy of egg sampling is identical: a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found. Stations are located at intervals of 3 nm along 15 nm apart transects, perpendicular to the coast. In areas of high abundances of eggs, the transects are 7.5 nm apart. A research vessel performs this sampling, if necessary, performed adult sampling as well. The adult samples are obtained on board another research vessel (pelagic trawler) coinciding in space and time with the plankton sampling. This vessel prospects the same transects as the vessel that samples the plankton. In some years, some samples are obtained from the fleet, fishing in the spawning areas, to complete the sampling.
Gear used:	- PairoVET 150 µm mesh size net, - CUFES 335 µm mesh size net - CTD RBR (temperature, salinity)
Notes from survey:	*See Survey Summary Table*
Number of working days	24 working days

Other notes, any unusual	Many salps within the plankton hauls (PairoVET & CUFES) during the survey
Survey outputs (main and extra info)	- Main outputs see **Survey results summary table.** - Extra info: *Maurolicus muelleri* egg abundance obtained as well
Overall evaluation on survey&data quality for assessment (green, yellow,	Green

Survey summary table

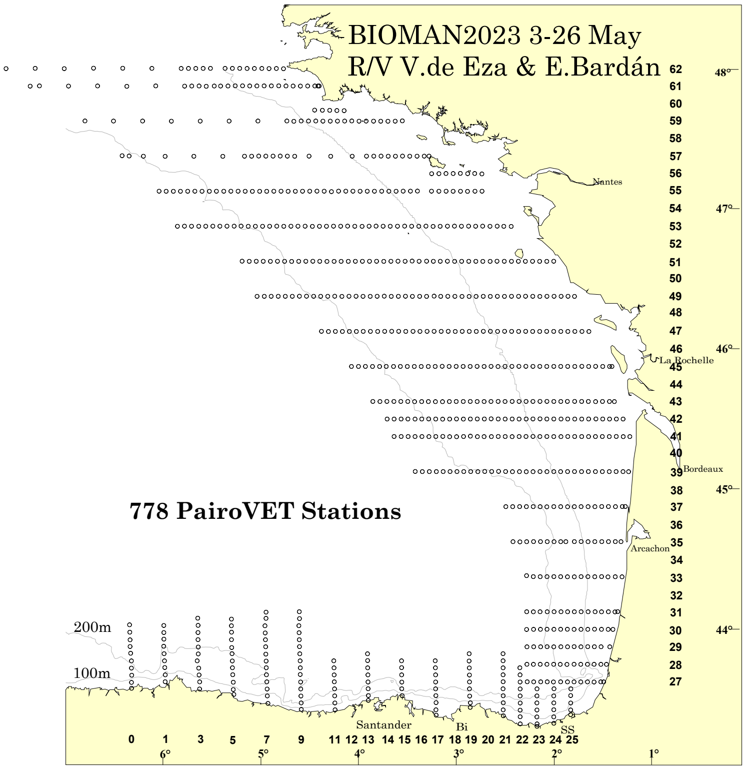
Study area	**ICES 8abcd**	
Survey dates	3 - 26 May	
EGGS SAMPLING		
Transects	40	
PairoVET stations	778	
CUFES stations	1824	
Specie	***anchovy***	***sardine***
Positive PairoVET stations	575 (74%)	276 (35%)
PairoVET total egg nº counted and staged	18039	2977
PairoVET maximum eggs/m² in a station	4350	1640
Positive CUFES stations	1240 (68%)	607 (33%)
CUFES total Egg nº counted	183644	13582
CUFES maximum eggs/m³ in a station	843	512
ADULTS SAMPLING		
Time range (hh:mm)	24h	
Fishing depth range (m)	1.8 - 126	
Number Hauls from research vessels	50	
Specie	***anchovy***	***sardine***
Number Hauls purse seines	1	0
Number of hauls from research vessels for the analysis	42	20
Total individuals sampled	2817	913
Length range (mm)	83 - 193	124 - 235
Weight range (g)	3.10 - 51.60	12.5 - 94.7
Females for histology	1043	121
Hydrated females for batch fecundity regression	81	33
Otoliths	2813	911
HYDROLOGY		
CTD stations	778	
SST (°C) min/mean/max	12.47 / 15.5 / 18.21	
SSS min/mean/max	31.31 / 34.98 / 35.96	

Survey results summary table

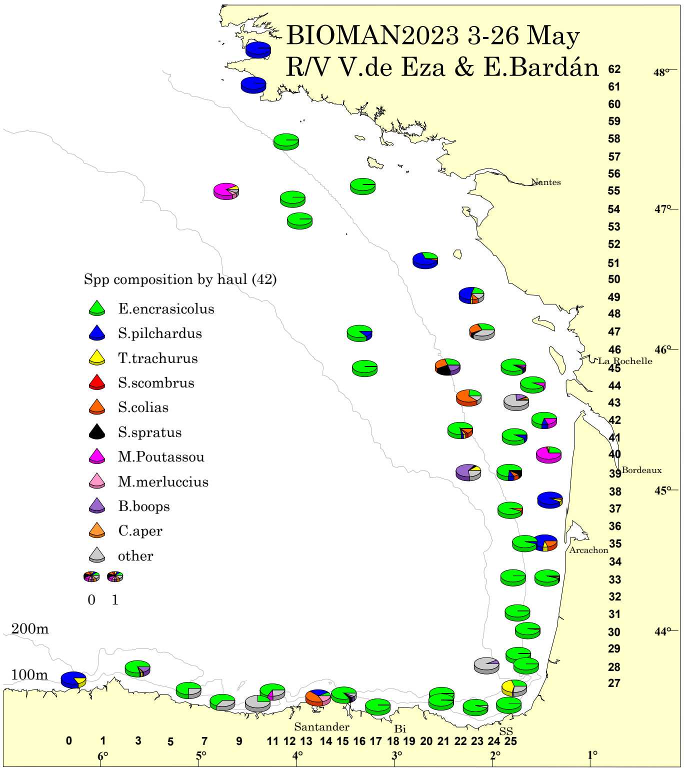
Study area	**ICES 8abcd**	ICES 8abd
Total area (Km²)	113814	
Specie	anchovy	sardine

Spawning area (Km²)	77312	34353
Z (daily rate) (CV%)	0.276 (20.26)	0.319 (32.89)
P_0 (eggs/m²) (CV%)	130.6 (9.49)	63.66 (14.75)
P_{tot} (eggs/day) (CV%)	1.01E13 (9.49)	2.19E12 (14.98)
Female Weight (g) (CV%)	15.94 (5.99)	43.17
Batch Fecundity egg/batch/mat.fem (CV%)	5566(7.86)	17399
Sex Ratio (%) (CV%)	53 (1.23)	0.53
Spawning Fraction (%) (CV%)	37.7 (5.33)	5.70(31.63)
Daily Fecundity (egg/day/g mat. female)	63.21 (6.99)	12.13 (33.87)
Spawning stock biomass (tons) (CV%)	**160549 (11.78)**	**200572 (37.03)**

Survey map of plankton stations



Survey map of fishing stations: spp composition by haul



WESPAS 2023

Survey Summary table WGACEGG 2023	
Name of the survey (abbreviation):	WESPAS / MSHAS (IRL)
Target Species:	Herring, boarfish, horse mackerel
Survey dates:	17 June – 22 July, 2023
Summary: http://hdl.handle.net/10793/1871	**Cruise Report Link:**

The objectives of the survey were carried out as planned and timing was consistent with previous years. Survey coverage (area) and acoustic sampling (transect miles) were comparable to 2022. The number of trawls carried out (n=53) was greater than in 2022 (n=40)

Boarfish distribution was similar to previous years in terms of latitudinal range. Total biomass (TSB) increased by 16% and total abundance (TSN) decreased by 14% compared to observations in 2022. The decrease in abundance is driven by the lower numbers of immature fish observed. Spawning stock biomass increased by 18% compared to 2022.

The highest density of biomass was observed in the Celtic Sea (65.1 % of TSB and 50% of TSN), followed by the Irish west coast (28.3% TSB & 21.7% TSN). The west coast stratum ranked second contributing 28.4% of TSB (21.7% TSN). The biomass of fish observed in this stratum was comparable to 2022. However, abundance (TSN) was lower, driven by the lower number of immature fish in the catches. Boarfish were observed on the Porcupine Bank, contributing 1.7% TSB and 1.3% TSN. The distribution of boarfish north of 55°N (South and West Hebrides strata), was characterised by medium density aggregations in close proximity to the shelf edge. The West Hebrides (northernmost) contained the largest proportion of older fish, which is in line with previous survey findings.

The 4-year age class dominated the 2023 estimate contributing 25% of TSB and 29.4% of TSN (Table 6). Ranked second and third were the 3-year old (16% TSB & 24.9% TSN) and 7-year old fish (14.1% TSB & 11.5% TSN) respectively. Ranked fourth is the 6-year old fish (12.2% TSB & 11.4% TSN). Combined, these three age classes repre-sented 67% of TSB and 77% of TSN. The survey has successfully tracked these four cohorts from recruitment into the spawning stock. The 15+ age class represented 10.4% of TSB and 4.3% of TSN. Maturity analysis indicated over 99.6% of TSB and 99% of TSN was represented by mature fish. The proportion of immature fish in the stock estimate has decreased from a high in 2021 (41% TSN) over recent years (2022; 5% and 2023; 1%). This is in line with observations from the PELGAS survey where the abundance of boarfish has in-creased over the same period.

Aggregations of Celtic Sea herring were encountered around the Labadie and Jones' Bank on traditional summer feeding grounds. A new exploratory analysis exercise was undertaken using data from WESPAS (2017-2023) The objective of the exercise was to investigate if provide a complementary stock in-dex to the current quarter four pre-spawning survey (CSHAS). The revised time series applied a smaller, more focused stratum area during the analysis of existing acoustic data.

The estimate of Celtic Sea (CS) herring TSB (total stock biomass) and relative abundance (TSN) estimates were 29,267 t and 241,762,500 individuals (CV 0.93) respectively. Four winter ring fish dominated the total estimate, representing 36.8% of TSB and 35.1% TSN. Five winter ring fish ranked second contributing 32.5% and 28.6% respectively. Ranked third were 2 winter ring fish (11% TSB & 16.8% TSN). Ranked fourth were 6 winter ring fish (10.9% TSB & 9.7% TSN). Immature fish represented 11.4% of the total abundance (TSN) and 8% of the total biomass (TSB) observed.

Horse mackerel TSB (total stock biomass) and abundance (TSN) estimates were 94,852.1 t and 342,763,900 individuals (CV 0.22) respectively. The 2023 estimate is almost 4 times greater in terms of biomass and abundance compared to 2022.

Horse mackerel were observed predominantly in the Celtic Sea (71% TSB) and to the north of Ireland and west of Scotland, representing 28% combined. No echotraces were assigned to the Porcupine Bank. The west coast strata contributed <1% of TSB as compared to 66% in 2022. The overall acoustic density was greater than in recent years and the total estimate represents the third highest in the time series. Medium density and high density, monospecific aggregations of horse mackerel were encountered in the Celtic Sea and north of Scotland

The 9-year-old fish dominated this year's survey estimate representing 29% of TSB and 26% of TSN. Six-year-old fish ranked second representing 17% of TSB and 20% of TSN and 15-year-old fish ranked third (12% to TSB & 9% TSN). Combined these three age classes represented 58% of TSB and 54% of TSN. Maturity analysis of horse mackerel samples indicated 100% maturity.

