

8 Sardine in 8c and 9a

8.1 ACOM Advice Applicable to 2022, STECF advice and Political decisions

ICES advises that when the MSY approach is applied that catches in 2022 should be no more than 41 777 tonnes (ICES, 2021a). This advice for 2022 replaces the advice provided in June 2021 and was issued in December 2021 after the Interbenchmark carried out in October 2021 (ICES, 2021b) in which the assessment model was revised to include a recruitment index for the first time.

In 2022 the fishery was managed according to a bilateral agreement between Portugal and Spain (Despacho n.º 5126-A/2022; BOE-A-2022-5783). Portugal and Spain agreed to implement a total catch of 44 262 tonnes, based on the harvest control rules of the Management Plan assessed as precautionary by ICES (ICES, 2021c)

In Spain, purse-seine fishery for sardine remained closed since November 2021 and reopened on April 4th 2022 (with a planned closure in December 1st; BOE-A-2022-5783), with a quota allowing to catch a total of 14 828 tonnes.

In Portugal, the purse-seine sardine fishery was closed on the 30th November (Despacho n.º 11820-A/2021), when the national quota limit for 2021 was reached. In 2022, the fishery was opened on May 2nd with a quota allowing a total catch of 29 400 tonnes (Despacho n.º 5126-A/2022).

8.2 The fishery in 2021

8.2.1 Fishing fleets in 2021

Sardine is taken in purse-seine throughout the stock area and the fleet has remained relatively constant in recent years. In Spain (Gulf of Cadiz and northern waters), data from 2021 indicate that the number of purse-seiners taking sardine were 478, with mean power of 236 Kw. In Portuguese waters, fleet data indicate that 174 vessels landed sardine with mean vessel tonnage of 70.0 GT and engine power category of 358 Kw.

8.2.2 Catches by fleet and area

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

Total sardine landings in 2021 are shown in Tables 8.2.2.1, 8.2.2.2 and Figure 8.2.2.1. Total 2021 landings in divisions 8c and 9a were of 40 685 tonnes, which represents an increase of 84% with respect to total 2020 landings (22 143 tonnes). The bulk of the landings (99%) were made by purse-seiners.

In Spain, sardine landings, 13 835 tonnes, represent a 106% increase in relation to values from 2020 (6 727 tonnes). In all ICES subdivisions catches experienced a large increment, but especially in the western area (9aN, with an increase of 162%), compared to the other areas (increase by 74% in 8c and by 95% in 9aSouth subdivisions).

In Portugal, sardine landings were of 26 851 tonnes, which represents an increase of 74% compared to 2020 landings, 15 416 tonnes. The increase in landings was generalized, but as with Spanish catches, the largest increase occurred close to the area of highest recruitment (with an increase of 158% in 9aCN) compared to the rest of the subdivisions (increase by 80% in Algarve and by 16% in 9aCS).

Table 8.2.2.1 summarizes the quarterly landings and their relative distribution by ICES subdivisions. In 2021, due to management regulations implemented in Spain and Portugal (see section 8.1.), the sardine fishery opened late in the year and it closed in November for having reached the total catches admitted. For that reason, the sums of the second and third quarter landings represent almost 75% of the annual catches.

The relative contribution of the different areas to the total catch was similar to 2020, being the western Portuguese Atlantic coast (9aCN and 9aCS subdivisions) the areas that obtained 54% of the total catches of the stock.

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

Discards are negligible for this stock.

8.2.3 Effort and catch per unit of effort

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

8.2.4 Catches by length and catches-at-age

Tables 8.2.4.1.a,b,c and d show the quarterly length distributions of landings from each subdivision. Annual length distributions (Table 8.2.4.1) were unimodal in Spain in 8cE, 9aN and 9aS-Cádiz subdivisions (with modes at 18.5 cm in northern areas and as usual, smaller individuals were caught in 9aS-Cádiz subdivision, with mode at 14.5 cm). In 8cW, length distribution was bimodal, with a smaller mode at 15.5 cm and another at 19 cm.

For Portugal, sardine annual length distributions were unimodal in 9aCN and 9aS-Algarve, with modes at 17.5 and 18.5 cm, respectively. For 9aCS, length distribution was bimodal with modes at 18 and 19.5 cm.

Table 8.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision and Table 8.2.4.3 shows the historical catch-at-age data. In Table 8.2.4.4, and Figure 8.2.4. the relative contribution of each age group in each Subdivision is shown as well as their relative contribution to the catches.

Dominance of age-3 (2019 strong year class) individuals in all areas except Cádiz, where age-0 and age 1 represent 87% of catches. Age-3 had the higher contribution, with a 52% to the total biomass in catches, followed by age 1, with the 20% of the catches. By areas, age 0 showed a clear predominance in 9aS-Cádiz and older individuals (age-5 and age-6+) were particularly landed in 9aCS subdivision.

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

Mean length and mean weight-at-age by quarter and subdivision are shown in Tables 8.2.5.1 and 8.2.5.2.

8.3 Fishery-independent information

Figures 8.3.1, 8.3.2 and 8.3.3 show the time-series of fishery-independent information for the sardine stock.

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

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

The DEPM survey is planned and discussed within WGACEGG where final results were presented and fully discussed (ICES, 2021d).

The latest DEPM data available corresponds to 2020. There is no new information regarding DEPM surveys after the last assessment (November 2021) and a new DEPM is rescheduled for 2023.

8.3.2 Spring Iberian acoustic survey (PELACUS-PELAGO)

As part of the Iberian acoustic survey, surveys are carried out each year by Portugal and Spain to estimate small pelagic fish abundance in divisions 8c and 9a. The Iberian acoustic survey is planned and discussed within WGACEGG (e.g WGACEGG, 2022). As described in the Stock Annex, the total numbers of individuals and numbers-at-age from the two surveys are used as input to the assessment.

There are two annual surveys carried out to estimate small pelagic fish abundance in 9a and 8c using acoustic methods: PELAGO and PELACUS. For the first time, in 2021, both surveys were carried out on the same vessel, RV Miguel Oliver.

In 2022, due to electrical problems on the RV Miguel Oliver during the start of the PELAGO survey, a change of vessel took place and the second part of the Portuguese survey and the entire PELACUS survey were carried out on board RV Vizconde de Eza, a vessel with the same acoustic equipment.

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

8.3.2.1 Portuguese spring acoustic survey

The PELAGO acoustic surveys have sampled the Portuguese and Bay of Cadiz continental shelves, since 1995 and until 2019 with the RV Noruega, a 49 m trawl vessel. Since 2020 this survey is planned on-board RV Miguel Oliver.

The PELAGO2022 survey was conducted between the 1st and 31th of March. First leg (01/03 – 09/03) was carried out on board RV Miguel Oliver and second leg (12/03 – 31/03) on board RV Vizconde de Eza.

Seventy-one (71) transects were acoustically sampled between Caminha and Cape Trafalgar.

Figure 8.3.2.1.1 shows the acoustic transect along the surveyed area and Figure 8.3.2.1.2. shows the fishing operations conducted during the survey and the proportion of species in each fishing station. A total of 42 pelagic trawl hauls were carried out by the research vessel and 29 additional hauls were done by purse-seiners. Sardine was present in most of the fishing hauls (88%) and the energy attributed to this species was distributed throughout the coast, with the highest concentrations in the north, in 9aCN subdivision (between Porto and Figueira da Foz) and in 9aCS subdivision (between Cascais and Setúbal; Figure 8.3.2.1.3).

Figures 8.3.2.1.4., 8.3.2.1.5. and Table 8.3.2.1.1. show the abundance in number and biomass by length and age class, respectively. During 2022 PELAGO survey, age 0 sardine individuals were not detected.

In 9aCN the length distribution was bimodal with modes at 15.5 and 18 cm. The main mode (18.5 cm) corresponds to age 3 individuals, still showing signs of the strong 2019 cohort.

In 9aCS and in 9aSouth-Cadiz, the modal age corresponds to age 1 (2021 cohort), with modes at 16.5 and 17 cm respectively. In 9aS-Algarve, the modal age was age 4 and a secondary mode of age 1 individuals was observed. For the total area sampled during PELAGO, age 1 accounted for

48% in abundance, indicating a strong age class of 2021. This fact is in controversy with IBERAS index in 2021, which in relation to previous years showed weak recruitment (age 0 individuals; see section 8.3.3).

In relation to total abundance in PELAGO2021, 2022 sardine estimation (18907 million individuals) showed a strong increase by 73%.

The sardine B1+ was estimated to be 808.6 thousand tonnes for the whole area, representing a very important increase of 94% in relation to the PELAGO2021 survey.

8.3.2.2 Spanish spring acoustic survey

Spanish PELACUS0422 survey was conducted on board RV Vizconde de Eza. The first leg of the survey was delayed one week (due to the change of vessel) and started in Vigo on 1st April. This first part of the survey was characterized by very bad weather and had to be stopped 11 days due to COVID issues. Second part of PELACUS started on 24th April and finished on 31th April. Despite the reduction in the number of days, it was possible to cover the target area and meet the objectives.

Sampling design and methodology was similar to that of the previous surveys and is summarized in Massé *et al* (2018) with supplementary material available [online](#). Tracks were placed at 10 nautical mile, with a random start and only steamed during day hours. The survey progressed eastwards (Figure 8.3.2.2.1).

A total of 27 fishing stations were carried out, which represents a decrease with respect to previous years (i.e. 45 fishing hauls in 2021), in part related to the decrease in the number of days available, but especially due to the reduction in the number of schools present in the study area during the 2022 survey. Figure 8.3.2.2.2 shows the species proportion (% in number) in the fishing stations. Unlike previous years, when mackerel was the main species in the catch, this year, due to the delay of PELACUS, the migration of this species in the Cantabrian Sea had already ended. Sardine was the most important species in the fisheries, accounting for 34% in weight and 38% in abundance of the catch and was mainly located in the area of Galicia (8cWest and 9aNorth subdivisions), where the bulk of the sardine NASC distribution was recorded (Figure 8.3.2.2.3).

A total of 252 thousand tonnes, corresponding to 4081 million fish were estimated, most of them in the western part (9aN-8cW; Table 8.3.2.2). Compared to the previous year, the sardine abundance estimated by PELACUS showed a decrease of 39%, which was reflected in a decrease in biomass of 27%. Age group 1 only accounted for 1% of the total biomass, with the bulk of the fish belonging to age group 3 (70% in number and biomass); which is consistent with the strong cohort of 2019 (Figure 8.3.2.2.4).

8.3.3 Autumn acoustic survey index

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

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

Last IBERAS survey, in 2022, was carried out on board Angeles Alvareño RV. Due to logistical problems IBERAS0922 survey suffered some delay and the duration had to be reduced from 17 to 9 days (from 30th September to 8th October). Due to the time constraint, the survey sampling focused on the main recruitment area (used as an index in the assessment model) and mainly on juvenile sardine, without extending the sampling to areas where other age classes were present (Figure 8.3.3.1).

Sampling design and methodology was similar to that of the previous surveys and is summarized in Doray *et al.*, 2021.

A total of 16 fishing stations were carried out and additional samples were obtained from 9 fishing stations carried out by purse-seiner vessels (Figure 8.3.3.2). Sardine was present in almost all tracks, as long as most of the fishing stations were targeted on this species.

Sardine distribution showed a wide distribution area, with its centre of gravity stable around Figueira da Foz, in 9aCN subdivision, and approximately at 20m depth. (Figures 8.3.3.3 and 8.3.3.4).

2022 recruitment for the whole surveyed area, was estimated to be 8×10^9 age 0 individuals (158×10^3 million tonnes) and represents the highest value in the time-series (Figure 8.3.3.5).

Age 0 abundance in the 9aCN subdivision, which will be used in the assessment model, corresponds to 7020×10^6 individuals (137×10^3 tonnes).

During IBERAS22 many of the juvenile sardine schools showed a near-surface occurrence. In some cases, as shown in the Figure 8.3.3.6, thick fish schools were at the blind area, outside the echosounder detection area. For this reason, the recruitment index in 2022 may be underestimated.

8.3.4 Other regional indices

Although not included as an input in the sardine assessment, ECOCADIZ survey (fully described in Section 4, Anchovy in 9a division), provides sardine abundance and biomass estimates in the Gulf of Cadiz and Algarve (9aS subdivision) in summer, which can be compared with the results obtained by the spring Portuguese acoustic survey in the same area. For both surveys, trends in abundance (and biomass) are broadly similar (specially for age-0 individuals), although they have interannual differences.

Since 2021, ECOCADIZ survey could not be carried out due to logistical problems.

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

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

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

According to the stock annex, mean weights-at-age in the stock (Table 8.3.5.1b) come from the DEPM surveys. See Annex 3.

- For years with no DEPM survey, a linear interpolation of the data from two consecutive surveys is carried out to obtain the estimates of mean weight-at-age.
- For the period 1978–1998 (before the DEPM series started) it was decided to consider the two closest DEPM surveys, and assume for that period the average between 1999 and 2002 estimates.
- For the years after the last DEPM survey, the estimates of the last DEPM survey (2020) are assumed.

8.3.6 Maturity-at-age

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

- For years with no DEPM survey, a linear interpolation of the data between two consecutive surveys is carried out to obtain the estimates of maturity-at-age.
- For the period 1978–1998 (years before starting the DEPM series), constant proportions of maturity-at-age were assumed, based on the average of the estimates obtained from the six DEPM surveys of the 1999–2014 period, thus including both years of strong year classes and years of low recruitment.
- For the years after the last DEPM survey, the estimates of the last DEPM survey (2020) are assumed.

8.3.7 Natural mortality

Following the stock annex, natural mortality is:

	M, year ⁻¹
Age 0	0.98
Age 1	0.61
Age 2	0.47
Age 3	0.40
Age 4	0.36
Age 5	0.35
Age 6	0.32

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

The historical series of catches-at-age and abundance-at-age in the spring acoustic survey are presented in Figure 8.3.8.1.

8.4 Assessment Data of the state of the stock

8.4.1 Stock assessment

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

Input data	WGHANSA 2022
Catch	Catch biomass 1978–2022 (tonnes)
	Catch-at-age 1978–2021 (thousands of individuals)
Spring acoustic survey (Joint SP+PT) *	Total numbers 1996–2022 (thousands of individuals)
	Numbers-at-age 1996–2022 (thousands of individuals)

DEPM survey (Joint SP+PT)	SSB 1997, 1999, 2002, 2005, 2008, 2011, 2014, 2017, 2020 (tonnes)
Autumn acoustic survey (recruitment index)	Numbers at age 0 in 9aCN 1997-2022 (thousands of individuals)
Weight-at-age in the catch	Yearly averages 1978–2021 (constant up to 1989), kg
Weight-at-age in the stock	From DEPM surveys in DEPM years, linear interpolation for years in-between (constant 1978–1998, 2020 onwards), kg
Maturity-at-age	From DEPM surveys in DEPM years, linear interpolation for years in-between (constant 1978–1998, 2020 onwards), proportions
Model structure and assumptions:	
M	M-at-age 0=0.98, M-at-age 1=0.61, M-at-age 2=0.47, M-at-age 3=0.40, M-at-age 4=0.36, M-at-age 5=0.35, M-at-age 6+=0.32
Recruitment	Density-dependent R model; annual recruitments are parameters, defined as lognormal deviations from Beverton–Holt stock–recruitment model, penalized by a sigma of 0.74, and an input steepness of 0.71.
Initial population	N-at-age in the first year are parameters derived from an input initial equilibrium catch of 135 000 tons, equilibrium recruitment and selectivity in the first year and adjusted by recruitment deviations estimated from the data on the first years of the assessment. Equilibrium assumed to take place in 1972.
Fishery selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 0 used as the reference; S-at-ages 4 and 5 assumed to be equal to S-at-age 3.
Fishery selectivity over time	Three periods: 1978–1987, 1988–2005 and 2006–onwards. Selectivity-at-age is estimated for each period and within each period assumed to be fixed over time.
Spring acoustic survey selectivity-at-age	Selectivity assumed to be equal at all ages.
Autumn acoustic survey selectivity-at-age	Selectivity tailored to young fish (age 0)
Fishery catchability	Scaling factor, median unbiased
Spring acoustic survey catchability	Simple model with extra standard error parameter
DEPM catchability	Simple model with extra standard error parameter
Autumn acoustic survey catchability	Power model with extra standard error parameter
Log-likelihood function:	
Weights of components	All components have equal weight

Data weights

Sample size of age compositions by year (50 in 1978-1990 and 75 in 1991-onwards for the fishery, 25 for the acoustic survey; Acoustic and DEPM abundance observations with equal weight = CV = 25%; age reading uncertainty; user input sample sizes and survey CV are used as inverse weights of likelihood components.