The same vessel and sampling equipment (transducers and trawl) were used.

	Description
Survey design	Stratified systematic parallel design with randomised starting point within each stratum. Zig-zag transects in the Minch strata.
Index Calculation method	StoX (V3.6.1) and RStoX (V1.9.0) Data uploaded to the ICES Trawl acoustic portal
Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	Poor weather was an issue during the survey. Transducer placement is 8.8m below the sea surface (drop keel), combined with the near-field exclusion, data integration takes place below 12m
Extinction (shadowing)	Yes, in some areas in the southwest Celtic Sea and northwest IRL/SCO
Blind zone	Aggregations of immature boarfish tend to be located above the thermocline in near surface waters and so it is likely that an unknown proportion was unaccounted for in the estimate
Dead zone	Some shelf slope areas
Allocation of backscatter to species	Directed trawling for verification purposes
Target strength	Herring TS = 20log10(L) – 71.2 (38 kHz) Boarfish TS = 20log10(L) – 66.2 (38 kHz) Horse Mackerel TS = 20log10(L) – 67.5 (38 kHz)
Calibration	All survey frequencies calibrated and results within recommended tolerances (RMS <0.4)
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*

Stock containment	Herring (Celtic Sea); Yes Boarfish and horse mackerel; Good geographical alignment on the southern boundary (Fra: PELGAS) No survey coverage in the western Channel area.
Stock ID and mixing issues	Herring (Celtic Sea); Potential mixing with unidientified stocks on the feeding grounds. Genetic sampling underway.
Measures of uncertainty (CV)	*CV on abundance* Boarfish: 0.11 Horse mackerel: 0.22 Herring (Celtic Sea): 0.93 Herring (Malin Shelf): 0.40 *Calculation carried out using StoX (V3.6.1) and R-StoX (V1.9.0)
Biological sampling	Good sampling carried out for boarfish and herring and hore mackerel (Celtic Sea & Malin Shelf). Horse mackerel estimate utilised otolith aged fish from the survey.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

BOCADEVA 0723

Nation:	SPAIN	**Institute**	IEO- CSIC. CENTER OF CÁDIZ. SPAIN
Survey:	BOCADEVA 0723 (ICES survey code: I8942).	**Dates:**	Egg survey: 24-28/07/2023 (Adult samples collected in the acoustic-trawl survey ECOCADIZ 2023-07 (ICES survey code: A3933) between 29/07-
Vessel:	R/V RAMÓN MARGALEF	**Survey area**	ICES 9.a South.
Target species and stock	Engraulis encrasicolus. Ane.27.9a.s (Southern component)	**Results to join with other survey (code)**	The results are not joined with another survey.
Survey coordination Group	ICES WGACEGG	**Data submitted for assessment (WG)**	ICES WGHANSA: SSB 27.ane.9.as (southern component) estimate provided but not yet used in the assessment.
Survey responsible	M. Paz Jiménez Gómez; paz.jimenez@ieo.csic.es		

Survey description:	- Link to the WD: link not yet available. WD uploaded in WGACEGG sharepoint. - Estimation of SSB for Gulf of Cadiz (GoC) anchovy triennially and DEPM parameters (egg mortality, spawning area, daily egg production, total egg production, mean female weight, sex ratio, batch fecundity and spawning fraction; results submitted to ICES WGHANSA as direct additional information, but not yet used in the assessment). - Collection of hydrological data. - Collection of extra information: fish eggs and larvae, biological/physiological fish data (during the acoustic-trawl survey).
Gear details:	- Egg samplers: *PairoVET* 150 µm mesh size net; *CUFES* 335 µm mesh size net routinely used in the survey series, but it was not used in the current survey due to logistic issues. - Adult sampler: Pelagic trawl *Gloria HOD-352*. - Hydrography samplers: *EXO2* Multiparameter Sonde (Temperature, Salinity, Chla, Turbidity, Dissolved Oxygen, pH); *TSG SBE-45* & *Turner* Fluorometer.
Notes from survey:	**See Survey Summary Table**
Number of working days/adverse weather days or other constraints	- Egg survey (*BOCADEVA 0723*): 5 working days - Acoustic-trawl survey providing DEPM adult samples (*ECOCADIZ 2023-07*): 11 working days. - No adverse weather. - CUFES sampling was not possible during the survey due to logistical problems that prevented the CUFES from being shipped on board on time. - Preliminary Batch fecundity (F) estimate based on 30 from 103 hydrated females. - Preliminary Spawning fraction (S) estimate based on the time-series average.

Other notes, any unusual observations (eg. rare species)	Given the necessity of collecting DEPM anchovy adult samples for the 2023 GoC anchovy DEPM survey, an *ad hoc* combined anchovy egg (*BOCADEVA* leg) and acoustic-trawl (*ECOCADIZ* leg) survey (*ECO/BOCADEVA_0723* survey) was planned by IEO to be conducted on board R/V *Ramón Margalef*, with the *BOCADEVA* leg (*BOCADEVA 0723*) being conducted first (24th – 28th July), and then the *ECOCADIZ* one (*ECOCADIZ 2023-07*; 29th July – 8th August). The adult samples for the *BOCADEVA* survey were taken during the *ECOCADIZ 2023-07* acoustic-trawl survey, which coincided in time and space.
Survey outputs (main and extra info)	- Main outputs see **Survey results summary table** - Extra info: Egg and larvae abundance and distribution of round sardinella *Sardinella aurita* (and *Maurolicus muelleri*, when present) from PairoVET and CUFES samplers.
Overall evaluation on survey and data quality for assessment (green, yellow, red)	
Index revisions:	

Survey summary table

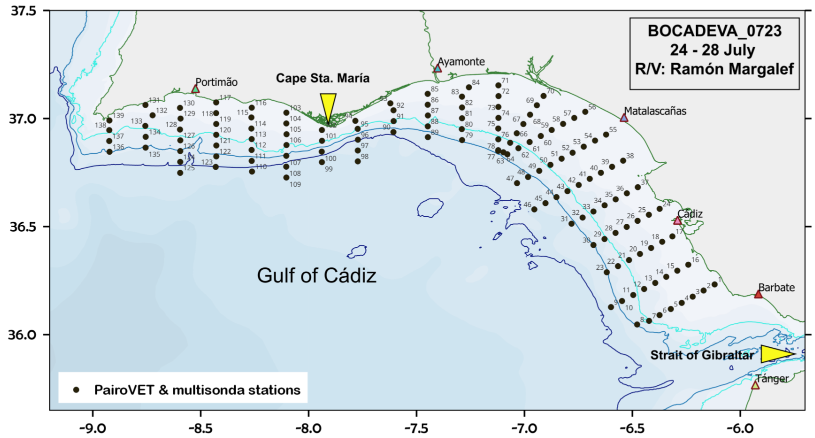
Survey area *(stratum)*	**ICES 9.a South**
SURVEY EGGS	
Dates	24-28/07/2023
Transects (planned/achieved)	21/21
PairoVET stations (planned/achieved)	139
Positive stations (with eggs of target sp)	65
Tot. Eggs	1736
Max eggs/m²	4260
Temp (ºC) min/mean/max	14.90/19.05/23.48
CUFES stations	---
Positive CUFES stations	---
Tot. Eggs CUFES	---
Max eggs/m³	---
CTDF stations	139
SURVEY ADULTS	
Number Hauls R/V	20 (16 for ground-truthing echo-traces + 4 for hydrated females)
Number Hauls C/V	---
Number R/V (+) trawls	12 (9+3)
Date	29 July-08 August
Depth range (m)	20-164
Time range (hh:mm)	7:14-19:42 GMT
Total individuals target species sampled	674
Length range (cm)	7.8-18.8
Weight range (g)	2.5-52.3
Females for histology	416
Hydrated females	103 (preliminary F estimated with 30 hydrated females)

Otoliths	674

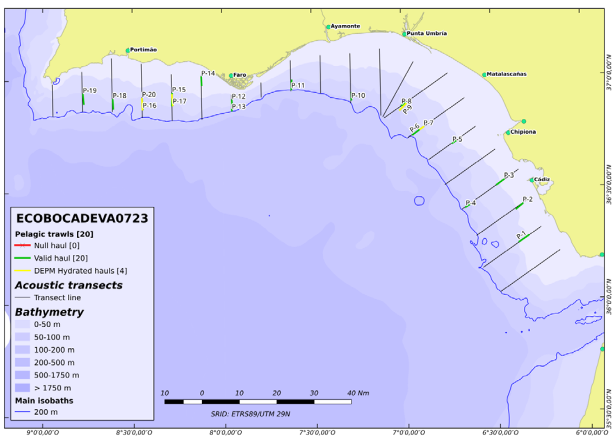
Survey results summary table

Area *(stratum)*	**ICES 9.a South**
Survey area (Km²)	13261
Positive area (Km²)	5662
Z (hour⁻¹)(CV%)	-0.1228 (0.45)
P_0 (eggs/m²/day)(CV%)	181.9 (0.54)
$P_{0\ tot}$ (eggs/day) (x10¹²) (CV%)	1.03 x10¹² (0.54)
Female Weight (g) (CV%)	17.64 (0.25)
Batch Fecundity (CV%)	9515 (0.14)
Sex Ratio (CV%)	0.52 (0.02)
Spawning Fraction (CV%)	0.248 (time-series average)
Daily Fecundity (eggs/day.g female)	---
Spawning Biomass (tons) (CV%)	15138 (0.62)

Survey map of plankton stations



Survey map of fishing stations



ECOCADIZ 2023-07

Survey Summary Table WGACEGG 2023	
Name of the survey (abbreviation):	Spanish summer acoustic-trawl survey in the Gulf of Cadiz (*ECOCADIZ). ECOCADIZ 2023-07*.
Target Species:	Anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*) and chub mackerel (*Scomber colias*). Acoustic estimates are also regularly provided for Atlantic mackerel (*S. scombrus*), horse mackerel species (*Trachurus trachurus*, *T. mediterraneus*, *T. picturatus*) and bogue (*Boops boops*). Estimates for round sardinella (*Sardinella aurita*), blue whiting (*Micromesistius poutassou*), boarfish (*Capros aper*), longspine snipefish (*Macrorhamphosus scolopax*) and pearlside (*Maurolicus muelleri*),when present.
Survey dates:	Initially not planned to be conducted in 2023. Finally was conducted between 29th July and 8th August, just after the *BOCADEVA* Anchovy DEPM triennial survey.
Summary:	

The *ECOCADIZ 2023-07* Spanish (pelagic ecosystem-) acoustic-trawl survey was the acoustic component of a combined anchovy egg (*BOCADEVA*) and acoustic-trawl (*ECOCADIZ*) *ad hoc* survey (*ECO/BOCADEVA_0723* survey), which were performed one after the other, the egg survey first. The survey was conducted between 29th July and 8th August 2023 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz (GoC) onboard the R/V *Ramón Margalef*. This year's survey was marked by a reduction of 3-4 days to the usual survey length (ca. 14 days at sea), due to the R/V tight schedule. The survey's main objective is the acoustic assessment and mapping of the main pelagic fish resources and the biological and oceanographic conditions of the GoC continental shelf, but also provided anchovy adult samples and extra biological samplings for the application of the DEPM.

The 21 foreseen acoustic transects were sampled. A total of 16 valid fishing hauls were carried out for echo-trace ground-truthing purposes. Chub mackerel, anchovy and sardine were the most frequent captured species in the fishing hauls, followed by horse mackerel and Atlantic mackerel. Mediterranean horse mackerel and pearlside showed an incidental occurrence in the hauls performed in the surveyed area. Chub mackerel and anchovy showed the highest yields in these hauls, followed by sardine, horse mackerel and longspine snipefish. Total estimates of total NASC allocated to the "pelagic fish species assemblage" in this survey were 47% lower than those recorded in 2020. GoC anchovy was found more frequently in Spanish waters, with the areas of high densities being observed between Punta Umbria and Bay of Cádiz. Anchovy acoustic estimates in summer 2023 were of 1479 million fish and 9 714 tonnes, accounting for 71% and 78% decreases in abundance and biomass, respectively, as compared to 2020 estimates and they are slightly below their time-series averages. GoC sardine was widely distributed all over the surveyed area in summer 2023 with high density areas being recorded in the inner-shelf parts of the GoC. Sardine abundance (2294 million fish) and biomass (62 216 t) estimates increased (19% in abundance and 22% in biomass), when compared to 2020 estimates, but with no increasing or decreasing trend clearly detected. Spanish waters

recorded relatively low population levels mainly supported by small sardines. Chub mackerel was restricted to the area between Cape San Vicente and Cape Santa María, where high density areas were recorded, whereas in the rest of the surveyed areas was almost absent. Chub mackerel estimated biomass and abundance were 89 million fish and 11 762 t, which were 57% and 64% lower than 2020 estimates. This year's abundance and biomass were well below the time series average.	
	Description
Survey design	Systematic design of a grid of 21 8-nm inter-spaced parallel transects normal to the shoreline, between 20 and 200 m depth, including both GoC Portuguese and Spanish waters. Acoustic sampling is carried out during day-light, starting in the easternmost transect. Acoustic Elementary Distance Sampling Unit (EDSU)= 1 nm. Average survey duration= 14 days (calibration in the previous consecutive MEDIAS survey). EK 80 echo-sounder working at 18, 38, 70, 120, 200 kHz. 38 kHz as reference frequency for biomass estimation.
Index Calculation method	Biomass and abundance per species are calculated at the post-stratification region level only. A mean NASC value (arithmetic mean) is calculated in post-stratification regions with homogeneous species composition. Post-stratification regions are defined as areas where trawl hauls display non significantly different averages in their Length Frequency Distributions (LFD), according to Kolgomorov-Smirnov test. Hauls LFDs and scrutinized NASC of the target species are averaged within post-stratification regions. The products of TS by size class and NASC values per species per regions are multiplied by the region area to calculate fish biomass estimates. Estimates of abundance and biomass at length and age are then derived for each species and region. Numbers are converted into biomass through a length–weight relationship. Methodology described in Doray, M., Van Der Kooij, J., Boyra, G. (Eds.), 2021. ICES Survey Protocols - Manual for acoustic surveys coordinated under the ICES Working Group on Acoustic and Egg Surveys for Small Pelagic Fish (WGACEGG). https://doi.org/10.17895/ICES.PUB.7462
Random/systematic error issues	Echo-sounder properly calibrated. This year it was calibrated several weeks before, taking the advantage of the presence of the R/V in the study area. Background-noise levels are usually recorded during the survey, but it was not possible this year because time constraints. Target strength values are not specific for each of the assessed species. Acoustic backscattering is allocated to different fish species by taking into account the species composition of trawl samples (subjective method and not testable for bias). Spatial coverage of identification trawls usually very high (0.06 haul/nm), but this year was lower (16 hauls; 0.05 haul/nm) because the shortage of the available ship-time. Fish avoidance not tested, but R/V assumed as a relatively "silent" vessel following ICES recommendations (Mitson, 1995; Mitson & Knudsen, 2003). Post-stratification regions, where species/size compositions and echo-integrals are supposed homogeneous, are defined to estimate total fish biomass. Homogeneity in species-specific length frequency distributions is tested with KS test. For the time being, acoustic estimates (i.e. indices) are provided without any

	measure of uncertainty. Mitson RB. 1995. Underwater noise of research vessels: review and recommendations. *ICES Cooperative Research Report*, 209, 61 pp. Mitson RB, Knudsen H.P. 2003. Causes and effects of underwater noise on fish abundance estimation. *Aquatic Living Resources*, 16 (3): 255-263 .
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	*Time-series:* Hull mounted transducers at 6.5 m depth, downward facing. Upper integration limit set at 10 m depth. Background-noise levels are recorded during the survey with transmitters disabled during an exercise of passive echosounder operations at different increasing propeller blade regimes (i.e. different speeds; 0-10 knots) and two contrasting depths. Post-processing corrections of the estimated background noise levels are considered in the EchoView multi-frequency algorithms (masks) used for echograms scrutinizing (De Robertis and Higginbottom, 2007). *Survey Year specific*: No exercise to evaluate the background noise levels was carried out during the survey because time constraints. De Robertis, A., Higginbottom, I. 2007. A post-processing technique to estimate the signal-to-noise ratio and remove echosounder background noise. *ICES Journal of Marine Science*, 64: 1282–1291.
Extinction (shadowing)	*Time-series:* Shadowing effect has not been properly assessed in dense schools of the assessed species, but no clear attenuation of echoes from deeper cells of these schools seems to have clearly been detected. In any case, the most recent echosounders (EK 500, EK60, EK 80), which have a wide dynamic range, do not saturate — even at very high densities (Bodholt *et al*., 1989; de Moor *et al*., 2008; Coetzee *et al*., 2008). *Survey Year specific*: NA. Bodholt H, Nes H, Solli H. 1989. A new echo sounder system. *Proceedings of the Institute of Acoustics* (UK) 11: 123–130. de Moor CL, Butterworth DS, Coetzee JC. 2008. Revised estimates of abundance of South African sardine and anchovy from acoustic surveys adjusting for echosounder saturation in earlier surveys and attenuation effects for sardine. *African Journal of Marine Science* 30(2): 219–232. Coetzee JC, Merkle D, de Moor CL, Twatwa NW, Barange M, Butterworth DS.2008. Refined estimates of South African pelagic fish biomass from hydro-acoustic surveys: quantifying the effects of target strength, signal attenuation and receiver saturation. *African Journal of Marine Science* 30(2): 205–217.
Blind zone	*Time-series:* Hull mounted transducers at 6.5 m depth, downward facing. Upper integration limit set at 10 m depth. *Survey Year specific*: NA.
Dead zone	*Time-series:* A 0.1 m offset is added to the bottom line detected by the transducers. *Survey Year specific*: NA.

Allocation of backscatter to species	Expert echogram scrutiny is performed at the EDSU scale using Echoview software package. Virtual echograms are generated from multifrequency algorithms (templates) to extract fish echotraces. Allocation mainly based in the species composition of close trawl catches considered representative of the real species composition. Spatial coverage of identification trawls used to be very high (0.06 haul/nm), but slightly lower (0.05 haul/nm) during the 2023 survey because of time constraints. Only in a few cases of clearly identifiable individual schools the direct allocation to the species, based on the expert judgment, is applied.
Target strength	Species-specific b20 values are listed in Table A2.2 in Massé *et al*. (2018) and Table 3.12 in Doray *et al*. (2021). TS values are not species-specific. Anchovy and sardine: -72.6; chub mackerel and *Trachurus* spp.: -68.7; mackerel: -84.9. Massé, J., Uriarte, A., Angelico, M. M., and Carrera, P. 2018. Pelagic survey series for sardine and anchovy in ICES subareas 8 and 9 (WGACEGG) – Towards an ecosystem approach. *ICES Coop. Res. Rep*., 332, 268 pp. Doray, M., Boyra, G., and van der Kooij, J. (Eds.). 2021. ICES Survey Protocols – Manual for acoustic surveys coordinated under the ICES Working Group on Acoustic and Egg Surveys for Small Pelagic Fish (WGACEGG). 1st Edition. ICES Techniques in Marine Environmental Sciences Vol. 64. 100 pp. https://doi. org/10.17895/ices.pub.7462
Calibration	Acoustic equipment used to be calibrated during the previous IEO survey (MEDIAS) following the ICES standard procedures (Demer *et al*., 2015; see also Foote *et al*., 1987), but this year was calibrated some weeks before in the same survey area taking the advantage of the presence of the R/V in the study area. Demer, D.A., Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., *et al*. 2015. Calibration of acoustic instruments. *ICES Coop. Res. Rep*, 326, 133 pp. Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan, E.J. Simmonds, 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. *ICES Coop. Res. Rep*., 144, 57 pp.
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	*Time-series:* The timing and spatial coverage of the *ECOCADIZ* survey has been defined to achieve stock containment of target species whose survey indices are used in analytical stock assessment (anchovy, sardine) at the mesoscale of the survey (and stocks). Containment is consistently achieved at the survey mesoscale, for anchovy (southern component of ane.27.9.a). For sardine (pil.27.8c9a), the survey only provides a regional index for the sub-division 9a South. These surveys do not capture the actual summer extension of blue whiting, mackerel, horse mackerel, blue jack mackerel, boarfish, snipefish and pearlside because the whole population of these species or a fraction of it (larger fish) are distributed in upper continental slope waters not sampled by the survey. *Survey Year specific*: NA.

Stock ID and mixing issues	*Time-series:* Affinities of the GoC anchovy and sardine with populations further south (NW Moroccan waters) and east (Alboran Sea) probable but not yet confirmed. Adult sardine displacements between 9a S-Algarve and 9a C-S also probable. *Survey Year specific*: NA.
Measures of uncertainty (CV)	Quality Control checks of size and biological samplings incorporated in the IEO's OSB-PELAKAMP open source-open hardware paperless sampling system. Homogeneity in species-specific length frequency distributions is tested with KS test. Only considered those LFDs containing ≥30 individuals.
Biological sampling	*Time-series:* random sample of 50 fish/haul of anchovy, sardine (since 2004 on), *Scomber* spp., *Trachurus* spp. and bogue (since 2007 on). Individual length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content. Otolith dissection in all the sampled anchovy and sardine specimens (chub mackerel since 2019 on). Anchovy (since 2004), sardine (since 2014) and chub mackerel (since 2019) own survey's ALKs. *Survey Year specific*: A complete biological sampling was only performed with anchovy, sardine and chub mackerel, because time constraints and limitations with the expertise of the scientific-technical team and the requirements of the extra anchovy DEPM-based biological sampling.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

JUVENA23

Survey Summary table WGACEGG 2023	
Name of the survey (abbreviation):	JUVENA23
Target Species:	Anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*), spratt (*Sprattus sprattus*), horse mackerel (*Trachurus trachurus*), mackerel (*Scomber scombrus*), chub mackerel (*Scomber colias*) pearlside (*Maurolicus muelleri*), krill (*Euphasiacea*), boarfish (*Capros aper*) and blue whiting (*Micromesistius poutassou*).
Survey dates:	15/08/2023 – 28/09/2023
Summary:	**Cruise Report Link:** http://dx.doi.org/10.13140/RG.2.2.12646.40003

The project JUVENA aims at estimating the abundance of the pelagic community, with emphasis on anchovy juvenile population as an early estimator of recruitment, with trawl-acoustic methodology in the Bay of Biscay at the end of the summer every year. The survey is coordinated between AZTI and IEO. AZTI leads the assessment studies and IEO leads the ecological studies. The survey took place in two research vessels: the Angeles Alvariño (AA) and the Emma Bardán (EB). It took place between the 2023-08-15 and the 2023-09-28. The survey sampled around 2036 n.mi. that provided a coverage of about 36,652 n.mi.2 along the continental shelf and shelf break of the Bay of Biscay, from the 7º22′ W in the Cantabrian area up to 47º 65′ N at the French coast. 91 hauls were done during the survey to identify the species detected by the acoustic equipment, 57 of which were positive for **anchovy**. The biomass of juvenile anchovy estimated this year is around 531,000 tons, which represents a high estimation. The mean size of anchovy was 7.4 cm long, lower than in 2022 but still above the average. The mean weight and length of juvenile anchovy has decreased since last year, but the values are still above the mean. As usual, most of this biomass was located off-the-shelf or in the outer part of the shelf in the Cantabrian Sea, but on the French shelf this year was different from last year in that it was concentrated in the more coastal area of the shelf and was not observed in the more oceanic area. The biomass of adult anchovy was 73,000 tonnes, a bit lower than the mean of the temporal series. The combination of both results foresees a healthy and sustainable status of the overall anchovy stock for the next year.