Table 8.4.1.1 shows the parameters estimated by the assessment model. Fishing mortality-at-age and numbers-at-age are presented in Tables 8.4.1.2 and 8.4.1.3. Virgin recruitment was estimated to be $R_{0,2022} = 20\,662\,800$ (CV = 3.8%) and the initial F was estimated as $\text{init}F_{2022} = 0.39 \text{ year}^{-1}$. Catchability parameters are close to 1 for both the acoustic ($Q = 1.34$, RMSE = 0.33) and the DEPM ($Q=1.22$, RMSE=0.30) surveys. Catchability parameter for the recruitment index is $1.72\text{e-}06$ (RMSE = 1). The extra standard deviation parameters are low for the spring acoustic and the DEPM surveys (0.08 and 0.05 respectively) but higher for the recruitment index (0.78). Correlations between the assessment parameters range from -0.99 to 0.46 although the majority are very close to zero. Negative correlations below -0.50 are observed between the two parameters of the power model of $Q_{\text{recruitment index}}$ (-0.99), R_0 and $Q_{\text{acoustic survey}}$ (-0.57) and between selectivity parameters from the first period (four cases) and one case in the last period.

The assumed standard error for the acoustic and the DEPM index, all years = 0.25, is consistent with the residual mean square errors estimated by the model, 0.33 and 0.30. The harmonic mean of the fishery age composition sample size, 73, is consistent with the current assumption of 75. In the case of the spring acoustic survey survey, the sample size of 25 is consistent with the precision indicated by the model (the harmonic mean for the acoustic survey is estimated to be 22).

Figures 8.4.1.1, 8.4.1.2 and 8.4.1.3 show the fit of the model to the three indices of abundance. All are similar to the fit of the 2021 assessment model. The assessment of 2022 still shows a poor fit to the 2022 point estimate of the acoustic survey index. It is observed that in previous years, high values of the point estimate of the acoustic surveys have poorer fits, i.e. positive residuals for the recruitment estimates in the surveys. It seems that the model has a tendency to underestimate abundance in years when the survey index is large.

Figure 8.4.1.4 shows the model residuals from the fit to the catch-at-age composition (top panel) and the acoustic survey age composition (bottom panel). Catch-at-age residuals in 2021 are positive for ages 1, 2 and 4 and negative for all the other ages. The acoustic survey residuals in 2022 are positive for age four and older and negative for the other ages.

The fishery selectivity patterns estimated in the present assessment show less abrupt changes over time and through ages (particularly at the age-6+ group; Figure 8.4.1.5). The patterns over age are dome-shaped in the three periods with the early (1978–1987) and recent periods (2006–2021) showing higher selectivity at ages 1–2 than the middle period (1988–2005), in agreement with the higher fraction of the catches coming from recruitment areas in those periods. The increase of age 0 selectivity estimated in the most recent period is consistent with large catches of this age group in a period that recruitment is lower.

The summary of the 2022 assessment results is shown in Table 8.4.1.4 and Figure 8.4.1.6 (in the Figure compared to the 2021 assessment model results). The estimate of B1+ in 2022 assumes stock weights are equal to the mean in the last six years, the same assumption taken in the short term forecast, and in accordance to the stock annex. Catches assumption for 2022 are based on the EU members published legislation (see Section 8.1). The model estimates standard errors of SSB, recruitment and ApicalF (maximum F over age within years). We assume the CVs of SSB and ApicalF apply to B1+ and F(2–5), respectively.

B1+ in 2022 is estimated as 432 379 t (CV = 16%), assuming that the stock weights are equal to the mean of the last six years. This represents an increase of 2% when compared with B1+ in 2021 = 424 514 t (CV = 15%). B1+ is above $B_{\text{lim}} = 196\,334 \text{ t}$, $B_{\text{pa}} = 252\,523 \text{ t}$ and $\text{MSY } B_{\text{trigger}} = 252\,523 \text{ t}$ of the current low productivity regime of the stock (see Section 8.7). Total numbers of individuals increased by 37% from 2021 to 2022.

$F_{\text{bar } 2-5}$ in 2021 is estimated to be 0.098 year^{-1} (CV = 17%) which represents an increase of 58% when compared to $F_{\text{bar } 2-5}$ in 2020. $F_{\text{bar } 2-5}$ is now just above $F_{\text{MSY}} = 0.092$.

The series of historical recruitments 1978–2022 shows a marked downward trend until 2006 and since then, has been fluctuating around historically low values. The 2019 recruitment estimate ($R_{2019} = 26\,171\,500$, CV = 16%) constitutes the highest value since 2004. The 2022 recruitment

estimate ($R_{2021} = 19\,424\,400$, $CV = 47\%$) represents a decreased of 78% when compared to the recruitment estimate of 2021.

8.5 Retrospective pattern

Retrospective patterns for Biomass 1+, $F_{\text{ages2-5}}$ and recruitment were computed for years 2017–2022. For each run, assessment was performed including survey data until the terminal year and catch data until the previous year, as done in the current assessment (2022). This range of runs include a run prior the benchmark (ICES, 2017) and three runs prior the Inter-benchmark (ICES, 2021c). The potential retrospective bias in the assessment was quantified using an approach based on the Mohn's rho (Mohn, 1999), following ICES guidelines, and was computed using the function `mohn()` available in the R package called `icesAdvice`.

Results are shown in absolute terms (Figure 8.5.1). The model underestimates Biomass 1+ (Mohn's rho of -0.333) and recruitment (Mohn's rho of -0.139) while it overestimates $F_{\text{ages2-5}}$ (Mohn's rho of 0.350). Differences in the estimation of these parameters between runs are more pronounced for $F_{\text{ages2-5}}$ and, in all cases, in the last portion of the time-series. Most probably, changes in the most recent years are a consequence of the model fit to the most recent data. However, trends do not change between runs. Finally, the retrospective plots indicate that the model is robust.

8.6 Short-term predictions

The short-term forecast assumptions were updated in 2021 after Inter-benchmark of October 2021 (ICES, 2021b) and are specified in the stock annex (Annex 3).

Catch predictions were carried out following the stock annex (Annex 3). Recruitment in the interim year (2022) is now the estimate from the assessment model. Recruitment in the forecast year (2023) was set to the geometric mean of the last five years (2018–2022), $R_{2023} = 13\,330\,753$ thousand individuals. Fishing mortality in the interim year is the fishing mortality that corresponds to a catch constrain. The catch assumption for 2022 was assumed to be 44 262 tonnes based on the official documents published in Portugal and Spain prior to WGHANSA-2 (Despacho n.º 5126-A/2022; BOE-A-2022-5783). This corresponds to a $F_{\text{ages2-5}, 2022} = 0.101$.

Table 8.6.1 shows input data of the short-term forecast. Table 8.6.2 shows the results of the short-term forecast. The complete set of results for fine steps of F scenarios is stored in file `pil.27.8c9a_scenarios` in the TAF github repository.

8.7 Reference points

Reference Points for this stock were re-evaluated at the beginning of 2021, during the Workshop for the evaluation of the Iberian sardine HCR (WKSARHCR; ICES, 2021c).

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

Table 8.7.1: Sardine in 8c and 9a. Reference Points. The biological reference points were estimated during WKSARHCR (ICES, 2021c) based on the state of low productivity (2006–2019). Weights are in tonnes.

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

8.8 Management considerations

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

The proposed HCR was described as follows:

- i) If $B1+ \leq 112\,943$ t, then $F = 0$
- ii) If $112\,943\text{ t} < B1+ \leq 252\,523$ t, then F increases linearly from 0 to 0.064
- iii) If $252\,523\text{ t} < B1+ \leq 446\,331$ t, then F increases linearly from 0.064 to 0.12
- iv) If $B1+ > 446\,331$ t, then $F = 0.12$

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

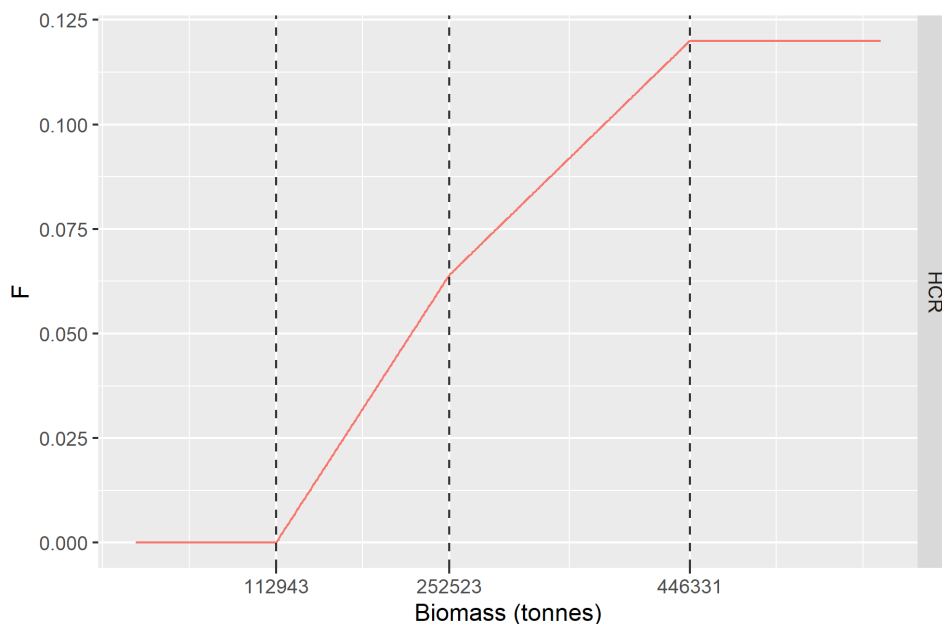


Figure 8.8.1. Sardine in 8c and 9a. Proposed HCR. The biomass reference levels of biomass (B1+) reported correspond to $B_{loss(2018)} = 112\,943$ t, $MSY\ B_{trigger_low} = B_{pa_low} = 252\,523$ t and $MSY\ B_{trigger_medium} = B_{pa_medium} = 446\,331$ t.

ICES found that the generic harvest control rule was precautionary in a persistent low productivity regime with maximum allowed catches between 30 and 50 kt (ICES, 2021c). For 2022, the EU Commission requested ICES to provide advice based on the MSY approach. The precautionary generic harvest control rule should be included in the catch scenario table.

8.9 References

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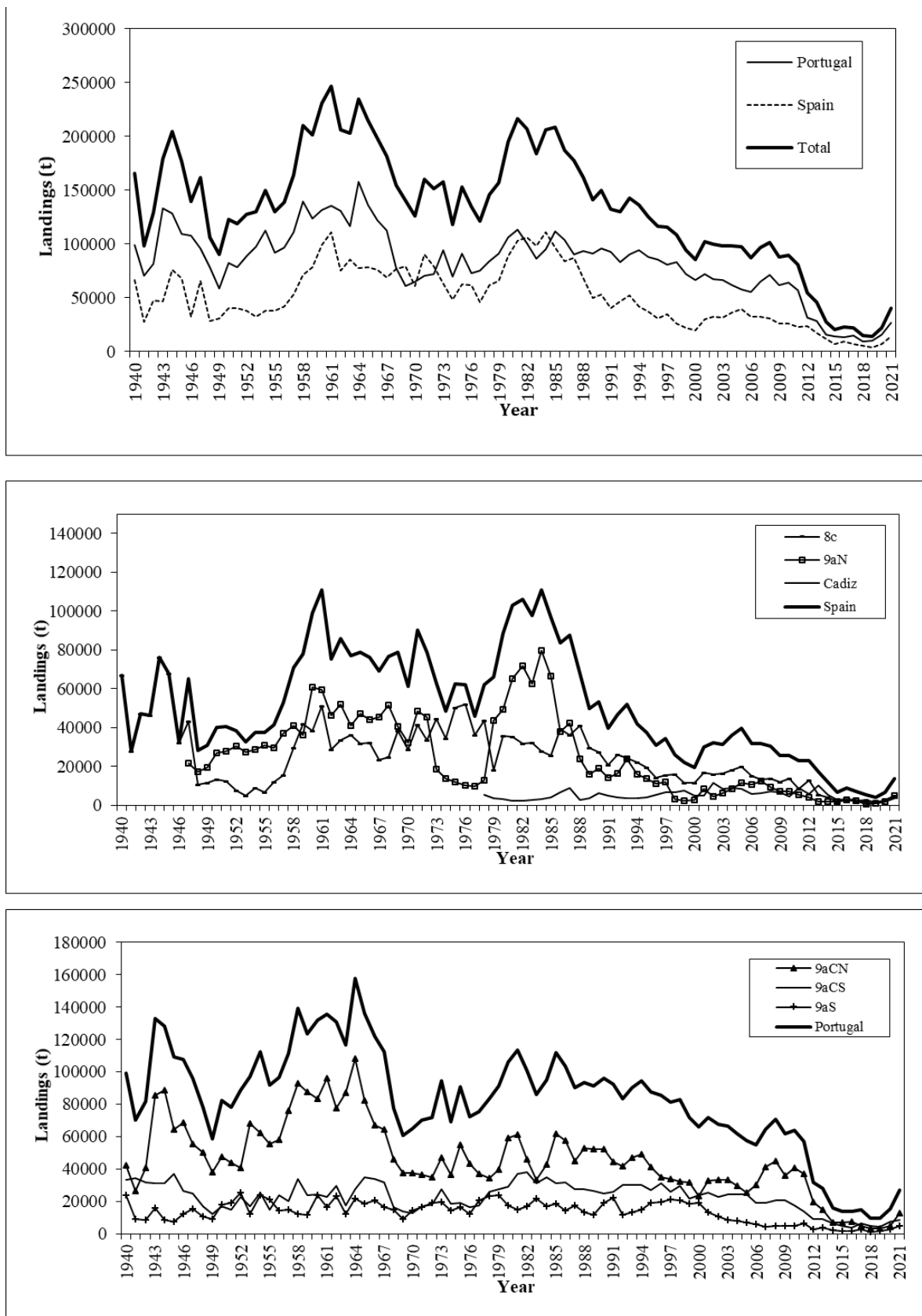


Figure 8.2.2.1. Sardine in 8c and 9a. WG estimates of annual landings of sardine, by country (upper panel) and by ICES subdivision and country.