Sardine was mainly distributed between 45 and 47ºN, well close to the French coast, specially near the Garonne and Loire river plumes, as expected from the temporal series. Some sardine was also observed in the Cantabrian Sea, but remarkedly less than in the previous year. The biomass of sardine was ~133,000 tones, still among the highest values of the temporal series (Figure 8). The mean length and weight of sardine experienced a continuous decrease for 5 years, from 2011-2016, but a succession of highs and lows along the following years describe a general increasing trend of the means reaching 28 gr and 15 cm of length this year, but still under the mean of the temporal series.

Horse mackerel this year was mainly found all along the French shelf, concentrated along the coast specially under the riverine influences, but close to the bathymetry of 200 m. Some horse mackerel was also present in the westernmost part of the Cantabric Sea, with smaller presence towards the eastern part of the Spanish coast. The biomass was ~82,000 tones, following the increasing trend already observed last year and near the average of the time series. Mean length and weight have increased from last year contributing to the increasing tendency that has been observed for the last 3 years. **Mackerel** was found in very small quantities and sizes of ~16 cm along the French coast. The biomass ~12,500 tones, seems to have decreased from last year and stays well below the average. The mean length and weight have decreased considerably since last year. **Boarfish** has dropped since last year, although it is still visible around the French shelf. The biomass this year was ~18,000 tonnes. **Sprat** was found as usual distributed along the French platform, mainly close to the coast. The biomass decreased from last year to 153 tons and stays well below the average. The mean length and weight have increased considerably since last year, probably due to a failure of recruitment. **Pearlside** was distributed off and at the outer shelf in both the Spanish and French coasts. The biomass was around 180,000 tonnes, recovering from last years′ drop. The mean length and weight seem to have decreased compared to last year in a general decreasing trend since the start of the temporal series in 2013.

	Description
Survey design	The sampling area covered the waters of the Bay of Biscay (being 7º22′ W and 47º39′ N the limits). Sampling started with the R/V EB at the Southwesternmost part of the sampling area, in Galician waters, moving gradually to the East and covering only partially the southern part of the French area. The R/V AA covered the waters in front of the French Coast. The acoustic sampling was performed during the daytime, when the juveniles are supposed to aggregate in schools (Uriarte 2002 FAIR CT 97-3374) and can be distinguished from plankton structures. Both vessels followed parallel transects, spaced 18 n.mi., perpendicular to the coast along the sampling area, taking into account the expected spatial distribution of anchovy juveniles for these dates, that is, crossing the continental shelf in their way to the coast from offshore waters (Uriarte et al. 2001; Boyra et al., 2016). Details of the sampling design and data analysis can be found in Boyra et al., 2013 and Boyra, 2016.
Index Calculation method	No changes with respect to last year, details in Boyra *et al*., 2013; Doray *et al*., 2021. Data uploaded to the ICES Trawl acoustic portal.
Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	NA. Under bad weather conditions we pause the survey.
Extinction (shadowing)	No such high densities of fish are usually observed.
Blind zone	Transducers are located at the drop keel, looking downwards at 6.5 m from the surface. Since juvenile anchovy is often observed at shallower layers, scrutinization of the shallower layers is done with the aid of a 333 kHz transducer (reduced blind zone) installed in a lateral perch at 2 m depth vertically oriented, and a multibeam lateral sonar MS70. These measurements are used to calculate a correction factor to account for the individuals in the blind zone of the transducers located in the keel.
Dead zone	A 0.5 m offset is added to the bottom line detected by the transducers.
Allocation of backscatter to species	Directed trawling was performed for verification purposes. The composition by size and species of each homogeneous stratum is obtained by averaging the composition of the individual hauls contained in the stratum, being the contribution of each haul weighted to the acoustic energy found in the vicinity (2 nm of diameter). Only in a few cases of clearly identifiable individual schools the direct allocation to the species, based on the expert judgment, is applied. Expert echogram scrutiny is performed at the EDSU scale using Echoview software package. Virtual echograms are generated from multifrequency algorithms to extract fish echotraces.

Target strength	Species-specific b_{20} values are listed in Table A2.2 in Massé *et al.* (2018). TS values are not species-specific. Anchovy and sardine: -72.6 dB; chub mackerel and Trachurus spp.: -68.7 dB; mackerel: -84.9 dB; pearlside: -71.4 dB
Calibration	Calibration of the acoustic equipment at the end of the survey following the ICES standard procedures (Demer et al., 2015). All results within recommended tolerances (RMS<0.4). Intercalibration between 2 vessels: not performed this year
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	*Time-series:* The timing and spatial coverage has been defined to achieve stock containment of target species at the mesoscale of the survey (and stocks). Containment is then consistently achieved for target species whose survey indices are used in analytical stock assessment (mainly anchovy and sardine). Where possible, JUVENA survey timings are coordinated with CSHAS, PELTIC, IBERAS and ECOCADIZ-RECLUTAS within WGACEGG to ensure a quasi-synoptic sampling of the European continental shelf from Portugal to the Celtic Sea, although logistics, such as vessel availability affect this. The combination of semi-adaptive strategy and coordination with other autumn surveys assure containment for anchovy and sardine. *Survey Year specific*: this year additional analysis showed significant relationship between the time series of sardine from PELGAS and JUVENA.
Stock ID and mixing issues	Bay of Bicay anchovy is now mixing in the middle of the English Channel with overwintering southern North Sea anchovy
Measures of uncertainty (CV)	CV estimates of 22/23 have been calculated according to TIMES (Doray *et al.*, 2021) and are currently being validated. This year, an exhaustive revision of the formulation has been carried out to definitively establish the common methodology for obtaining CV in all campaigns.
Biological sampling	Good sampling carried out for anchovy. Pearlside is sub-sampled because of their escaping abilities from the net. Samples are enough to get size distribution of the species. In the last years, the number of sardine catches have increased ~25%.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

IBERAS23

Survey Summary Table WGACEGG 2023	
Name of the survey (abbreviation):	IBERAS23
Target Species:	Recruitment of the Iberoatlantic stock Sardine (*Sardina pilchardus*) and Anchovy (*Engraulis encrasicolus*)
Survey dates:	1st leg: 12th September – 17st September 2023 2nd leg: 19th September – 25th September 2023
Summary:	

IBERAS0923 was carried out on board R/V Ramón Margalef, first leg from 12th to 17th September, and second leg from the 19th to the 25th September 2023. Calibration of the acoustic equipment tool place on the 18th September in las Rias (Galicia, Spain).

The survey´s main objective is the acoustic assessment of sardine and anchovy juveniles (age 0 fish) in the Iberian west coast recruitment areas. Weather conditions were in general good.

During the survey 25 pelagic trawl hauls were performed for the research vessel and this year because of the short calendar period available for the vessel in IBERAS0923, there was a participation of 1 purse-seiners in the second leg, which performed 12 fishing operations, which were used to ground-truth the fish community and the length/age distribution of each species. The main species present in most of the fishing stations were sardine, anchovy, mackerel and horse mackerel.

As main result, biomass estimates for adult sardine (individuals >16.0cm) achieved 339674 metric tonnes that corresponds to $6.8*10^9$ fish. The most representative was age group 1, which accounted for 29913 metric tonnes ($2.8*10^9$ fish), confirming the strength of the 2022 cohort. 2023 was very low and the centre of gravity was found around Figueira da Foz, with a large dispersion. Overall, IBERAS is providing a good indicator of the strength of the sardine recruitment for the iberoatlantic stock.

Biomass estimates for adult anchovy (individuals >12.0cm) was 56414 metric tonnes that corresponds to $1.6*10^9$ fish.

Age group 0 counts with 88429 metric tonnes ($2.19*10^9$ fish), age group 1 with 56414 metric tonnes ($1.6*10^9$ fish). Anchovy was mostly found in the Northern part (9aN and 9aCN). As general, the center of gravity was found in 9aCN area.

	Description
Survey design	The survey covered 8cW, 9aN, 9a CN and the northern of 9aCS (e.g. western coast of the Iberian Peninsula, since Fisterra Cape until Sines Cape) on a survey design consisting in parallel tracks 6 nmi apart, with random start, and covering from 20-15 m depth up to 100 m. This zone coincides with the main potential distribution area of sardine recruitment of the Iberoatlantic stock. Moreover, in the main recruitment area (e.g. middle part of 9aCN) sampling intensity has been increasing up to 4 nmi among transects.
Index Calculation method	Acoustic equipment consisted of a Simrad EK-80 scientific echosounder, operating at 18, 38, 70, 120 and 200 kHz, working in CW mode. The elementary sampling distance unit (EDSU) was fixed at 1 nm. Acoustic data

	were obtained only during daytime at a survey speed of 8-10 knots, although, some tracks were also steamed at night. Data were then stored in raw format and post-processed using SonarDataEchoview software (Myriax Ltd.) (Higginbottom et al, 2000). All echograms were first scrutinized, the bottom line incorporated, and background noise was also removed according to De Robertis and Higginbottom (2007). Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002), although echograms from 18, 70, 120 and 200 kHz frequencies were used to visually discriminate between fish and other scatterproducing objects such as plankton or bubbles, and to distinguish different fish species according to the frequency response. The 18, 70, 120 and 200 kHz frequencies were used to create a mask allowing a better discrimination between swimbladder fish species and other organisms. The threshold used to scrutinize the echograms was –70 dB. The integration values were expressed as nautical area scattering coefficient (NASC) units or sA values (m2 nm-2) (MacLennan et al., 2002).
Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys.
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	NA, good weather dominated the survey
Extinction (shadowing)	Not observed during the survey.
Blind zone	Drop-keel mounted transducers at 6.5 m depth, downward facing. Upper integration limit set at 10 m depth.
Dead zone	A 0.5 m offset is added to the bottom line detected by the transducers.
Allocation of backscatter to species	When possible, direct allocation was done, accounting for the shape of the schools and also the relative frequency response (Korneliussen and Ona, 2003, De Robertis et al, 2010). For all school candidates, several of variables were extracted, among them the NASC (sA, m^2 /nmi^2) together with the proportioned region to cell (ESDU, 1 nmi) NASC and the sV mean and sV max and geographic position and time. PRC_NASC values were summed for each ESDU and distances were referenced to a single starting point for each transect. Results for 38 and 120 kHz were compared. Besides, the frequency response for each valid school (i.e. those with length and sV which allows them be properly measured) was calculated as the ratio sA(fi)/sA(38), being fi the sAvalues for 18, 70, 120 and 200 kHz.
Target strength	Species-specific b20 values are listed in Table 2.12 in Doray *et al*. (2021). Anchovy and Sardine: -72.6. For more information please check the following literature: Doray, M., Boyra, G., and van der Kooij, J. (Eds.). 2021. ICES Survey Protocols – Manual for acoustic surveys coordinated under the ICES Working Group on Acoustic and Egg Surveys for Small Pelagic Fish (WGACEGG). 1st Edition. ICES Techniques in Marine Environmental Sciences Vol. 64. 100 pp. https://doi. org/10.17895/ices.pub.7462