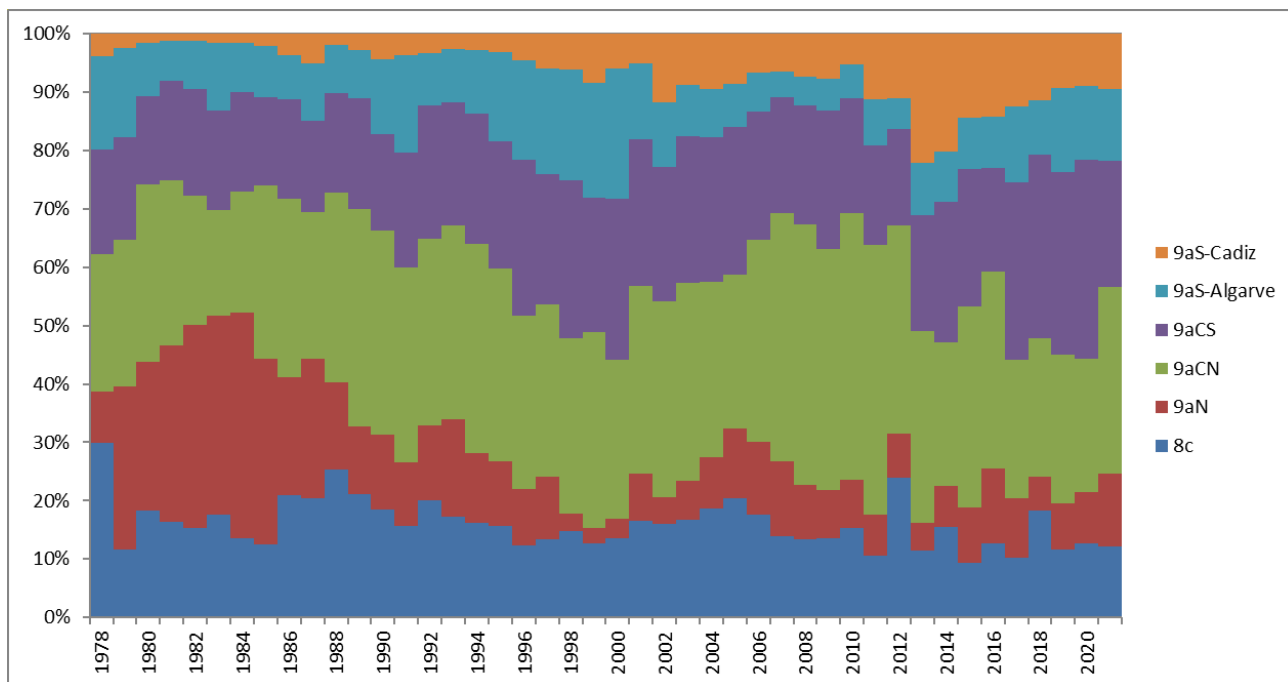


Figure 8.2.2.2. Sardine in 8c and 9a. Historical relative contribution of the different subdivisions to the total catches (1978-2021).

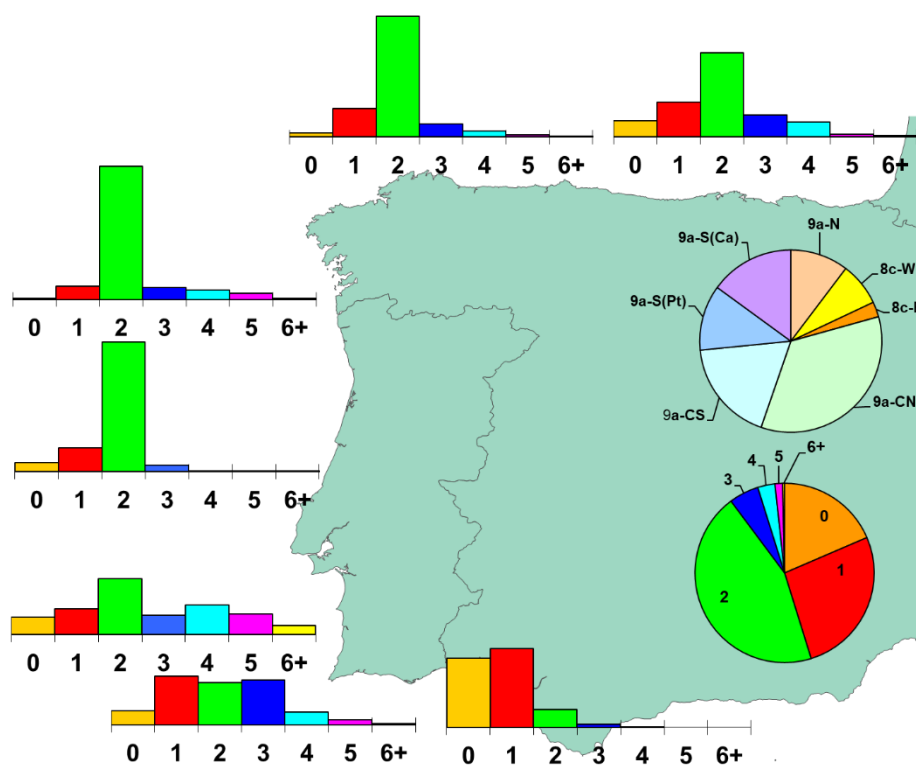


Figure 8.2.4.1. Sardine in 8c and 9a. Relative contribution of each age-class by subdivisions as well as their relative contribution to the 2021 catches (pie-chart).

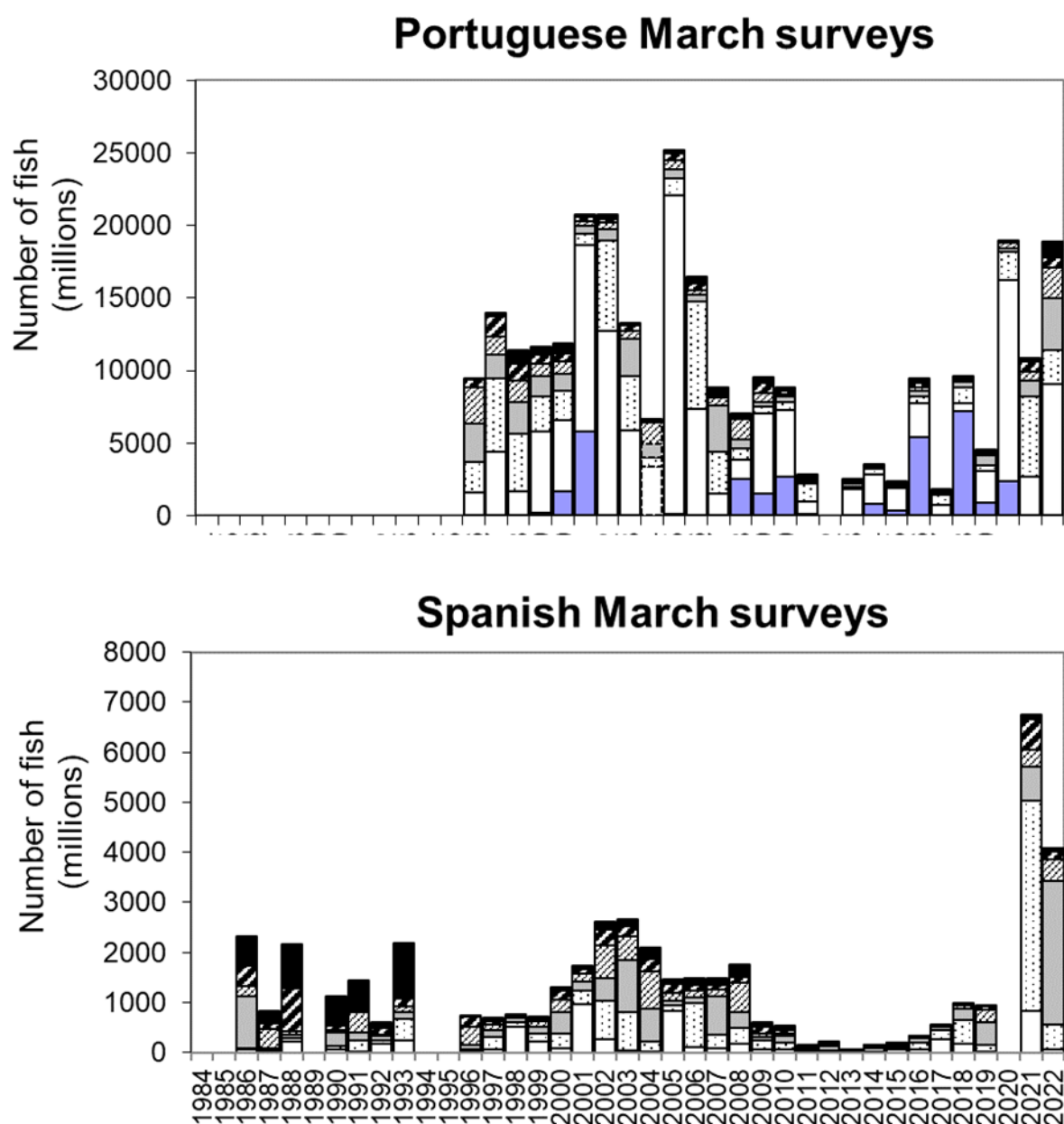


Figure 8.3.1. Sardine in 8c and 9a. Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area 8c and 9a-N (top panel) and the Portuguese March surveys covers 9aCN, 9a-CS, 9aS-Algarve and 9aS-Cadiz subdivisions (bottom panel). Portuguese acoustic survey in June 2004 was only considered as indications of the population abundance and is not included in assessment. Estimates from Portuguese acoustic surveys are not available for 2012 and for Spanish survey in 2020 (years without survey).

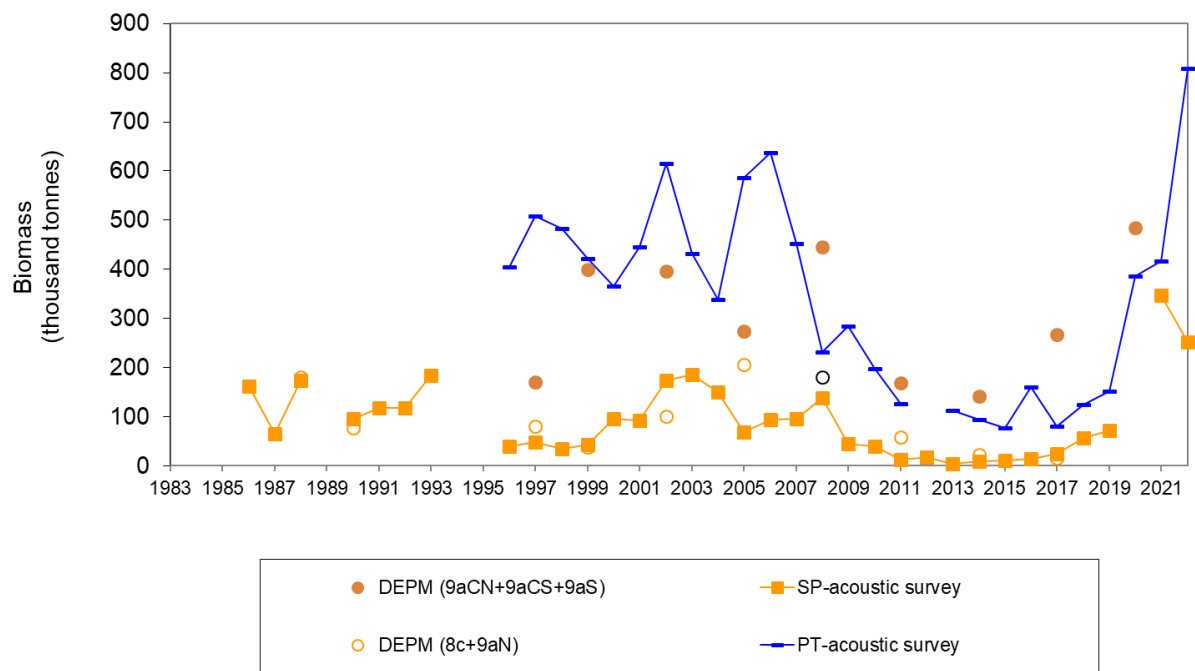


Figure 8.3.2. Sardine in 8c and 9a. Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.



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

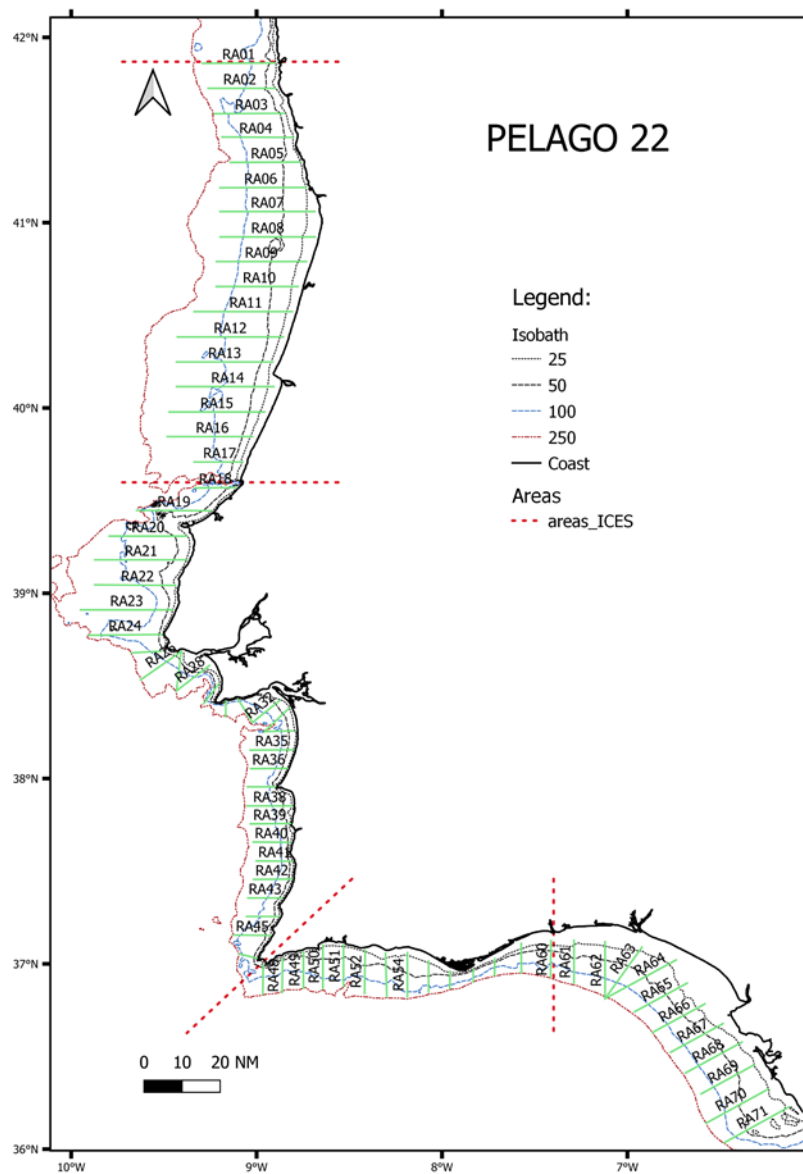


Figure 8.3.2.1.1. Sardine in 8c and 9a. acoustic transects during PELAGO 2022 survey.

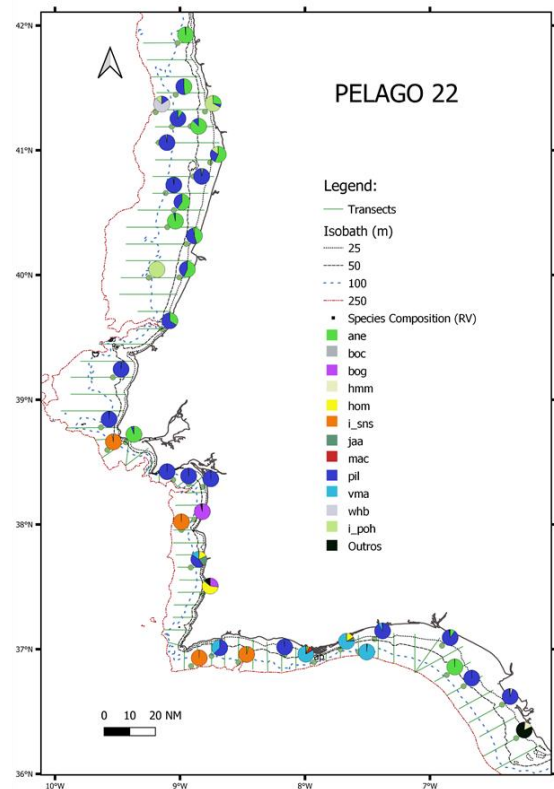
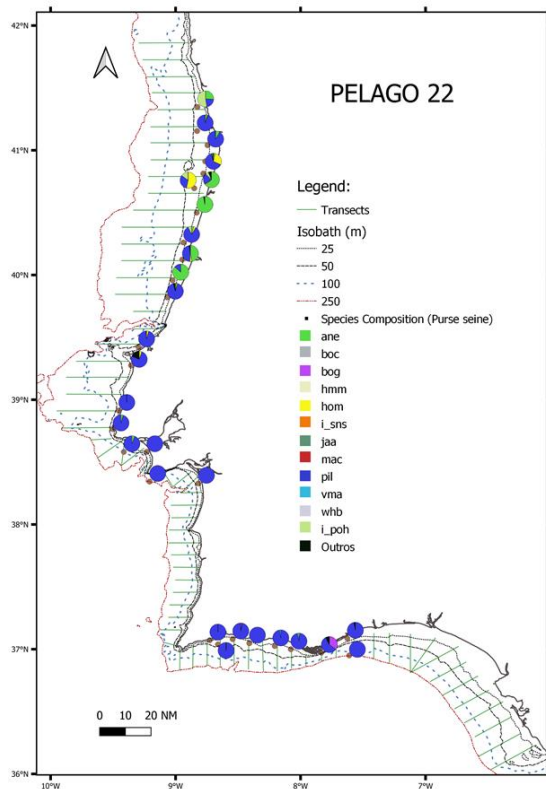


Figure 8.3.2.1.2. Sardine in 8c and 9a. Fishing haul operations during PELAGO 2022 survey. Left) Purse seiners hauls. Right) Research vessels hauls.

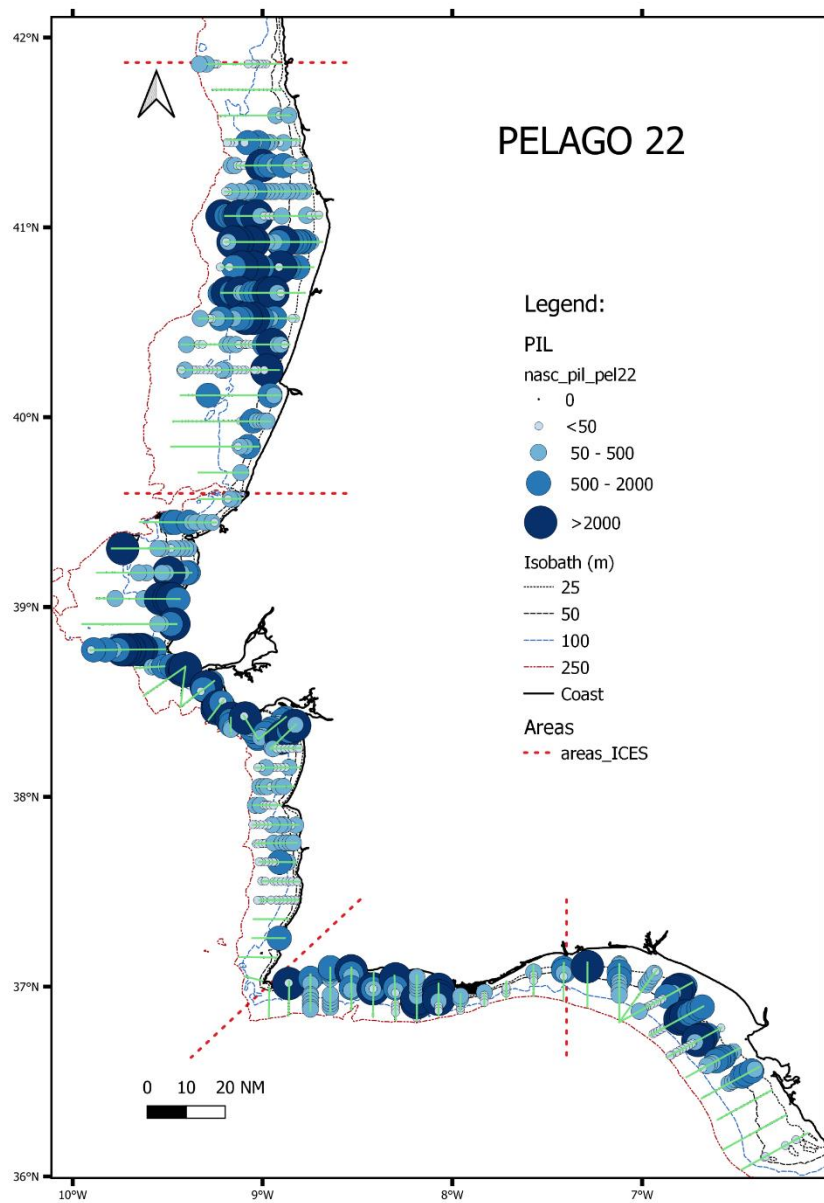


Figure 8.3.2.1.3. Sardine in 8c and 9a. Acoustic energy during PELAGO2022.

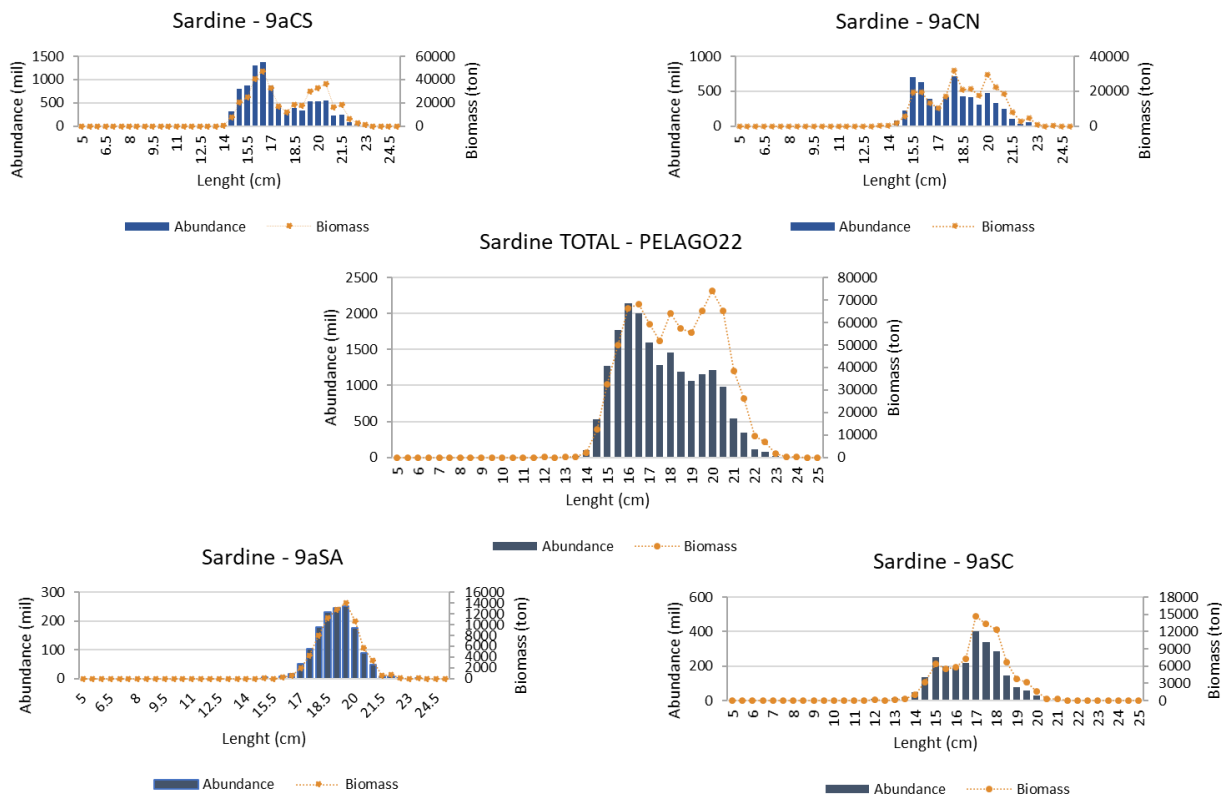


Figure 8.3.2.1.4. Sardine in 8c and 9a. Size composition during PELAGO2022.

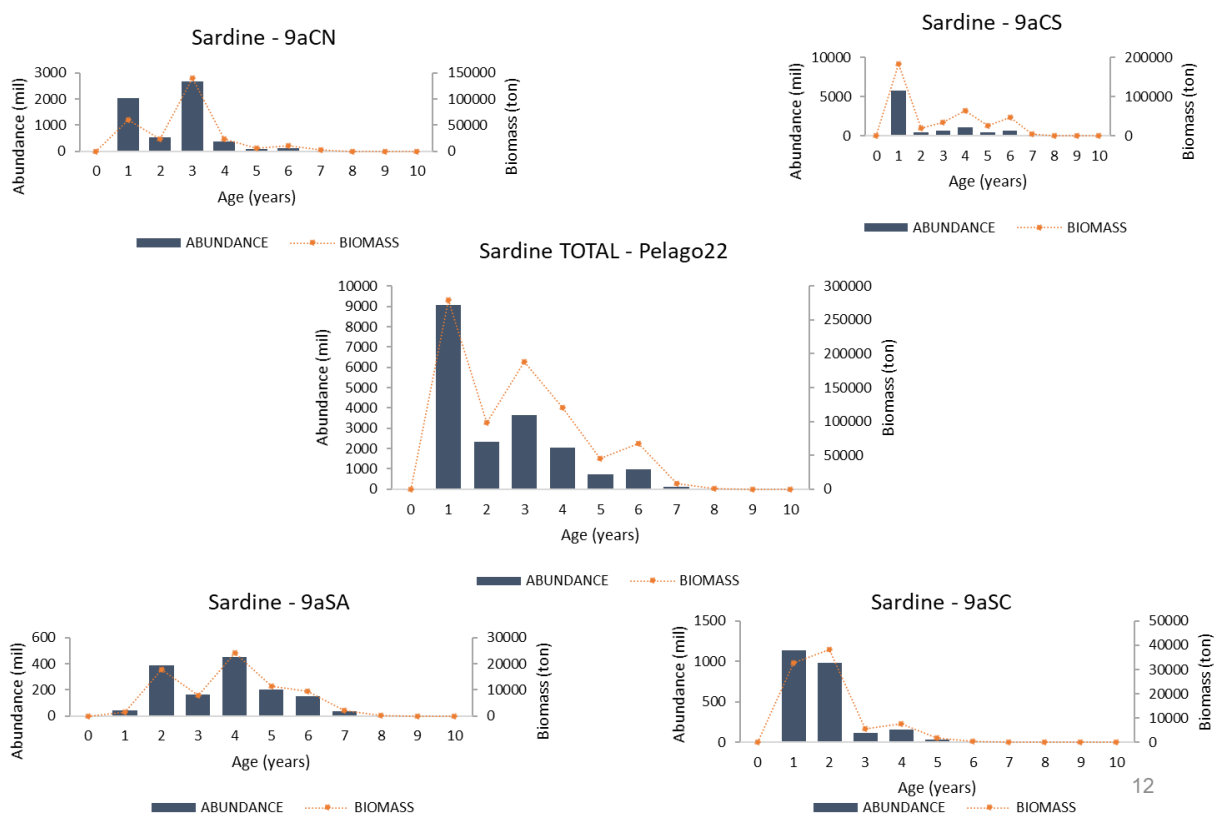


Figure 8.3.2.1.5. Sardine in 8c and 9a. Age composition during PELAGO2022.

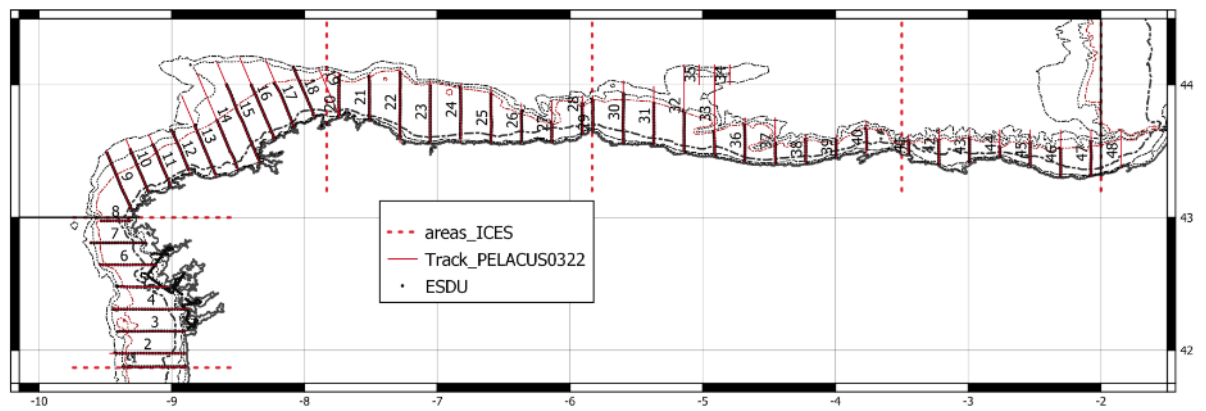


Figure 8.3.2.2.1 Sardine in 8c and 9a. Survey track of PELACUS0422 survey.

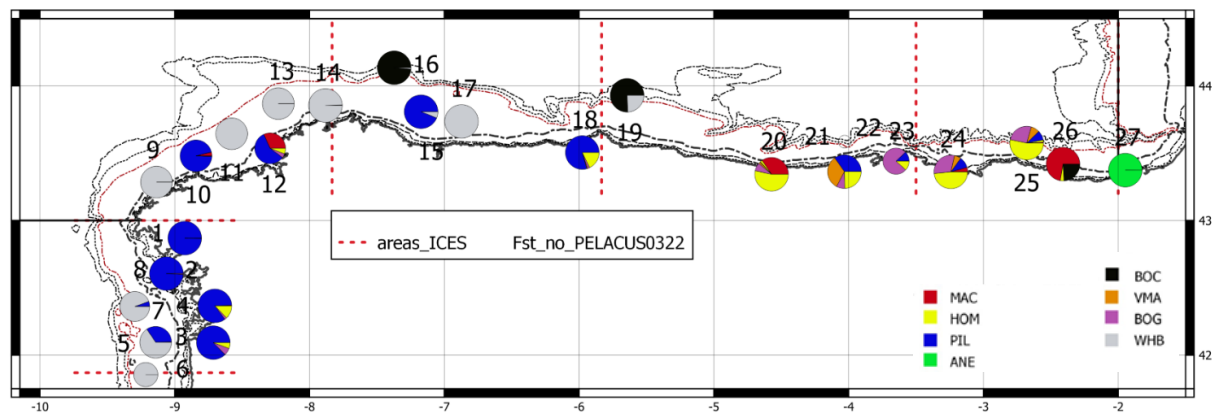


Figure 8.3.2.2.2. Sardine in 8c and 9a. Fishing stations and catch composition (% in number of fish caught) in PELACUS0422 survey.