Calibration	All frequencies were calibrated according to the standard procedures (ICES-CRR326) during the first two days, following the ICES standard procedures (Demer *et al*., 2015; see also Foote *et al*., 1987). Demer, D.A., Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., *et al*. 2015. Calibration of acoustic instruments. *ICES Coop. Res. Rep,* 326, 133 pp. Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan, E.J. Simmonds, 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. *ICES Coop. Res. Rep*., 144, 57 pp.
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	The main distribution area of sardine was located in 9aN close to the mouth of Ria de Muros (~42.5°N) and in 9aCN between Porto and Figueira da Foz, being similar to the pattern observed years before, but with scarcer presence. The mean depth for sardine was 27 metres. In 9aCS the main concentration was observed around Ericeira (~38.5°N). For the anchovy, the main distribution area was in 9aCN between Aveiro and Figueira da Foz, as usual.
Stock ID and mixing issues	Presence of fixed commercial fishing gears or irregular and rocky bottoms: it was not possible to perform hauls in some areas. Potential mixing between anchovy, sardine and chub mackerel in some specific areas can be a reality, so the energy allocation to the species considering the closest trawl haul(s) (relative species composition) may underestimating one specie over another. Reduced number of survey days available: 1 purse-seiners was hired to perform additional fishing operations to help in the sampling and validation of acoustic targets, assisting the fishing activities of the Research Vessel in more coastal areas of the Portuguese coast; the 100 meters slope wasn`t well covered and also in 9aCS south Sines wasn`t covered.
Measures of uncertainty (CV)	Acoustic data are checked using taylor-made routines before biomass estimation. Biomass per echotype and species, internal consistency checks (mean weight, total abundance vs. sum of at length abundances, comparison of mean weights calculated with different methodologies)
Biological sampling	Biological sampling of sardine and anchovy was performed in each fishing station, whenever the species was captured. Subsamples of 100 individuals per haul and species to collect weight-at-length, age, and other biological data.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*

Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

PELTIC 2023

Survey Summary table WGACEGG 2023	
Name of the survey (abbreviation):	PELTIC (UK)
Target Species:	Sardine , Sprat, Anchovy
Survey dates:	28 September – 31 Octcober, 2023

Summary: **Cruise Report Link:** Inventory of UK research cruises maintained by BODC from ROSCOP forms

All survey objectives were successfully met. Survey timing, coverage (area), acoustic sampling (2109 nautical miles) and number of trawls (n=42) were comparable to the most successful previous years. As was the case in 2020 and 2021, PELTIC was extended into Cardigan Bay. The survey started in the north (Swansea) and worked down, around the Isles of Scilly and into the western English Channel eastwards. On average the sea surface temperatures were 2 °C warmer than the long term average.

Sardine total biomass was the highest of the time series series at 456,482 t (CV 0.19). Sardine was widely distributed as in previous years although this year two main two hotspots were observed, one around the Isles of Scilly and one south of the southwestern point of Cornwall. These included the largest sardines in the survey area and the large numbers of eggs found in plankton samples at both sites suggested these were primarily spawning aggregations. Higher than usual numbers also found in the Bristol Channel and in Cardigan Bay. Some of the smallest sardines were found in French waters.

The 2023 sprat biomass in the western Channel of 61,270 t (CV 0.53) was the second highest in the time series since 2016. As has been observed in last few years, the total biomass was primarily made up of 0-group sprat.

Anchovy biomass in area in 2023 was 243,392 t (CV 0.22), approximately five times the previous highest estimate (2021), continuing an increasing trend. While some of the highest densities were found in the Eddystone Bay, anchovy was widespread throughout the survey area, including in the Bristol Channel. As was observed in 2019 and 2020, in 2023 again large numbers of surface and mid-water schools of juvenile anchovy were found off the Brittany coast, from the Isle of Ouessant in the west to the Channel Islands in the east of the survey. These fish are very likely Bay of Biscay fish moving into the Channel. This new scenario of two stocks mixing in the Channel during the winter is likely to complicate future assessments (van der Kooij et al., in prep).

The same vessel was used although the echosounder system had been upgraded to EK80 with five operating frequencies..

	Description
Survey design	Stratified systematic parallel design with 10 and 15 nmi inter-transect distance.
Index Calculation method	StoX (V3.6.2) and RStoX (V1.9.0) Data uploaded to the ICES Trawl acoustic portal

Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	Attenuation filter was applied to remove pings affected by poor weather/seas during some survey days; weather contibued to be workable throughout the survey.
Extinction (shadowing)	Not an issue (school backscatter explored in situ for high values >20,000 NASC)
Blind zone	Time-series: survey conducted daylight only to avoid effects of diurnal vertical migration. High pingrate (0.5 s-1) also ensures that surface fish schools just below nearfield are captured acoustically at 10 knots. 2023: juvenile anchovy schools at surface (on French side) may have been undersampled. Most schools seemed to be below the surface deadzone however (exercise comparing biomass in reduced blindzones from higher frequencies confirmed this).
Dead zone	1m; no known issue for target species and bottom line was adjusted for occasional pelagic schools extending into deadzone
Allocation of backscatter to species	Directed trawling for verification purposes
Target strength	Recommended (-71.2 clupeids, -66.2 boarfish; -68.7 horse mackerel; -67.5 gadoids); Mackerel processed at 200 kHz using b20 of 84.03
Calibration	On drift at 0.512 µs for 38, 70, 120 and 200 kHz (333 kHz not done). Results comfortably within recommended parameters (RMS <0.3)
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	Sardine (Celtic Sea); Yes to West and North although no coverage in eastern Channel and possible links with Biscay fish. Sprat (Lyme Bay); questions remain about the link of Lyme Bay sprat to other populations in Channel and beyond although seemingly isolated in autumn. Sprat in Celtic Sea not captured as extending further west (covered by MI, Ireland during CSHAS) .
Stock ID and mixing issues	Time series:Sprat is genetically linked to wider NE Atlantic but population is likely to be split (geographic separation); Sardine is thought to be single stock although likely to be interacting with sardine in Bay of Biscay and southern North Sea; northern anchovy is separate stock. 2023 survey: Strong evidence that post-larval and juvenile anchovy from Bay of Biscay are mixing with northern anchovy in the Channel during

	the survey and contribute to biomass.
Measures of uncertainty (CV)	*CV on abundance* Sardine: 0.16 Sprat (7de): 0.53 Anchovy: 0.23 *Calculation carried out using StoX (V3.6.2) and R-StoX (V1.9.0)
Biological sampling	Good sampling carried out across the key species with details provided in survey report.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

ECOCADIZ-RECLUTAS 2023-10

Survey Summary Table WGACEGG 2023	
Name of the survey (abbreviation):	Spanish autumn acoustic-trawl survey in the Gulf of Cadiz (*ECOCADIZ-RECLUTAS*). *ECOCADIZ-RECLUTAS 2023-10*.
Target Species:	Anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*) and chub mackerel (*Scomber colias*), with special reference to their Age-0 population fractions. Acoustic estimates are also regularly provided for Atlantic mackerel (*S. scombrus*), horse mackerel species (*Trachurus trachurus*, *T. mediterraneus*, *T. picturatus*) and bogue (*Boops boops*). Estimates for round sardinella (*Sardinella aurita*), blue whiting (*Micromesistius poutassou*), boarfish (*Capros aper*), longspine snipefish (*Macrorhamphosus scolopax*) and pearlside (*Maurolicus muelleri*),when present.
Survey dates:	29th September – 13rd October 2023.
Summary:	

The *ECOCADIZ-RECLUTAS 2023-10* Spanish (pelagic ecosystem-) acoustic-trawl survey was conducted by IEO between 29th and 13rd October 2023 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, sardine and chub mackerel juveniles (age 0 fish) in the GoC recruitment areas. The survey dates were forwarded ca. 10 days and shortened 3-4 days regarding the usual dates and duration of the survey. Half a day working day was also invested in picking up a spare fishing gear at land. Furthermore, the end of the survey was anticipated in 1 day because logistic issues. The start and direction of the acoustic sampling had to be shifted to a W to E direction because of the occurrence of NATO navy manoeuvres which also shortened the available time to sample Spanish waters. Notwithstanding the above, the 21 foreseen acoustic transects were sampled. 19 transects (140 CTD-LADCP casts) from the 23-transect sampling grid of oceanographic variables could be finally performed. Census of top predators was also carried out during the survey. A total of 13 valid fishing hauls were carried out for echo-trace ground-truthing purposes (below the historical mean of about 20 hauls per survey). No information on age structure of the resulting estmates is still available.

Horse mackerel, sardine, anchovy and chub mackerel were the most frequent captured species in the fishing hauls, followed by Mediterranean horse mackerel, Atlantic mackerel, bogue and round sardinella were less frequent. Boarfish, longspine snipefish and pearlside showed an incidental occurrence in the hauls performed in the surveyed area, whereas blue-jack mackerel was absent. Hauls' yields were very low, with only occasional high yields of sardine, chub mackerel, Mediterranean horse mackerel and anchovy in some hauls. Total estimates of total NASC allocated to the "pelagic fish species assemblage" in this survey were 21% lower than those recorded in 2022.