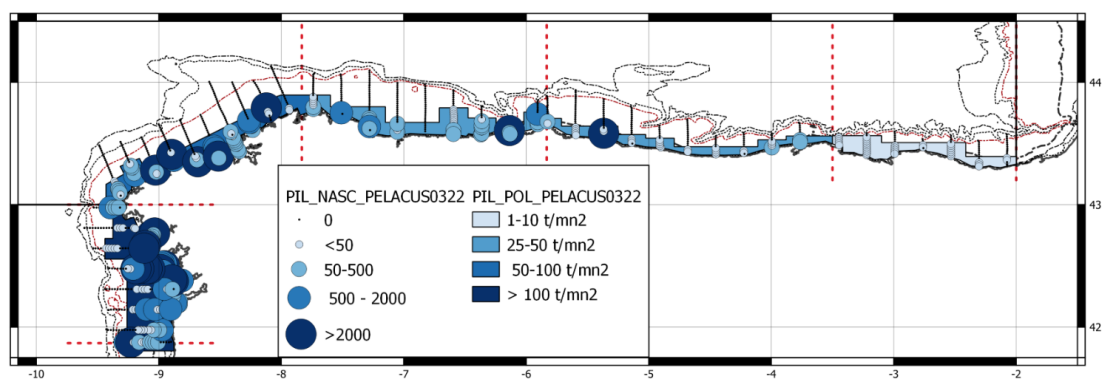


Figure 8.3.2.2.3. Sardine in 8c and 9a. Sardine spatial distribution in PELACUS0422 survey.

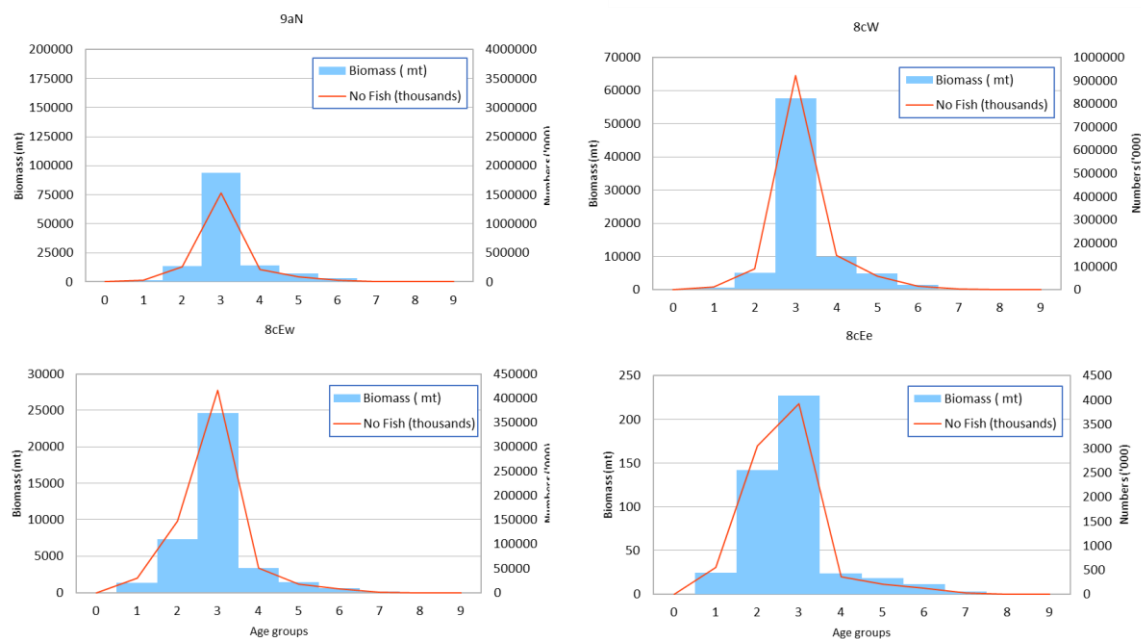


Figure 8.3.2.2.4. Sardine in 8c and 9a. Sardine abundance by age group and area, estimated in PELACUS 0422.

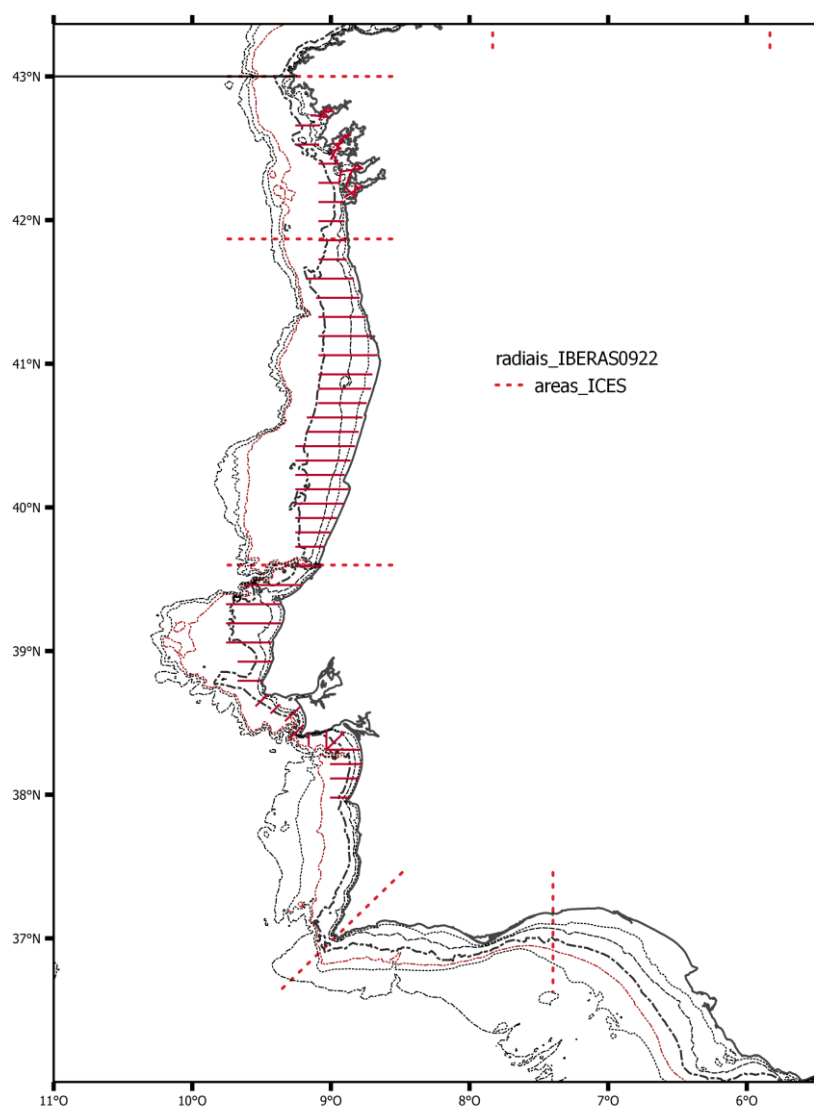


Figure 8.3.3.1. Sardine in 8c and 9a. Survey track of IBERAS0922 survey.

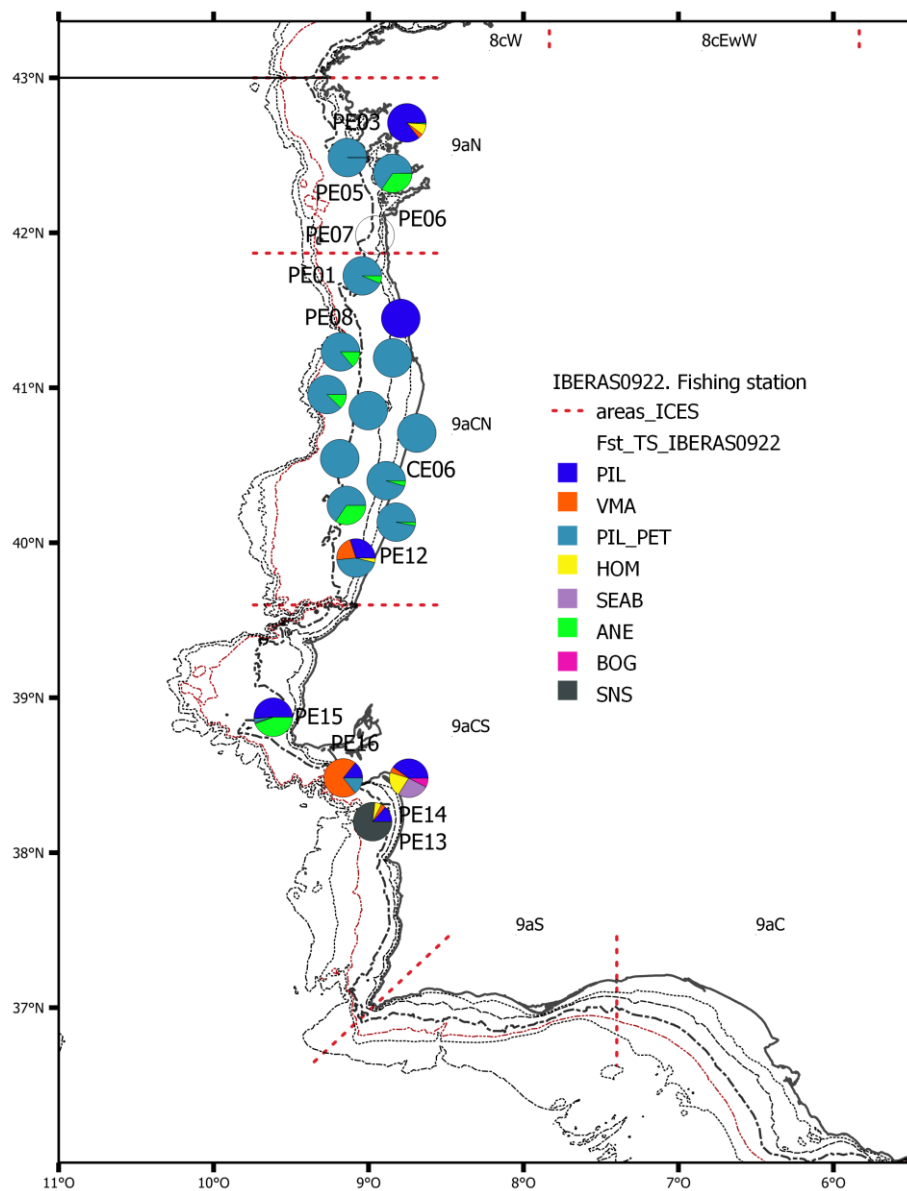
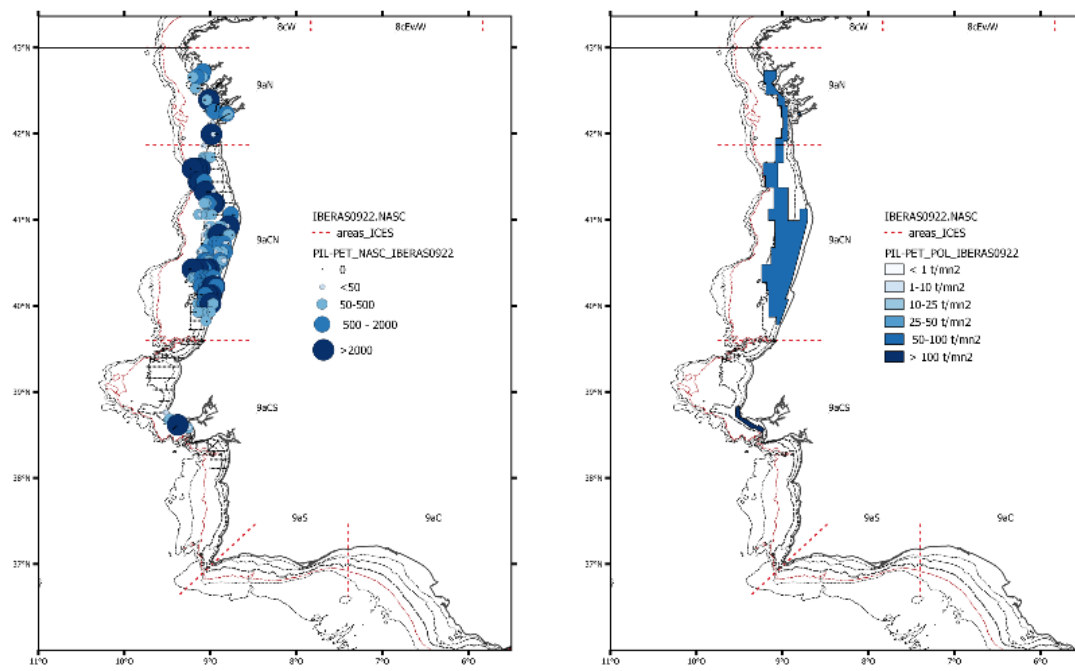


Figure 8.3.3.2. Sardine in 8c and 9a. Fishing stations and catch composition (% in number of fish caught) in IBERAS2022 survey; PIL: adult sardine; PIL_PET: juvenile sardine.



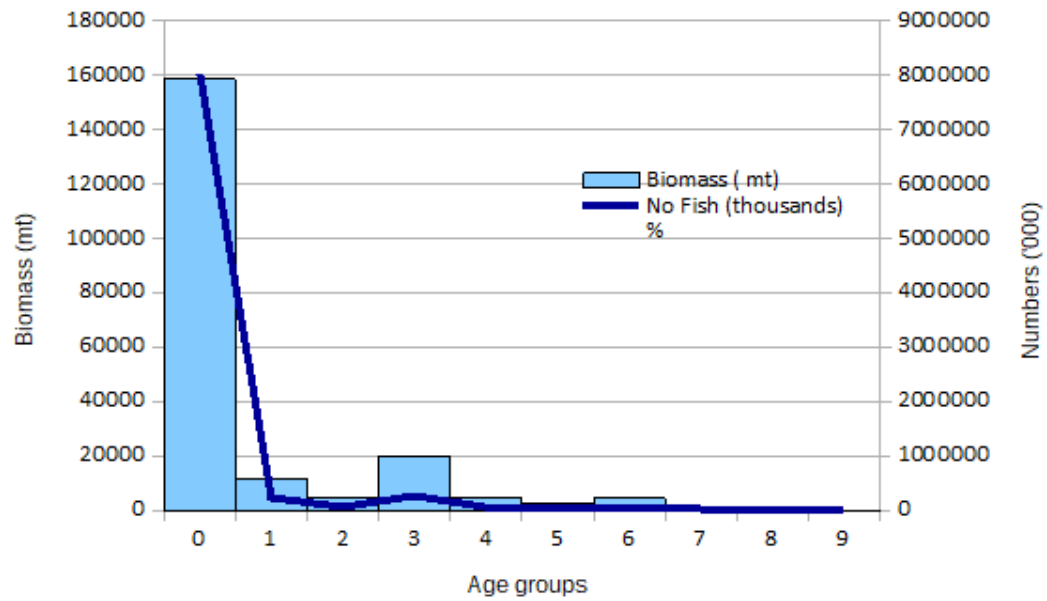


Figure 8.3.3.4. Sardine in 8c and 9a. Sardine abundance and biomass by age group estimated in IBERAS2022 survey.

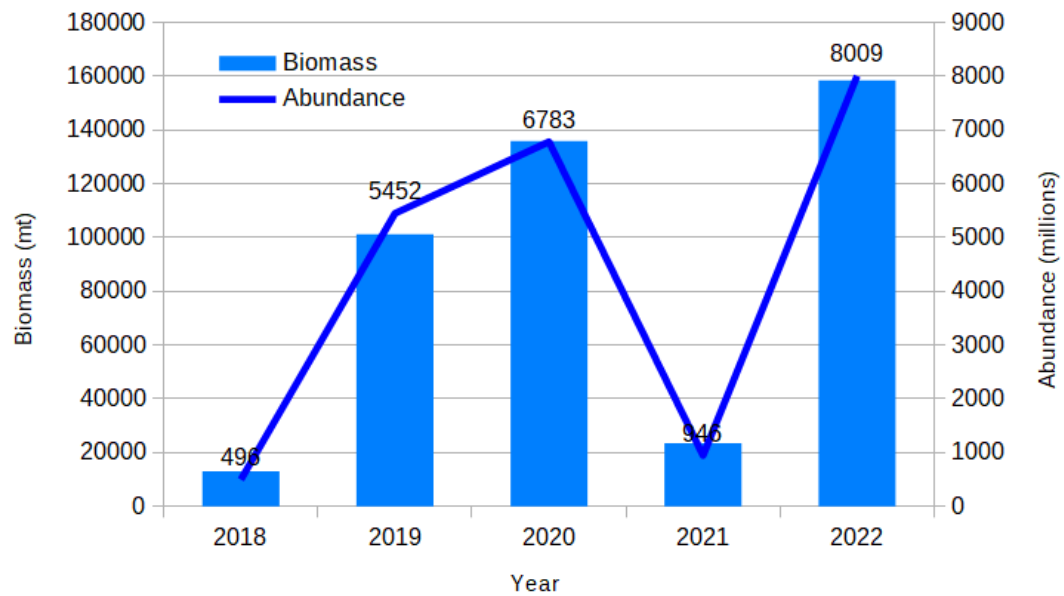


Figure 8.3.3.5. Sardine in 8c and 9a. Age 0 Sardine abundance and biomass in the IBERAS time series.

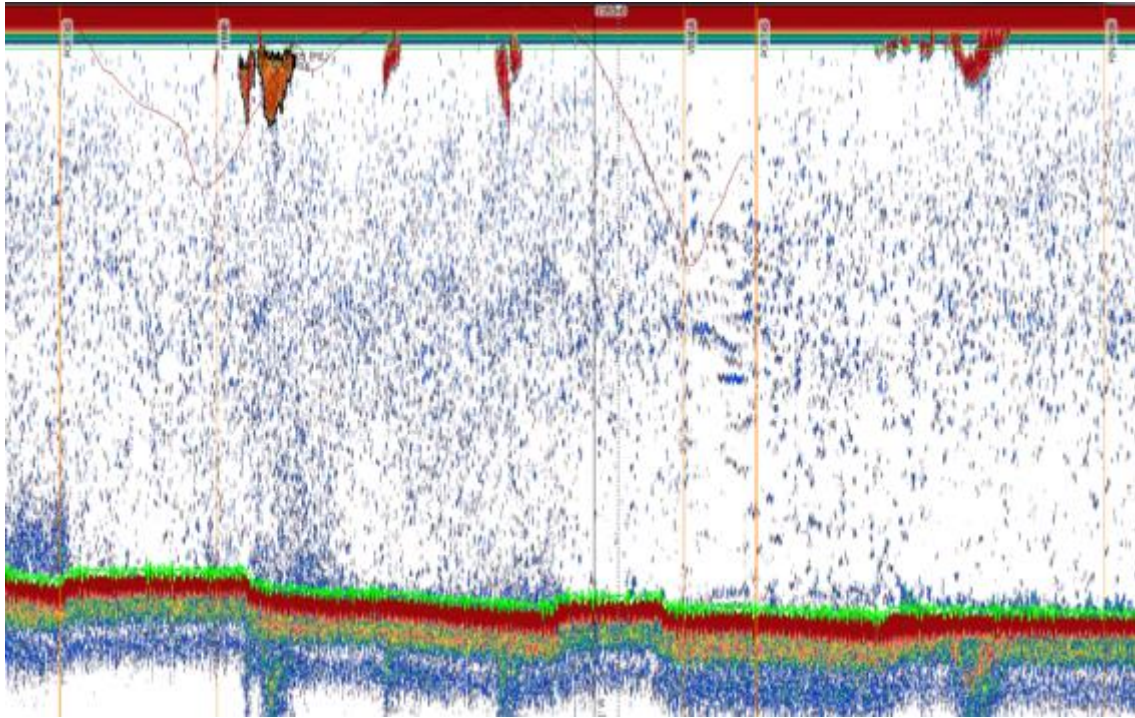


Figure 8.3.3.6. Sardine in 8c and 9a. Echogram showing the location of juvenile sardine schools during the IBERAS22 survey.

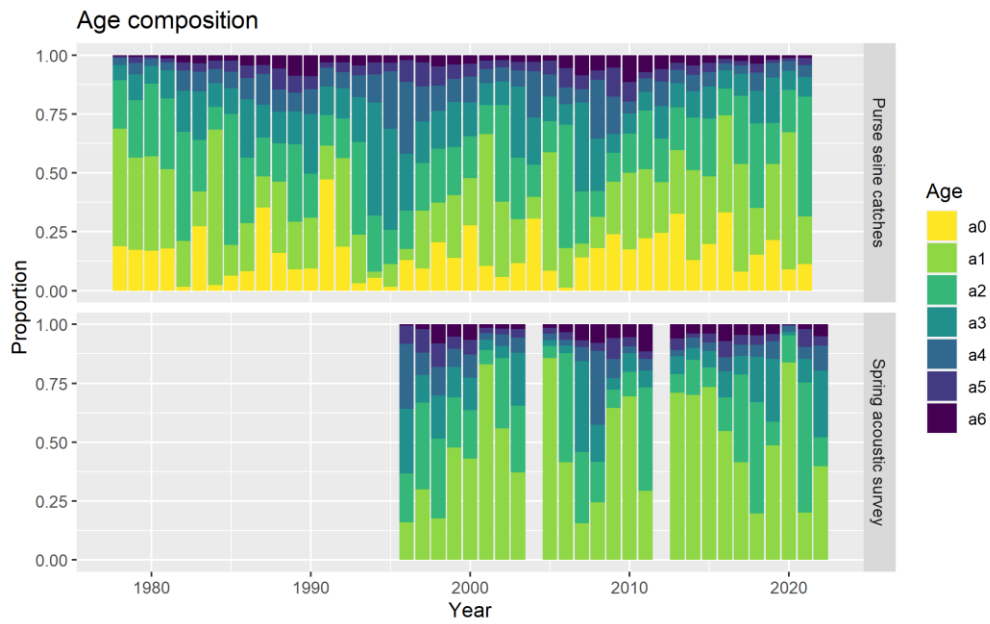


Figure 8.3.8.1. Sardine in 8c and 9a. Catches-at-age for 1978–2021 (top panel) and abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996–2022 (bottom panel).

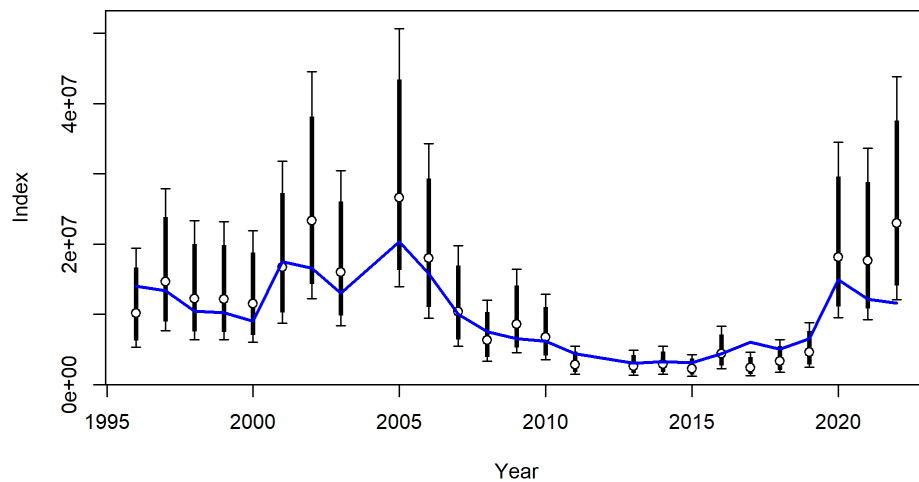


Figure 8.4.1.1. Sardine in 8c and 9a. Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines indicate input uncertainty before addition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

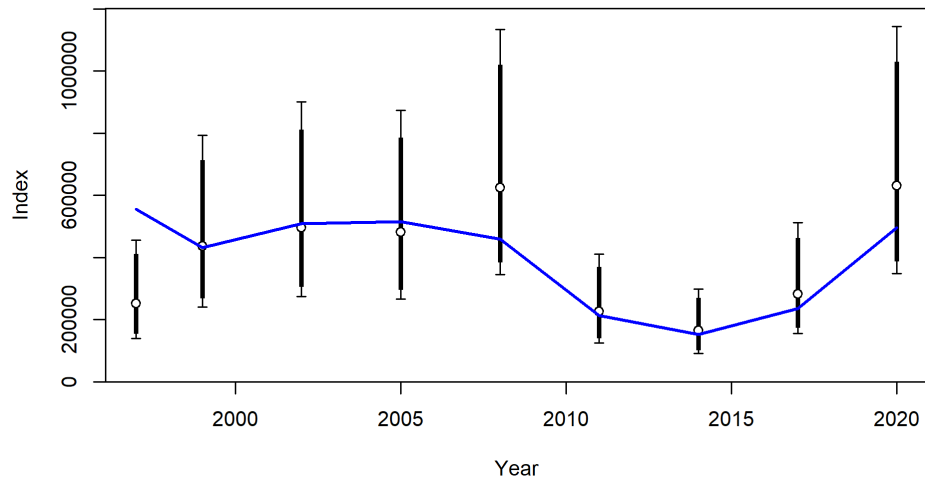


Figure 8.4.1.2. Sardine in 8c and 9a. Model fit to the DEPM survey series. The index is SSB (in thousand tonnes). Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines indicate input uncertainty before addition of estimated additional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

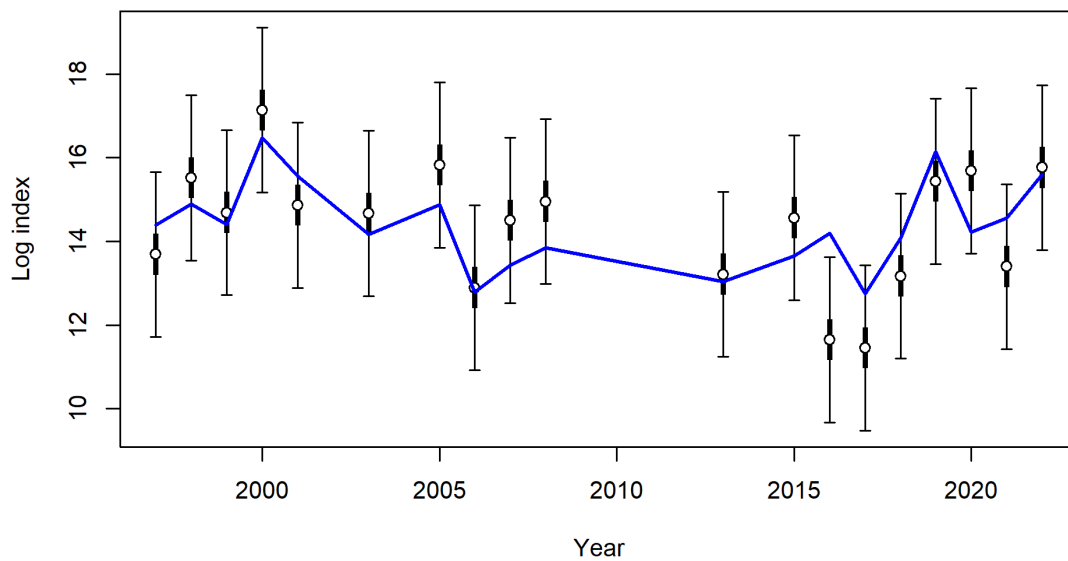


Figure 8.4.1.3. Sardine in 8c and 9a. Model fit to the log autumn acoustic survey series data on log scale. The index is age 0 abundance in subarea 9aCN (in thousand individuals). Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines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

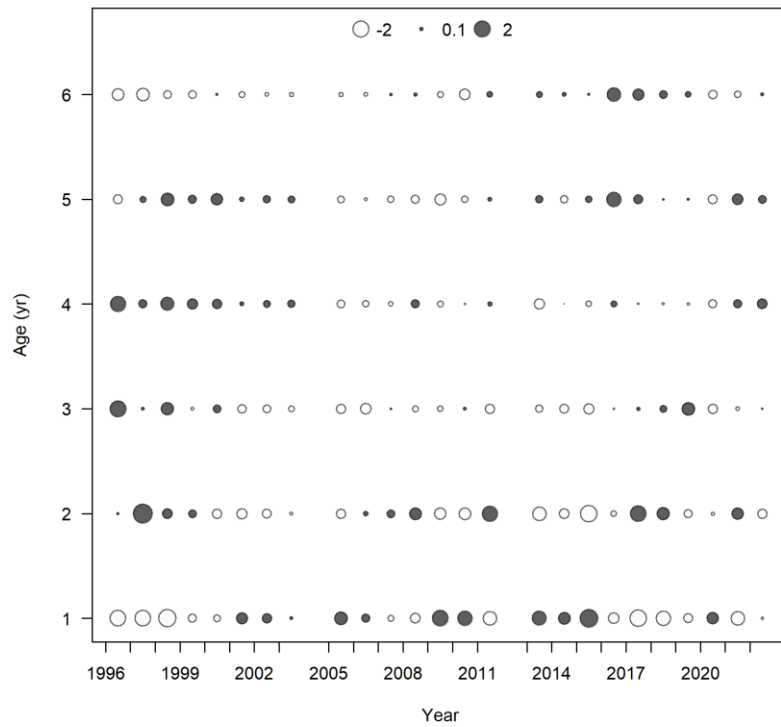
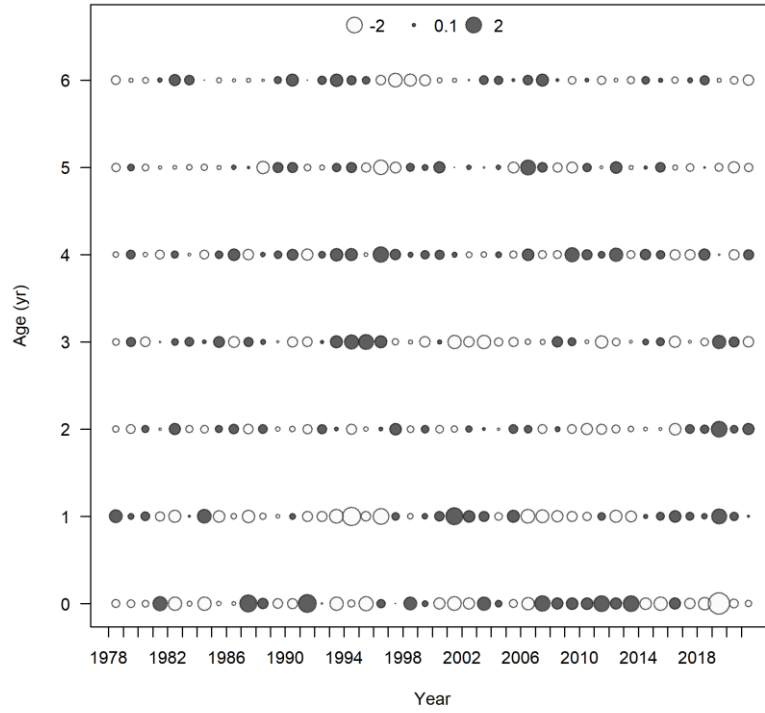


Figure 8.4.1.4. Sardine in 8c and 9a. Model residuals from the fit to the catch-at-age composition (top) and the acoustic survey age composition (bottom).

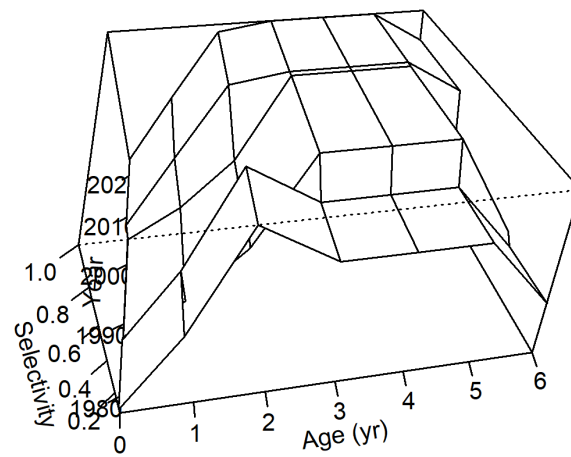


Figure 8.4.1.5. Sardine in 8c and 9a. Selectivity-at-age in the fishery showing the three blocks of fixed selectivity, 1978–1987, 1988–2005 and 2006–2022.