GoC anchovy was widely distributed in the GoC, but showing low integration and almost absent in the Cape Santa María area. Densities found in the westernmost Algarve waters were

higher than those recorded ones in spring-summer. Anchovy acoustic estimates in autumn 2023 were of 816 million fish and 8 300 tonnes, accounting for 56% and 30% decreases in abundance and biomass, respectively, as compared to 2022 estimates and they are well below their time-series averages. GoC sardine showed few and weak acoustic detections in central and eastern Algarve and the easternmost Spanish waters, whereas in the remaining Spanish waters the acoustic detections were of a medium integration. Sardine abundance (2v125 million fish) and biomass (27 373 t) estimates increased (96% in abundance and 31% in biomass), when compared to 2022 estimates, but Portuguese waters recorded a very strong decrease and adult large sardines (<16 cm) were almost absent all over the GoC. The bulk of the GoC chub mackerel population was restricted to the western Algarve waters and between Tavira and Punta Umbría-Mazagón. Low integration was recorded in the rest of the Spanish waters. Chub mackerel estimated biomass and abundance were 118 million fish and 8 451 t, which were 52% and 45% lower than 2022 estimates. This year's abundance and biomass were below their time series averages.	
	Description
Survey design	Systematic design of a grid of 21 8-nm inter-spaced parallel transects normal to the shoreline, between 20 and 200 m depth, including both GoC Portuguese and Spanish waters. Acoustic sampling is carried out during day-light, starting in the easternmost transect. Acoustic Elementary Distance Sampling Unit (EDSU)= 1 nm. Average survey duration= 20 days (includes days for echo-sounder calibration). EK 80 echo-sounder working at 18, 38, 70, 120, 200 kHz. 38 kHz as reference frequency for biomass estimation.
Index Calculation method	Biomass and abundance per species are calculated at the post-stratification region level only. A mean NASC value (arithmetic mean) is calculated in post-stratification regions with homogeneous species composition. Post-stratification regions are defined as areas where trawl hauls display non significantly different averages in their Length Frequency Distributions (LFD), according to Kolgomorov Smirnov test. Hauls LFDs and scrutinized NASC of the target species are averaged within post-stratification regions. The products of TS by size class and NASC values per species per regions are multiplied by the region area to calculate fish biomass estimates. Estimates of abundance and biomass at length (all the fish species) and age (anchovy, sardine and chub mackerel) are then derived for each species and region. Numbers are converted into biomass through a length–weight relationship. Methodology described in Doray, M., Van Der Kooij, J., Boyra, G. (Eds.), 2021. ICES Survey Protocols - Manual for acoustic surveys coordinated under the ICES Working Group on Acoustic and Egg Surveys for Small Pelagic Fish (WGACEGG). https://doi.org/10.17895/ICES.PUB.7462
Random/systematic error issues	Echo-sounder properly calibrated. Background-noise levels are recorded during the survey. Target strength values are not specific for each of the assessed species. Acoustic backscattering is allocated to different fish species by taking into account the species composition of trawl samples (subjective method and not testable for bias). Spatial coverage of identification trawls used to be very high (0.06 haul/nm), but in this survey was lower (13 hauls; 0.04 haul/nm) because of time constraints. Fish avoidance not tested, but R/V assumed as a

	relatively "silent" vessel following ICES recommendations (Mitson, 1995; Mitson & Knudsen, 2003). Post-stratification regions, where species/size compositions and echo-integrals are supposed homogeneous, are defined to estimate total fish biomass. Homogeneity in species-specific length frequency distributions is tested with KS test. For the time being, acoustic estimates (i.e. indices) are provided without any measure of uncertainty. Mitson RB. 1995. Underwater noise of research vessels: review and recommendations. *ICES Cooperative Research Report*, 209, 61 pp. Mitson RB, Knudsen H.P. 2003. Causes and effects of underwater noise on fish abundance estimation. *Aquatic Living Resources*, 16 (3): 255-263 .
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	*Time-series:* Drop-keel mounted transducers at 6.5 m depth, downward facing. Upper integration limit set at 10 m depth. Background-noise levels are recorded during the survey with transmitters disabled during an exercise of passive echosounder operations at different increasing propeller blade regimes (i.e. different speeds; 0-10 knots) and two contrasting depths. Background noise was removed fron echograms according to De Robertis and Higginbottom (2007), using the EchoView's Background Noise Removal (BNR) filter. *Survey Year specific*: No specific survey error related with this issue. De Robertis, A., Higginbottom, I. 2007. A post-processing technique to estimate the signal-to-noise ratio and remove echosounder background noise. *ICES Journal of Marine Science*, 64: 1282–1291.
Extinction (shadowing)	*Time-series:* Shadowing effect has not been properly assessed in dense schoolsof the assessed species, but no clear attenuation of echoes from deeper cells of these schools seems to have clearly been detected. In any case, the most recent echosounders (EK 500, EK60, EK 80), which have a wide dynamic range, do not saturate — even at very high densities (Bodholt *et al*., 1989; de Moor *et al*., 2008; Coetzee *et al*., 2008). *Survey Year specific*: No specific survey error related with this issue. Bodholt H, Nes H, Solli H. 1989. A new echo sounder system. *Proceedings of the Institute of Acoustics* (UK) 11: 123–130. de Moor CL, Butterworth DS, Coetzee JC. 2008. Revised estimates of abundance of South African sardine and anchovy from acoustic surveys adjusting for echosounder saturation in earlier surveys and attenuation effects for sardine. *African Journal of Marine Science* 30(2): 219–232. Coetzee JC, Merkle D, de Moor CL, Twatwa NW, Barange M, Butterworth DS.2008. Refined estimates of South African pelagic fish biomass from hydro-acoustic surveys: quantifying the effects of target strength, signal attenuation and receiver saturation. *African Journal of Marine Science* 30(2): 205–217.
Blind zone	*Time-series:* Drop-keel mounted transducers at 6.5 m depth, downward facing. Upper integration limit set at 10 m depth. *Survey Year specific*: No specific survey error related with thi issue.

Dead zone	A 0.5 m offset is added to the bottom line detected by the transducers.
Allocation of backscatter to species	Expert echogram scrutiny is performed at the EDSU scale using Echoview software package. Virtual echograms are generated from multifrequency algorithms (templates) to extract fish echotraces. Allocation mainly based in the species composition of close trawl catches considered representative of the real species composition. Spatial coverage of identification trawls used to be very high (0.06 haul/nm), but in this survey was lower (13 hauls; 0.04 haul/nm) because of time constraints. Only in a few cases of clearly identifiable individual schools the direct allocation to the species, based on the expert judgment, is applied.
Target strength	Species-specific b20 values are listed in Table A2.2 in Massé *et al*. (2018) and Table 3.12 in Doray *et al*. (2021). TS values are not species-specific. Anchovy and sardine: -72.6; chub mackerel and *Trachurus* spp.: -68.7; mackerel: -84.9. Massé, J., Uriarte, A., Angelico, M. M., and Carrera, P. 2018. Pelagic survey series for sardine and anchovy in ICES subareas 8 and 9 (WGACEGG) – Towards an ecosystem approach. *ICES Coop. Res. Rep*., 332, 268 pp. Doray, M., Boyra, G., and van der Kooij, J. (Eds.). 2021. ICES Survey Protocols – Manual for acoustic surveys coordinated under the ICES Working Group on Acoustic and Egg Surveys for Small Pelagic Fish (WGACEGG). 1st Edition. ICES Techniques in Marine Environmental Sciences Vol. 64. 100 pp. [https://doi. org/10.17895/ices.pub.7462](https://doi.org/10.17895/ices.pub.7462)
Calibration	Acoustic equipment wais usually calibrated before the beginning of the survey in the Bay of Algeciras following the ICES standard procedures (Demer *et al*., 2015; see also Foote *et al*., 1987). This year the echosounder was calibrated during the survey, in the Algarve waters. Demer, D.A., Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., *et al*. 2015. Calibration of acoustic instruments. *ICES Coop. Res. Rep*, 326, 133 pp. Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan, E.J. Simmonds, 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. *ICES Coop. Res. Rep*., 144, 57 pp.
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	*Time-series:* The timing and spatial coverage of the *ECOCADIZ-RECLUTAS* surveys have been defined to achieve stock containment of target species whose survey indices are used in analytical stock assessment (anchovy, sardine) at the mesoscale of the survey (and stocks). Containment is consistently achieved at the survey mesoscale for anchovy adults (southern component of ane.27.9.a), and for anchovy and sardine recruits. Spanish coastal waters of GoC are the main (anchovy) or very important (sardine) recruitment areas within its respective stocks. For sardine adults (pil.27.8c9a), the survey only provides a regional index for the sub-division 9a South. These surveys do not capture the actual autumn extension of blue whiting, mackerel, horse mackerel, blue jack mackerel, boarfish,

	snipefish and pearlside because the whole population of these species or a fraction of it (larger fish) are distributed in upper continental slope waters not sampled by the survey. The 2012 survey only sampled the Spanish waters. The 2017 survey only sampled the 7 easternmost transects from the Spanish waters because R/V breakdown. No survey in 2013. *Survey Year specific*: NA.
Stock ID and mixing issues	*Time-series:* Affinities of the GoC anchovy and sardine (especially fishes inhabiting the Spanish waters) with populations further south (NW Moroccan waters) and east (Alboran Sea) probable but not yet confirmed. Adult sardine displacements between 9a S-Algarve and 9a C-S also probable. *Survey Year specific*: NA.
Measures of uncertainty (CV)	Quality Control checks of size and biological samplings incorporated in the IEO's OSB-PELAKAMP open source-open hardware paperless sampling system. Homogeneity in species-specific length frequency distributions is tested with KS test. Only considered those LFDs containing ≥30 individuals.
Biological sampling	*Time-series:* random sample of 50 fish/haul of anchovy, sardine, *Scomber* spp., *Trachurus* spp. and bogue (since 2014). Individual length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content. Otolith dissection in all the sampled anchovy and sardine specimens (chub mackerel since 2019 on). Anchovy, sardine and chub mackerel own survey's ALKs. *Survey Year specific*: No specific survey error related with this issue. Age structure of the acoustic estimates from these species was not yet available to WGACEGG 2023. They are expected to be presented in WGHANSA-1 2024.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

Annex 3: Working Documents-Other Topics

Working documents of the WGACEGG 2023 meeting are available at:

Doray Mathieu, Duhamel Erwan, Huret Martin (2023). **Comparison of ICES WGACEGG acoustic and egg-based fish biomass indices**. ICES WGACEGG 2023 Working Document. https://doi.org/10.13155/97286

Annex 4: List of Presentations

A. *Survey presentations:*

1. **Sardine DEPM23 – IPMA (PT-DEPM-PIL) (Area 27.9a: S & W)**
   Maria Manuel Angélico, Elisabete Henriques, María de Carmo Silva, Pedro Pechirra, Cristina Nunes, Paz Díaz
   (see section 4.1.4.3 and Annex 2)
2. **SAREVA 0423 – Sardine DEPM 2023: ICES 9.a North and 8.c**
   Paz Diaz, Antonio Solla, Dolores García, Elena Tel and Rosario Dominguez-Petit
   (see section 4.1.4.3 and Annex 2)
3. **SARDINE DEPM 2023 IBERIAN PENINSULA – pil.27.8c9a – INPUT TO WGHANSA**
   Paz Diaz Conde, Rosario Dominguez-Petit, Cristina Nunes, M. Manuel Angelico
   (see section 4.1.4.3 and Annex 2)
4. **PELAGO23 Acoustic survey ICES 27.9.a (Caminha – Cape Trafalgar)**
   Ana Moreno, Anxo Conde, Pablo Carrera, Diana Feijó, Elisabete Henriques, Hugo Mendes, Paulo B. Oliveira, Nuno Oliveira, Joao Pastor, Silvia Rodriguez, Dina Silva, Jose Antonio Vazquez, Maria Manuel Angélico
   (see section 4.1.4.1 and Annex 2)
5. **PELACUS 0423 Acoustic assessment survey in NW-Iberian waters**
   Pablo Carrera, Silvia Rodriguez, …
   (see section 4.1.1.2 and Annex 2)
6. **IBERAS 0923 Acoustic assessment in Iberian waters of the sardine and anchovy recruitment**
   Pablo Carrera, Ana Moreno, Anxo Conde, Silvia Rodriguez, …
   (see section 4.1.1.6 and Annex 2)
7. **Preliminary estimate of Gulf of Cadiz Anchovy Spawning Stock Biomass in 2023 by the DEPM (ECO-BOCADEVA 23.9.a S)**
   MP. Jiménez, F. Ramos, J. Tornero, C. Gonzalez, P. Diaz and I. Franco
   (see section 4.1.1.3 and Annex 2)
8. **Preliminary results from the ECOCADIZ 2023-07 Spanish acoustic-trawl survey (29 July - 08 August 2023)**
   Fernando Ramos, Jorge Tornero, José A. Canseco, Ana Juárez, Ignacio Franco, Ricardo Sánchez-Leal
   (see section 4.1.1.4 and Annex 2)
9. **Preliminary results from the ECOCADIZ-RECLUTAS 2023-10 Spanish acoustic-trawl survey (29 September – 13 October 2023)**
   Fernando Ramos, Pilar Córdoba, Jorge Tornero, José A. Canseco, Miguel Cojan, Isabel Bruno, Carmen González, Jose A. Martínez, Venicio Pita and Ricardo Sánchez-Leal
   (see section 4.1.1.5 and Annex 2)
10. **BIOMAN 2023 survey Report**
    María Santos Mocoroa, Bea Beldarrain, Udane Martinez, Carlota Pérez, Leire Citores, Amaia Astarloa, Iñaki Rico, Leire Ibaibarriaga and Andrés Uriarte
    (see section 4.2 and Annex 2)
11. **PELGAS23 Acoustic survey – Abundance indices by acoustics in the Bay of Biscay**
    E. Duhamel, M. Doray, JB. Romagnan, M. Huret, F. Sanchez, L. Bonniec, ...
    (see section 4.1.5.1 and Annex 2)
12. **JUVENA 2023 Survey Report**

Guillermo Boyra, Beatriz Sobradillo, Iñaki Rico, Udane Martínez, Amaia Astarloa, Carlota Perez, Ainhoa Arévalo, Arnaitz Muguerza, Maite Cuesta, Beñat Iglesias, Jose Luis Murcia, Itziar Munuera, Teresa Granell, Lara Sánchez, Irene Cuerva and Enrique Nogueira
(see section 4.1.5.3 and Annex 2)

13. **PELTIC 2023**

Jeroen van der Kooij, Fabio Campanella, Jo Silva
(see section 4.1.3.1 and Annex 2)

14. **Celtic Sea Herring Acoustic Survey 09-29th Oct 2023 – (Very) Preliminary results**

Ciaran O'Donnell
(see section 4.1.8 and Annex 2)

15. **WESPAS 2023**

Ciaran O'Donnell
(see section 4.1.9-10 and Annex 2)

B. *Presentations on other topics*

1. **ICES Acoustic database**

Hjalte Parner
During WGACEGG 2023 annual meeting, a small session on ICES Acoustic Trawl Data Portal and Database where completed. The presentation leading up to the discussion can be found at:

https://community.ices.dk/ExpertGroups/wgacegg/2023%20Meeting%20Documents/05.%20Presentations/ICES%20Acoustic%20Data%20Portal%20-%20WGACEGG%202023.pptx.

In summary, the ICES Acoustic Trawl Data Portal at https://acoustic.ices.dk provide an interface which enables users to validate and upload processed acoustic backscatter and biotic trawl data into ICES Acoustic Trawl Database. Documentation of both the acoustic and biotic format as well as the submission procedure can be found at the portal link:

https://www.ices.dk/data/Documents/Acoustic/ICES_Acoustic_data_format_description.zip.

In order to get started submitting data for a given survey, the survey in question needs to be defined within the list of currently recognised acoustic trawl survey at https://vocab.ices.dk/?codetypeguid=e760b02c-90af-494c-8c19-658c5de875ee hosted within ICES vocabulary server at https://vocab.ices.dk which also contains the other vocabularies used within the formats. In case of any questions towards the acoustic trawl data portal, please contact acoustic@ices.dk

2. **Introduction to SmartDots**

Carlos Pinto
SmartDots is a platform for quality assurance of biological parameters as input for stock assessment. It was launched in 2018 and has since been developed by The ICES Working Group on SmartDots Governance (WGSMART) who oversee all improvements and ensure all developments are in line with the ICES quality assurance framework (QAF). SmartDots has become a core tool in calibration and training of technicians across national laboratories, supporting the standardisation of procedures and data output. There are a number of modules which are interlinked; the software where images are annotated, a database where all images and associated data are stored, a web application which communicates between the two and

serves as a management site for users, and a reporting module which produces a report template based on a standardised statistical analysis run from an r-script. It is hosted at ICES and currently has 862 users registered from 45 countries.

ICES develop additional SmartDots software modules to host a fish larvae and an egg identification module and to provide user training for these modules. These two modules were developed individually, but relied on the work done for the age reading module. The age reading module served as a template for how to further develop the egg and larvae modules, both in a technical sense but also in a wider sense where the benefits of the improvements accredited to SmartDots are extended into management and advice processes.

These two new modules of fish larvae, and egg identification—represent significant advancements in the SmartDots platform. They are expected to streamline the quality control and calibration processes by enabling a greater number of events of these types without the logistical challenges of gathering in one location. SmartDots is set to facilitate the way data is collected, analysed and quality assured, making collaboration more accessible and efficient.

3. Database for fecundity and atresia

Maria Makri

The combination of egg production estimates with fecundity data can yield accurate spawning stock biomass estimates to be used in the design and implementation of stock management plans. To provide full access to the data for SSB estimation from egg production methods, ICES has extended its eggs and larvae database, building a new database and a respective data inventory, to host estimations of fecundity, batch fecundity and atresia of major commercially important fish species such as mackerel, horse mackerel, sardine, and anchovy. The goal of the Fecundity and Atresia database will be to provide a common platform for experts of the wider scientific community to share and access data in a transparent way.

The presentation outlined the current development status of the database which is currently available for testing and scheduled to be launched in January 2024. The reporting format for data submissions, the process for retrieving data and the user interface designed for doing so are described in detail. Future actions for optimization of the data submission and storing process and improvements in data quality assurance are mentioned. One of the future goals for the Eggs and Larvae and Fecundity and Atresia Governance Group, together with ICES data management would be the implementation of data quality checks, the drafting of user manuals and documentation for the database and generally the optimization of the submission process, the visualization, and the quality of the data.

4. A data-integration approach with hierarchical models to reveal spatiotemporal variations of small pelagic fish distribution in the Bay of Biscay

Mathieu Doray

(see section 4.2.4.1)

5. Multidisciplinary Mesopelagic Scouting Survey (M2S2)

Ciaran O'Donell

The mesopelagic zone, or twilight zone, stretches from 200 to 1000 metres depth and represents around 20% of the ocean's volume, yet it is one of the least studied (St. John et al., 2016). Studying the biodiversity and the structure forming the mesopelagic layers is essential to understand the spatio-temporal variation of the biomass and its drivers.

In the Northeast Atlantic, the upper layers seem to be structured by two fish species: the Sternoptychidae Maurolicus muelleri and the Myctophidae Benthosema glaciale (Grimaldo et al., 2020). These species have also been documented performing diel vertical migration (Christiansen et al., 2021; Dypvik et al., 2012) which gives them a functional role in the carbon budget of the ocean (Davison et al., 2013), another aspect of mesopelagic fish that is yet to be fully understood.

As part of the Horizon 2020 project: MEESO, Ecologically and Economically Sustainable Mesopelagic Fisheries. The Marine Institute undertook a dedicated survey; Multidisciplinary Mesopelagic Scouting Survey (M2S2) to the collect data on mesopelagic fish. The survey took place over 10 days in September 2022 onboard the RV Tom Crean.

Survey objectives:

• Collect multi-frequency acoustic data on aggregations and scattering layers in the upper mesopelagic zone during daylight hours.

• Determine the spatial extent and temporal persistence of any aggregations using a replicate line transect survey design

• Carry out directed trawling on insonified layers to determine species composition and collect biological data on key species including, M. mulleri and B. glaciale

• Field testing the utility of graded midwater trawl for targeting active swimming mesopelagic fishes.

• Investigate the escapement of through larger graded meshes using small mesh pocket nets and in-trawl optical systems

• Collect environmental DNA samples from stratified water sampling and trial on-board analysis procedures to aid near real-time interpretation of echograms

6. **Understanding the effect of along-transect resolution in acoustic abundance**
   Guillermo Boyra
   (see section 4.3.1.2)
7. **Working progress on vertical mackerel distribution in the BoB**
   Silvia Rodriguez-Clement, Pablo Carrera
8. **Northward range expansion of Bay of Biscay anchovy to the English Channel due to increased temperature envelope and recent population increase**
   Jeroen Van Der Koij, Niall McKeown, Fabio Campanella, Guillermo Boyra, Mathieu Doray, Maria Santos, Martin Huret.
   European anchovy is a widely distributed, warm-water species which has been postulated to be a climate change “winner”. For decades, the northern-most stock resided in the Bay of Biscay, where it typically spawned during late spring mostly in the southern part. An apparent regime shift in the mid-1990s saw the sudden appearance and subsequent increase of anchovy numbers in the North Sea and English Channel. This northward range expansion was found to be driven by improved survival of fish from remnant, genetically distinct, local summer spawning populations in the southern North Sea, rather than a poleward migration of lower latitude conspecifics. No evidence of anchovy spawning was found in the English Channel and increases in anchovy observed there were due to seasonal migrations of North Sea adults and juveniles to overwinter. During the autumn of 2019 and 2020, for the first time, post-larval anchovy were found in the English Channel during an annual acoustic-trawl survey, several hundreds of kilometres from the core of the nearest known spawning grounds. Identifying the origin of these anchovy is important for management purposes and to understand the mechanisms driving populations at the limit of their distribution. This study examines the processes behind these observations, by combining acoustic and egg data from spring and autumn surveys in the Bay of Biscay and western English Channel, with larval drift modelling and

genetics. Our analysis suggests that due to population increase, spawning activity in the Bay of Biscay has expanded in space and time, increasing larval transport and survival into the Channel area. This newly recorded process of anchovy expansion at the northern limit of its distribution adds to previously reported process of expansion in the 1990s, caused by improved survival and growth of remnant local populations at the northern extremities. The identification of two separate processes causing a range expansion of species at the northern distribution limit demonstrates the potentially complex impacts of climate change.

9. **Sardine population structure (Biscay to North Sea) based on genome wide SNP analysis**
   Nial McKeown, Martin Huret, Jeroen van der Kooij, Cristophe Lebigre.
   The European sardine (Sardina pilchardus) sustains some of the most important European fisheries and is exhibiting pronounced phenotypic responses and distributional shifts probably linked to climate changes. These ongoing changes necessitate robust information on population structure and adaptation to be transferred to managers of the stocks, however, data generated from a range of techniques are to date inconclusive and/or contradictory. To overcome resolution thresholds of previous genetic studies, we employed genome wide SNP analyses of adults and revealed pronounced differentiation of three regional groups (NE Atlantic, Morocco, and Western Mediterranean) with further structuring within the NE Atlantic from the southern Bay of Biscay to the North Sea through the English Channel. Structuring was also apparent at outlier loci suggesting local adaptation at various spatial scales. The data also: (i) confirm the demographic independence among regional hotspots of recruitment (ii) identify the North Sea – Eastern Channel stock as distinct from a Biscay-Celtic Sea-West Channel (BCW) group, and (iii) suggest that the Western English Channel may be an area where members of the BCW and East Channel-North Sea group co-occur. Moreover, the spatial structure indicates that the increasing sardine numbers in the North Sea reflects an expansion of an East Channel-North Sea fringe population, not a northward shift in the distribution of southern conspecifics. Application of genome-wide assays alongside intense sampling throughout the species range will help resolve the boundaries among the populations identified here. The study demonstrates that genomic methods can now provide an informative genetic framework to complement data from other approaches and help towards a holistic understanding of the species biocomplexity.