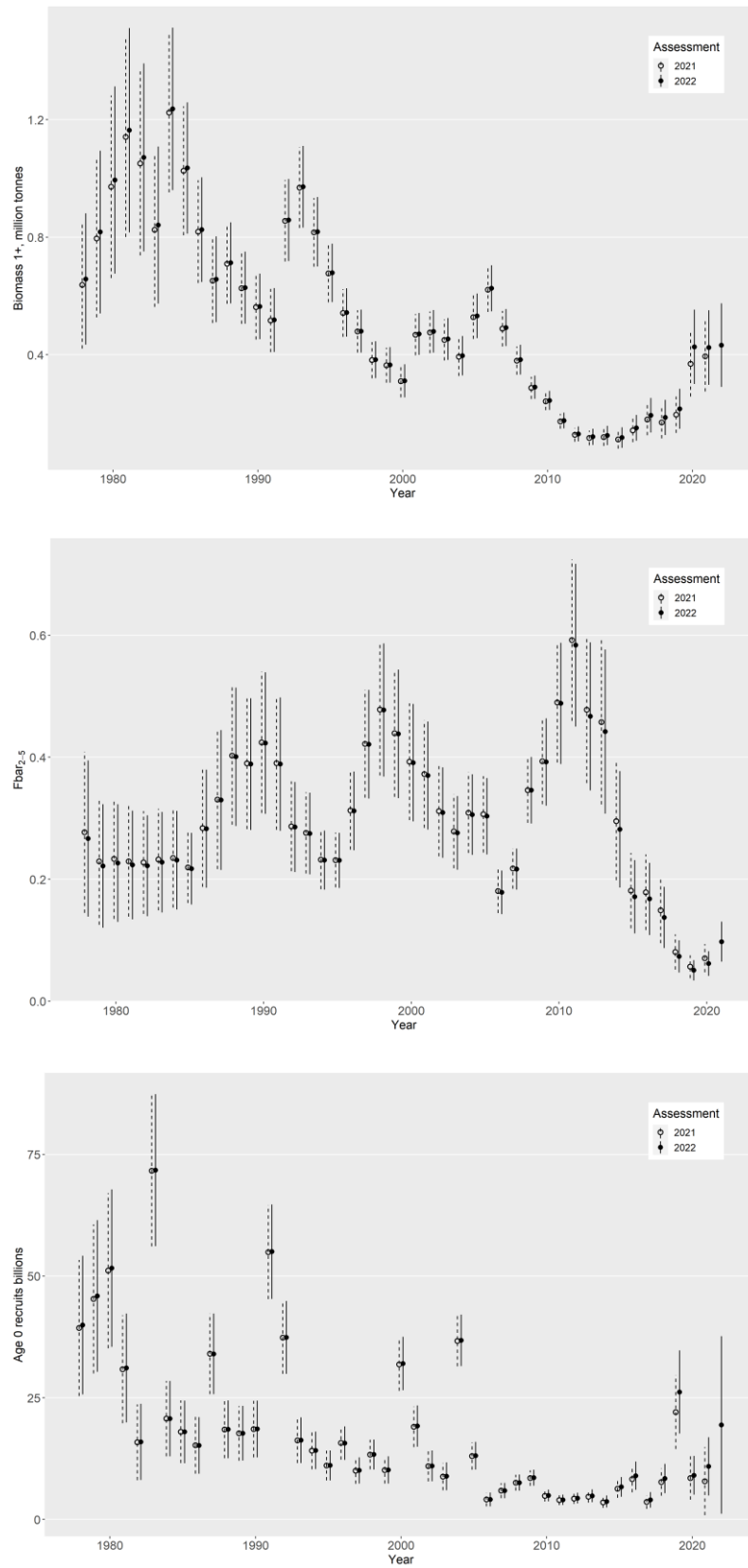


Figure 8.4.1.6. Sardine in 8c and 9a. Historical B1+ (top), $F_{bar(2-5)}$ (middle) and recruitment (bottom) trajectories in the period 1978–2022 (B1+ and recruitment is estimated up to 2022). The updated assessment of 2021 is shown for comparison (open dots and dashed lines).

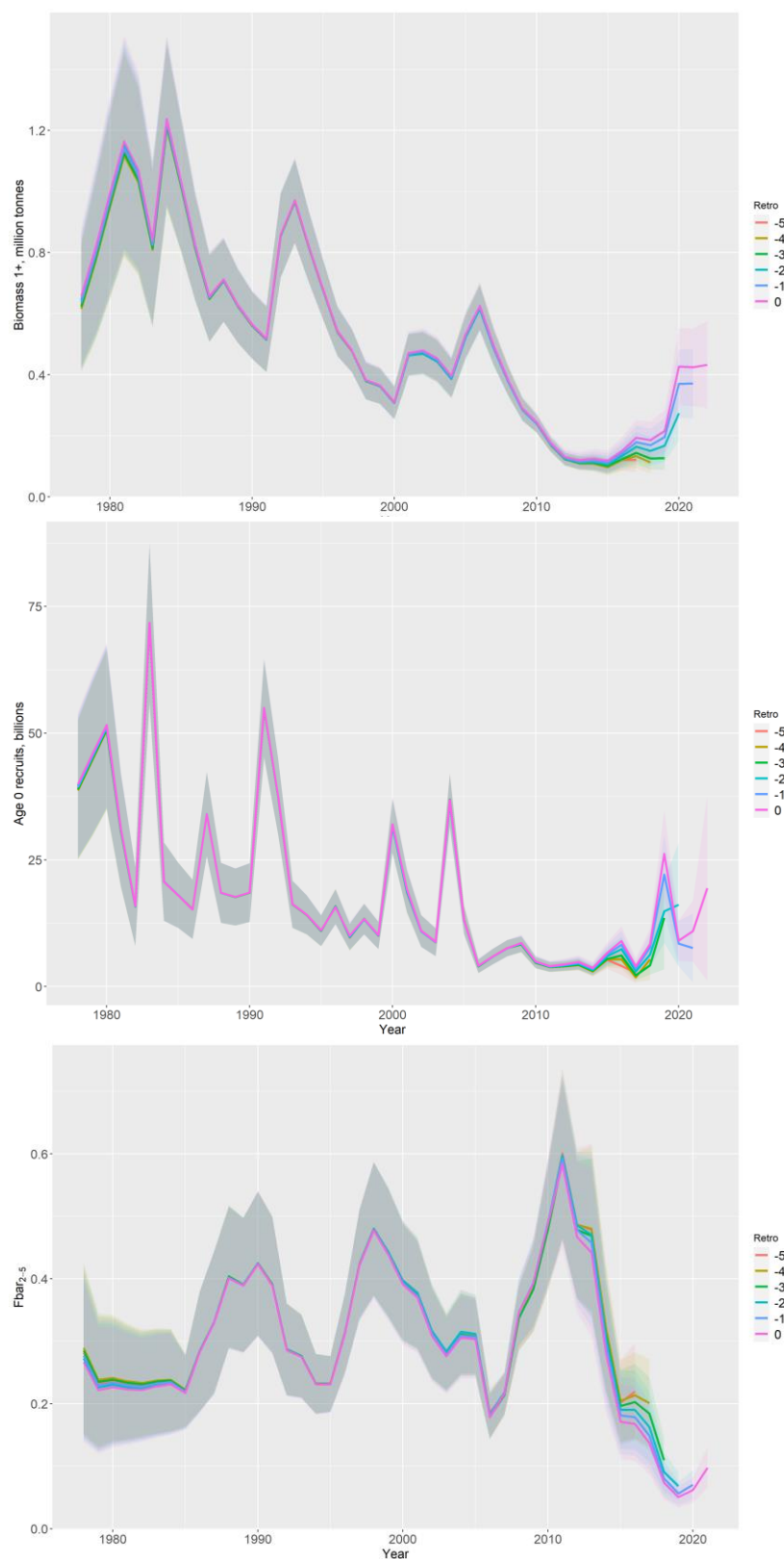


Figure 8.5.1. Sardine in 8c and 9a. Retrospective error for Biomass 1+ (top), recruitment (middle) and $F_{\text{bar } 2-5}$ (bottom) in the assessment.

Table 8.2.2.1. Sardine in 8c and 9a. Quarterly distribution of sardine landings (t) in 2021 by ICES Subdivision. Above absolute values; below, relative numbers.

Sub-Div	1st	2nd	3rd	4th	Total
8cE	35	506	389	221	1152
8cW	2.6	1306	2414	43	3766
9aN	5	1608	3229	268	5109
9aCN		2254	5491	5285	13030
9aCS		2296	4061	2412	8768
9aS-Algarve		1248	2448	1358	5053
9aS-Cadiz	27	598	2462	719	3808
Total	70	9817	20493	10305	40685

Sub-Div	1st	2nd	3rd	4th	Total
8cE	0.09	1.24	0.96	0.54	2.83
8cW	0.01	3.21	5.93	0.11	9.26
9aN	0.01	3.95	7.94	0.66	12.56
9aCN	0.00	5.54	13.50	12.99	32.03
9aCS	0.00	5.64	9.98	5.93	21.55
9aS-Algarve	0.00	3.07	6.02	3.34	12.42
9aS-Cadiz	0.07	1.47	6.05	1.77	9.36
Total	0.17	24.13	50.37	25.33	

Table 8.2.2.2. Sardine in 8c and 9a. Iberian Sardine Landings (tonnes) by subdivision for the period 1940-2021.

Year	Subdivision					
	8c	9a North	9a Central North	9a Central South	9a South Algarve	9a South Cadiz
1940	66816		42132	33275	23724	
1941	27801		26599	34423	9391	
1942	47208		40969	31957	8739	
1943	46348		85692	31362	15871	
1944	76147		88643	31135	8450	
1945	67998		64313	37289	7426	
1946	32280		68787	26430	12237	
1947	43459	21855	55407	25003	15667	
1948	10945	17320	50288	17060	10674	
1949	11519	19504	37868	12077	8952	
1950	13201	27121	47388	17025	17963	
1951	12713	27959	43906	15056	19269	
1952	7765	30485	40938	22687	25331	
1953	4969	27569	68145	16969	12051	
1954	8836	28816	62467	25736	24084	
1955	6851	30804	55618	15191	21150	
1956	12074	29614	58128	24069	14475	
1957	15624	37170	75896	20231	15010	
1958	29743	41143	92790	33937	12554	
1959	42005	36055	87845	23754	11680	
1960	38244	60713	83331	24384	24062	
1961	51212	59570	96105	22872	16528	
1962	28891	46381	77701	29643	23528	
1963	33796	51979	86859	17595	12397	
1964	36390	40897	108065	27636	22035	
1965	31732	47036	82354	35003	18797	
1966	32196	44154	66929	34153	20855	
1967	23480	45595	64210	31576	16635	
1968	24690	51828	46215	16671	14993	
1969	38254	40732	37782	13852	9350	
1970	28934	32306	37608	12989	14257	
1971	41691	48637	36728	16917	16534	
1972	33800	45275	34889	18007	19200	
1973	44768	18523	46984	27688	19570	
1974	34536	13894	36339	18717	14244	
1975	50260	12236	54819	19295	16714	
1976	51901	10140	43435	16548	12538	
1977	36149	9782	37064	17496	20745	
1978	43522	12915	34246	25974	23333	5619
1979	18271	43876	39651	27532	24111	3800
1980	35787	49593	59290	29433	17579	3120
1981	35550	65330	61150	37054	15048	2384
1982	31756	71889	45865	38082	16912	2442
1983	32374	62843	33163	31163	21607	2688
1984	27970	79606	42798	35032	17280	3319
1985	25907	66491	61755	31535	18418	4333
1986	39195	37960	57360	31737	14354	6757
1987	36377	42234	44806	27795	17613	8870
1988	40944	24005	52779	27420	13393	2990
1989	29856	16179	52585	26783	11723	3835
1990	27500	19253	52212	24723	19238	6503
1991	20735	14383	44379	26150	22106	4834
1992	26160	16579	41681	29968	11666	4196
1993	24486	23905	47284	29995	13160	3664
1994	22181	16151	49136	30390	14942	3782
1995	19538	13928	41444	27270	19104	3996

Table 8.2.2.2 (cont.). Sardine in 8c and 9a. Iberian Sardine Landings (tonnes) by subdivision for the period 1940-2021.

Year	Subdivision					
	8c	9aNorth	9a Central North	9a Central South	9a South Algarve	9a South Cadiz
1996	14423	11251	34761	31117	19880	5304
1997	15587	12291	34156	25863	21137	6780
1998	16177	3263	32584	29564	20743	6594
1999	11862	2563	31574	21747	18499	7846
2000	11697	2866	23311	23701	19129	5081
2001	16798	8398	32726	25619	13350	5066
2002	15885	4562	33585	22969	10982	11689
2003	16436	6383	33293	24635	8600	8484
2004	18306	8573	29488	24370	8107	9176
2005	19800	11663	25696	24619	7175	8391
2006	15377	10856	30152	19061	5798	5779
2007	13380	12402	41090	19142	4266	6188
2008	13636	9409	45210	20858	4928	7423
2009	11963	7226	36212	20838	4785	6716
2010	13772	7409	40923	17623	5181	4662
2011	8536	5621	37152	13685	6387	9023
2012	13090	4154	19647	9045	2891	6031
2013	5272	2128	15065	9084	4112	10157
2014	4344	1924	6889	6747	2398	5635
2015	1916	1946	7117	4848	1812	2956
2016	2886	2887	7695	4031	1972	3233
2017	2251	2225	5182	6676	2836	2742
2018	2764	856	3579	4759	1400	1704
2019	1608	1076	3520	4290	1986	1280
2020	2822	1950	5049	7560	2807	1955
2021	4918	5109	13031	8767	5052	3808

Table 8.2.4.1. Sardine in 8c and 9a. Sardine length composition (thousands), mean length (cm) and catch (t) by ICES subdivision in 2021.

Length	Subdivision							Total
	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S (Ca)	
6.5								
7								
7.5							6	6
8							27	27
8.5							20	20
9							29	29
9.5							47	47
10							144	144
10.5							589	589
11	7						577	584
11.5							897	897
12	34						1 431	1 466
12.5	55				245		2 998	3 299
13	128				403		5 860	6 391
13.5	246			205	1 706		10 364	12 522
14	447	211	3	473	3 145	153	14 019	18 450
14.5	287	351	10	3 646	2 226		18 440	24 961
15	237	702	28	4 671	2 264	268	13 451	21 620
15.5	215	1 334	61	8 947	3 618	2 022	14 149	30 347
16	553	941	75	18 564	6 560	5 194	7 638	39 525
16.5	906	726	374	16 354	3 929	10 050	8 519	40 858
17	1 569	716	2 383	41 723	7 418	11 964	5 473	71 245
17.5	1 721	2 143	7 164	64 132	11 240	11 293	3 089	100 781
18	2 626	3 974	13 348	48 924	13 356	11 963	1 630	95 821
18.5	2 688	9 288	16 022	24 050	9 904	12 219	1 261	75 431
19	2 684	12 648	11 196	17 236	13 257	10 858	1 640	69 520
19.5	2 233	11 569	8 026	8 621	17 340	6 268	548	54 606
20	1 502	6 797	5 610	3 674	14 558	3 429	588	36 158
20.5	871	3 244	3 486	969	11 079	1 306	211	21 166
21	611	1 639	2 985	151	5 073	739	49	11 246
21.5	269	924	2 560	244	3 219	326	13	7 554
22	302	538	2 495	126	2 672	13		6 146
22.5	84	180	1 665		1 964	13		3 905
23	107	275	686	21	1 404			2 493
23.5	11	29	128	21	586			775
24		2	30		240			272
24.5					125			125
25								
25.5								
26								
26.5								
Total	20 394	58 230	78 336	262 750	137 530	88 078	113 708	759 026
Mean								
L	18.6	19.2	NA	17.7	18.8	18.1	15.2	17.9
sd	1.83	1.36	NA	1.11	2.07	1.24	1.62	1.95
Catch	1152	3766	5109	13031	8767	5052	3808	40685

Table 8.2.4.1a. Sardine in 8c and 9a. Sardine length composition (thousands) , mean length (cm) and catch (t) by ICES subdivision in the first quarter 2021.