10. **Trophic role of small pelagics in the BoB**
    B. Iglesias, M. Louzao, I. Preciado, E. Bachiller, L. López-López, M. Santos, G. Boyra, E. Andonegi, U. Cotano, J. Gimenez, P. Méndez-Fernández, T. Chouvelon, P. Bustamante, J. Fort, N. Goñi and J. Spitz.
    Small pelagic fish (SPF) play a crucial role in marine ecosystems as both prey and predator. Our study explored the dietary habits of a diverse fish and megafaunal community of the Bay of Biscay (BoB). While assessing the predator-prey role of small pelagic fish through stomach content analysis (SCA) in two different seasons (spring and late summer), we simultaneously examined the dietary patterns of a megafaunal community using stable isotope analysis (SIA), highlighting the importance of SPF as prey. Among the six SPF species analysed (anchovy, sardine, sprat, horse mackerel, Atlantic mackerel, and chub mackerel) copepods emerged as the primary prey for four species, while salps dominated the diet of the two Scomber species. Notably, SPF, particularly anchovies, constituted the primary prey for hake throughout both seasons and for Atlantic mackerel during spring. Regarding the examined megafauna community, merely two out of the ten species predominantly relied on SPF: the common dolphin and the Balearic shearwater. This research sheds light on the significant trophic role of SPF and their influence on the broader food web dynamics in the BoB, offering insights into the intricate interdependencies of marine species within this region.

11. **Integrating relative abundance of marine megafauna to progress towards an ecosystem-based management approach**

Maite Louzao, Isabel García-Barón, Amaia Astarloa, Arkaitz Pedrajas, José Luis Murcia, José Antonio Vázquez, Beñat Iglesias, Aitor Lekanda, Anna Rubio, Iván Manso, Udane Martínez, Guillermo Boyra, María Santos, Unai Cotano

Marine megafauna species have been proposed as indicators of the state of the marine environment. To support megafauna management, we need to identify the ecological descriptors that best explain species distribution and abundance. Multidisciplinary oceanographic surveys provide a suitable monitoring platform to simultaneously collect oceanographic and biological information on the distribution and abundance of different trophic levels, from plankton to marine megafauna. The biological information collected includes estimates of the biomass of species such as pelagic fish, which are important prey for several species of marine megafauna. In this study, we used the integrated ecosystem-based surveys of BIOMAN and JUVENA, which have been carried out every year since 2013 in spring and autumn in the Bay of Biscay to study marine mammals, seabirds, litter and human activities. Our data are valuable in this regard, as they span more than a decade and can provide baseline information. These datasets have been used to improve our understanding of the (3D) environmental drivers of marine megafauna distribution and abundance in the Bay of Biscay, but also in the wider Atlantic, to provide insights of the pelagic ecosystem functioning, in addition to several management applications such as the identification of marine protected areas for the conservation of endangered species, identification of biodiversity conservation targets, identification marine litter hotspot areas, applications of systematic conservation planning, spatially explicit ecological risk assessments, among others.

12. **Comparison between acoustic and egg-based fish biomass indices**
    Mathieu Doray, Erwan Duhamel, Martin Huret
    (see section 4.3.3)
13. **A probabilistic machine learning model to classify echotraces**
    Aitor Lekanda, Guillermo Boyra and Maite Louzao
    (see section 4.3.1.3)
14. **Bycatch of short-beaked common dolphin (Delphinus delphis) in the pair bottom trawl fishery of the Bay of Biscay and its mitigation with an active acoustic deterrent device (pinger)**
    Esteban Puente, Leire Citores, Elsa Cuende, Iñigo Krug, Mikel Basterretxea.
    Bycatch of common dolphin (*Delphinus delphis*) in commercial trawl fisheries in the Bay of Biscay (NE Atlantic) is of concern and its mitigation a priority. Active acoustic deterrent devices (pingers) attached to fishing gear seem to be promising for bycatch mitigation, as they have demonstrated to effectively reduce cetacean bycatch in some set-net fisheries. However, the low occurrence of common dolphin bycatch in many trawl fisheries, coupled with the extensive amount of time needed to monitor them, makes it difficult to prove the effectiveness of pingers. Remote electronic monitoring (REM) systems in fisheries can substantially increase onboard observation, providing access to extensive databases to comprehensively address bycatch mitigation studies. In this study, the effectiveness of DDD®03H Dolphin Dissuasive Device (hereinafter DDD pingers) to reduce common dolphin bycatch was evaluated in a demersal pair trawler in FAO Division 27.8.c. In 195 fishing days, one of the vessels in the pair operated with a set of DDD pingers whereas the other operated without them, and the bycatch of common dolphin was monitored through the REM system. In total, 660 fishing hauls were conducted of which 223 hauls had the DDDs attached. The results showed that the DDDs reduced common dolphin bycatch by more than 90%, with both bycatch frequency and the number of individuals bycaught per haul being significantly lower. The results also showed that common dolphin bycatch in this fishery is related to factors such as the fishing zone and depth, whereas the type of net deployed, time of day and haul duration were found to not significantly affect the bycatch of this species.
15. **Uncrewed surface vehicle for dolphin and small pelagic prey acoustic mapping**

Mathieu Doray, M. Cambreling, A. Ariza, O. Van Canneyt, E. Veit, L. Berger, C. Poncelet, M. Ponchart, N. Le Bouffant.

(see section 4.3.1.1)

16. Monitoring of survey aggregations in Juvena

Guillermo Boyra et al.

(see section 4.3.1.4.2)

17. Investigation of bias in echosounder acoustic surveys using omnidirectional sonar from South to Northwest Africa

Héctor Peña, Fannie W. Shabangu, Kamal Mamza, Abdoulaye Sarre, Mohamed Ahmed, Uatjavi Uanivi, Filomena Vaz Vehlo, Erling Stenevik and Arne Johannes Holmin

Fish in echosounder blind zone and fish avoidance to surveying vessel are two main sources of bias in echosounder measurements in acoustic pelagic trawl surveys. Omnidirectional sonar data was collected in 6 acoustic surveys in west coast of Africa in 2017 and 2019. Sonar data was processed using module PROFOS part of post-processing system LSSS. Individual schools were scrutinized and per ping output was used to compute a sonar NASC, that was combined with echosounder NASC in software Stox. NASC values per nautical mile and 5 m depth layers up to 30 m was used to compare sonar and echosounder measurements. Preliminary results from surveys in Morocco and South Africa, show transects with only sonar measurements of pelagic fish in the upper 30 m, corresponding to ca. 20 and 40% of the total sonar NASC, respectively. These results provide an indication of the level of bias from echosounder measurements.

18. Bayesian DEPM

Leire Citores et al.

The Daily Egg Production Method (DEPM) estimates the daily egg production (P0) and the daily egg mortality rates (Z) by fitting the exponential decay mortality model fitted as a Generalized Linear Model (GLM) to the egg daily cohorts. Frequentist approaches for this GLM can result in mortality estimates out of the proper domain. In this work a Bayesian approach for estimation of P0 and Z is proposed, where estimates of Z are restricted to the proper domain through a prior distribution based on literature. Furthermore, the spatial nature of the sampled data enables estimating P0 by station, which can provide insight into the spatial variability of daily egg production. For that, three different approximations are proposed and compared: 1) introducing a random effect by station, 2) including a smoothing function across stations' geographical positions and 3) using a gaussian process/kriging like model. The proposed Bayesian approach was applied to the Bay of Biscay anchovy case study (and sardine, only the Bayesian non-spatial approximation) using the plankton samples collected during the BIOMAN survey for several years. Annual point estimates and the corresponding credible intervals for the Bay of Biscay anchovy egg production obtained with this Bayesian procedure were compared to the frequentist estimates. The sensitivity analysis to the prior distribution of Z showed that the influence on posterior distributions was minimal. Overall, the results of both methods were very similar, except for the years in which the frequentist method resulted in implausible mortality estimates. In these years the proposed method overcame the problem of inappropriate sign for mortality estimates, resulting in tighter credible intervals of both P0 and Z. Spatial approximations were compared to the non-spatial option in terms of resulting key quantities, as well as in terms of the Leave-one-out cross-validation (LOO-CV) and the widely applicable information criterion (WAIC) indicators. Spatial approximations resulted in slightly different total egg production estimates depending on the year data characteristics.

(see section 4.3.2.1)

19. Autonomous vehicles for acoustic monitoring in AZTI

Bea Sobradillo, Guillermo Boyra, Udane Martinez, Anna Rubio, Ivan Manso, Asier Nieto

(see section 4.3.1.1)

20. **Plankton PELAGO**

Maria Manuel Angelico
(see section 4.7)

21. **Anchovy and sardine springtime habitats in the European Atlantic area**

M. Doray, P. Carrera, P. Amorim, A. Moreno, E. Duhamel, G. Boyra, C. O'Donnell, M. Santos, J. Van Der Kooij, M.M. Angelico, C. Nunes, S. Rodriguez-Climent, F. Campanella, F. Ramos, P. Diaz, P. Jimenez, P. Petitgas, M. Huret.

Springtime habitats of anchovy and sardine habitats were jointly characterised for the first time at the scale of the European Atlantic shelf seas (from the Gulf of Cadiz to northern Brittany), based on data collected over the 2003-2019 period by the ICES WGACEGG international joint effort spring acoustic surveys. Multivariate ordination methods were applied to extract the main spatial patterns from series of multivariate maps. Spatial patterns were expressed as hierarchised principal components (PCs), whose time-varying amplitudes were analysed to assess temporal dynamics. Space-time ordinations were performed on: i) fish acoustic densities collected during the joint survey, ii) sea surface temperature and salinity collected from survey and remotely sensed Chlorophyll-a conditions. Maps of fish mean PCs were modeled as a function of maps of mean environment PCs, to characterise the anchovy and sardine habitats in the European Atlantic area. Anchovy and sardine co-occured in core springtime habitats located in onshore areas of the Bay of Biscay, Galicia and Western Portugal, and in the gulf of Cadiz. Core habitats were characterised by lower than average surface temperature and salinity and higher primary productivity. In those habitats, anchovy distribution expanded over time, while the sardine range shrank. Effects of the environment and fishing on anchovy and sardine distributions are discussed, as well as future changes under climate forcing.

22. **Review of the protocol for error calculation in WGACEGG acoustic surveys**

Guillermo Boyra, Udane Martínez, Bea Sobradillo and Andrés Uriarte
(See section 4.3.1.5)

23. **Effect of inter-transect distance on JUVENA acoustic estimates**

Guillermo Boyra
(see section 4.3.1.6)