Length	First Quarter							Total
	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S (Ca)	
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11	7							7
11.5								
12	34							34
12.5	49							49
13	71							71
13.5	122							122
14	234							234
14.5	148						47	195
15	63						125	188
15.5	16						362	378
16	21	1					196	218
16.5	43		1				113	157
17	174	5	5				21	205
17.5	124		9				17	150
18	66	10	18					94
18.5	32		16				33	81
19	15	14	13					42
19.5	6		5					11
20	12	12	6					31
20.5	3		2					5
21	4	6	4					14
21.5			2					2
22		1	2					3
22.5			1					1
23								
23.5								
24								
24.5								
25								
25.5								
26								
26.5								
Total	1 245	50	82				914	2 291
Mean L	15.5	19.4	19.0				16.0	15.9
sd	1.99	1.31	1.24				0.79	1.78
Catch	35	2. 637	5				27	4 597

Table 8.2.4.1b. Sardine in 8c and 9a. Sardine length composition (thousands) , mean length (cm) and catch (t) by ICES subdivision in the second quarter 2021.

Second Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5							5	5
11							10	10
11.5							379	379
12							859	859
12.5	7						2 349	2 356
13	16						4 745	4 761
13.5	44						5 940	5 984
14	63	211	3				5 277	5 553
14.5	59	351	10				2 828	3 249
15	62	702	28			240	1 702	2 734
15.5	56	1 334	61		42	1 468	1 336	4 297
16	125	894	75	130	600	2 622	132	4 577
16.5	219	605	233	4 118	956	3 487	242	9 861
17	351	229	1 359	14 238	4 922	3 606		24 706
17.5	525	796	3 540	19 386	6 863	4 318		35 427
18	1 197	2 140	6 378	9 186	4 358	3 945	8	27 211
18.5	1 339	4 545	6 552	2 081	2 450	2 979		19 947
19	1 298	3 898	3 991	337	2 832	1 513		13 869
19.5	1 038	4 256	1 933	41	2 875	744		10 886
20	868	2 193	1 288	20	3 848	578		8 795
20.5	509	1 019	865		2 916	307		5 616
21	369	276	963		2 195	246		4 047
21.5	182	264	816		1 240	129		2 632
22	256	228	638		668	13		1 803
22.5	78	33	265		511	13		901
23	107	99	42		206			453
23.5	11		23		66			100
24					21			21
24.5					21			21
25								
25.5								
26								
26.5								
Total	8 778	NA	NA	49 537	37 589	26 209	NA	201 061
Mean L	19.2	NA	NA	17.7	19.	17.7	NA	17.8
sd	1.63	NA	NA	0.51	1.60	1.24	NA	2.03
Catch	506	1 306	1 608	2 254	2 296	1 248	598	9 817

Table 8.2.4.1c. Sardine in 8c and 9a. Sardine length composition (thousands) , mean length (cm) and catch (t) by ICES subdivision in the third quarter 2021.

Third Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
7								
7.5								
8							7	7
8.5							6	6
9							10	10
9.5							41	41
10							116	116
10.5							540	540
11							537	537
11.5							505	505
12							275	275
12.5					245		519	764
13					403		719	1 121
13.5				205	1 573		4 059	5 837
14				454	2 877	153	8 344	11 829
14.5				279	2 077		15 021	17 377
15	2			351	998	28	11 080	12 460
15.5	11			821	2 428	554	12 104	15 919
16	108	46		1 939	4 175	2 572	6 414	15 253
16.5	200	119	141	6 506	2 194	6 563	6 410	22 133
17	358	473	1 019	23 131	832	8 357	3 605	37 776
17.5	496	1 324	3 615	35 393	785	6 087	999	48 699
18	725	1 791	6 952	27 402	2 214	6 144	2	45 231
18.5	872	4 659	9 454	9 328	3 332	5 492	13	33 150
19	1 009	8 582	7 192	3 327	7 962	4 118	83	32 274
19.5	959	7 183	6 089	749	11 887	1 481		28 347
20	506	4 511	4 316	218	9 306	385		19 241
20.5	287	2 185	2 590	91	6 969	210		12 331
21	205	1 333	1 960		2 306			5 804
21.5	76	648	1 535		686			2 946
22	40	304	939	84	281			1 648
22.5		144	602		85			831
23		173	231		28			432
23.5		29	16					45
24		2	1		11			14
24.5								
25								
25.5								
26								
26.5								
Total	5 855	33 505	46 652	110 277	63 654	42 145	71 411	373 499
Mean L	19.0	19.6	19.4	17.8	18.6	17.8	15.2	17.8
sd	1.21	1.01	1.23	0.76	2.21	1.03	1.22	1.92
Catch	389	2 414	3 229	5 491	4 061	2 448	2 462	20 493

Table 8.2.4.1d. Sardine in 8c and 9a. Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2021.

Fourth Quarter								
Length	8c E	8c W	9a N	9a CN	9a CS	9a S	9a S-C	Total
6.5								
7								
7.5							6	6
8							20	20
8.5							14	14
9							19	19
9.5							6	6
10							28	28
10.5							44	44
11							30	30
11.5							12	12
12							297	297
12.5							130	130
13	40						397	437
13.5	80				134		365	579
14	150			19	267		398	834
14.5	80			3 367	149		544	4 140
15	110			4 319	1 266		543	6 238
15.5	132			8 125	1 148		347	9 753
16	300	1		16 496	1 785		895	19 476
16.5	443	2		5 730	778		1 754	8 707
17	686	9		4 354	1 664		1 847	8 558
17.5	576	24		9 353	3 593	888	2 073	16 506
18	639	32		12 336	6 784	1 874	1 620	23 285
18.5	444	84		12 640	4 122	3 748	1 215	22 253
19	362	154		13 573	2 463	5 227	1 557	23 336
19.5	230	129		7 832	2 579	4 043	548	15 362
20	117	81		3 436	1 404	2 466	588	8 091
20.5	73	39	30	878	1 194	789	211	3 214
21	33	24	59	151	572	493	49	1 380
21.5	10	12	207	244	1 293	197	13	1 974
22	6	5	915	42	1 723			2 692
22.5	6	3	797		1 368			2 173
23		3	413	21	1 170			1 607
23.5		1	89	21	520			630
24			30		208			238
24.5					104			104
25								
25.5								
26								
26.5								
Total	4 516	602	2 539	102 936	36 286	19 724	15 570	182 174
Mean L	17.6	19.6	22.6	17.7	19.	19.4	17.2	18.2
sd	1.61	1.01	.58	1.55	2.19	.81	2.04	1.89
Catch	221	43	268	5 285	2 412	1 358	719	10 305

Table 8.2.4.2. Sardine in 8c and 9a. Catch in numbers (thousands) at age by quarter and by subdivision in 2021.

Age	First Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C
0							
1	836		1				384
2	345	2	68				415
3	52	35	7				76
4	10	6	3				36
5	1	3	3				3
6		3					
7							
8							
9							
10							
11							
12							
Total	1 245	50	83				914
Catch (Tons)	35	3	5				27

Age	Second Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C
0							
1	761	4 137	282	7	7 946	4 751	23 219
2	5 785	16 607	24 202	46 440	11 812	8 819	2 163
3	1 136	1 899	2 395	3 090	3 897	8 902	268
4	886	817	976		2 393	2 546	156
5	134	553	1 083		9 153	967	6
6	38	59	124		1 362	224	
7	38	2			924		
8					73		
9					28		
10							
11							
12							
Total	8 778	24 073	29 062		37 589	26 209	25 813
Catch (Tons)	506 1 306	1 608	2 254	2 296	1 248		598

Age	Third Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C
0	516	1 369	560	4 128	8 288	7 245	42 939
1	1 135	5 283	5 545	27 127	8 659	17 424	23 327
2	2 351	22 999	34 783	77 570	14 476	10 573	4 703
3	940	2 468	2 348	1 436	8 755	5 215	441
4	648	1 108	2 266		18 678	1 688	2
5	164	208	894		3 808		
6	101	71	140		727		
7					197		
8					64		
9							
10							
11							
12							
Total	5 855	33 505	46 536	110 261	63 654	42 145	71 411
Catch (Tons)	389	2 414	3 229	5 491	4 061	2 448	2 462

Age	Fourth Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C
0	1 364	25		9 921	5 042	3 140	3 414
1	1 297	95	3	9 338	3 275	2 661	5 839
2	1 191	414	74	76 959	16 983	9 271	4 519
3	413	44	601	5 255	2 168	2 547	1 443
4	189	20	986	851	1 969	1 760	312
5	44	4	651	467	3 097	345	43
6	19	1	12	124	1 751		
7			23		2 002		
8				21			
9							
10							
11							
12							
Total	4 516	602	2 348	102 936	36 286	106 462	15 570
Catch (Tons)	221	43	268	5 285	2 412	1 358	719

Age	Whole Year						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-C
0	1 880	1 394	560	14 049	13 330	10 384	46 353
1	4 029	9 515	5 830	36 473	19 880	24 837	52 769
2	9 672	40 022	59 127	200 969	43 272	28 663	11 801
3	2 541	4 445	5 351	9 781	14 821	16 664	2 227
4	1 734	1 951	4 231	851	23 040	5 994	506
5	343	768	2 631	467	16 058	1 312	52
6	158	133	276	124	3 840	224	
7	38	2	23		3 123		
8				21	137		
9					28		
10							
11							
12							
Total	20 394	58 230	78 030	262 734	137 530	88 078	113 708
Catch (Tons)	1 152	3 766	5 109	13 030	8 768	5 053	3 808

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

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	869437	2296650	946698	295360	136661	41744	16468
1979	674489	1535560	956132	431466	189107	93185	36038
1980	856671	2037400	1561970	378785	156922	47302	30006
1981	1025960	1934840	1733730	679001	195304	104545	76466
1982	62000	795000	1869000	709000	353000	131000	129000
1983	1070000	577000	857000	803000	324000	141000	139000
1984	118000	3312000	487000	502000	301000	179000	117000
1985	268000	564000	2371000	469000	294000	201000	103000
1986	304000	755000	1027000	919000	333000	196000	167000
1987	1437000	543000	667000	569000	535000	154000	171000
1988	521000	990000	535000	439000	304000	292000	189000
1989	248000	566000	909000	389000	221000	2.00E+05	245000
1990	258000	602000	517000	707000	295000	151000	248000
1991	1580580	477368	436081	406886	265762	74726	105186
1992	498265	1001860	451367	340313	186234	110932	80579
1993	87808	566221	1081820	521458	257209	113871	120282
1994	120797	60194	542163	1094440	272466	112635	72091
1995	30512	189147	280715	829707	472880	70208	64485
1996	277053	101267	347690	514741	652711	197235	46607
1997	208570	548594	453324	391118	337282	225170	70268
1998	449115	366176	501585	352485	233672	178735	105884
1999	246016	475225	361509	339691	177170	105518	72541
2000	489836	354822	313972	255523	194156	97693	64373
2001	219973	1172300	256133	195897	126389	75145	49547
2002	106882	587354	753897	181381	112166	55650	40219
2003	198412	318695	446285	518289	114035	61276	51172
2004	589910	180522	263521	386715	377848	78396	55312
2005	169229	1005530	266213	206657	191013	116628	46087
2006	18347	250200	777315	128695	108244	121043	81149
2007	199364	82084	313453	535706	80348	82713	120821
2008	298405	219205	182636	370253	411611	65397	108832
2009	378304	353839	195618	125324	251973	197185	83887
2010	278311	516544	263334	136037	82831	129434	182722
2011	341535	452259	383353	122136	87976	40949	110734
2012	220164	193884	168105	122976	94143	48700	52645
2013	280544	232934	155842	87924	48492	26591	27635
2014	63949	189093	109802	54550	35237	19462	21688
2015	68371	98936	84313	47069	20960	13656	11242
2016	172202	215051	58288	40726	15422	9815	8424
2017	35329	198627	126003	39727	15971	8393	10853
2018	37222	49140	88410	33715	19257	9003	9140
2019	53515	85035	49870	40297	13422	4307	3429
2020	41356	270602	83327	36914	20026	5690	5725
2021	87950	153333	393524	55831	38306	21632	4755

Table 8.2.4.4. Sardine 8c and 9a. Relative distribution of sardine catches. Upper panel relative contribution of each age group within each subdivision. Lower panel, relative contribution of each subdivision within each age group.

Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C	Total
0	9%	2%	1%	5%	10%	12%	41%	12%
1	20%	16%	7%	14%	14%	28%	46%	20%
2	47%	69%	76%	76%	31%	33%	10%	52%
3	12%	8%	7%	4%	11%	19%	2%	7%
4	9%	3%	5%	0%	17%	7%	0%	5%
5	2%	1%	3%	0%	12%	1%	0%	3%
6+	1%	0%	0%	0%	5%	0%	0%	1%
	100%	100%	100%	100%	100%	100%	100%	100%

Age	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C	Total
0	2%	2%	1%	16%	15%	12%	53%	100%
1	3%	6%	4%	24%	13%	16%	34%	100%
2	2%	10%	15%	51%	11%	7%	3%	100%
3	5%	8%	10%	18%	27%	30%	4%	100%
4	5%	5%	11%	2%	60%	16%	1%	100%
5	2%	4%	12%	2%	74%	6%	0%	100%
6+	2%	2%	4%	2%	88%	3%	0%	100%

Table 8.2.5.1. Sardine 8c and 9a. Sardine Mean length (cm) at age by quarter and by subdivision in 2021.

Age	First Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0							
1	14.4	17.3	16.9				15.9
2	17.9	19.0	18.7				16.1
3	17.9	20.1	19.7				16.5
4	19.5	21.2	21.4				16.2
5	20.3	21.3	21.7				16.8
6		21.3	22.2				
7		22.8					
8							
9							
10							
11							
12							

Age	Second Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0							
1	16.1	15.9	17.0	16.3	17.7	16.3	13.8
2	19.0	19.1	18.7	17.7	17.9	17.3	15.4
3	20.0	20.0	19.6	17.7	19.4	18.3	15.5
4	20.7	20.9	21.5		20.3	19.2	15.5
5	21.6	21.5	21.8		20.5	19.7	16.8
6	23.0	22.2	22.2		21.6	20.9	
7	22.6	22.8			22.5		
8					23.0		
9					22.8		
10							
11							
12							

Age	Third Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0	17.5	17.8	18.3	15.7	14.4	16.4	14.7
1	18.0	19.2	18.7	17.6	16.6	17.6	16.0
2	19.2	19.5	19.1	17.9	18.8	18.3	16.6
3	19.4	20.4	20.8	19.3	19.8	18.9	17.3
4	20.2	21.4	21.7		20.2	19.4	19.2
5	20.5	22.2	22.1		20.5		21.3
6	21.5	22.5	21.3		21.3		
7			23.3		22.1		
8					22.0		
9							
10							
11							
12							

Age	Fourth Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0	16.1	17.8		15.2	15.7	18.4	14.4
1	17.6	19.2	20.8	16.3	18.0	19.0	17.4
2	18.5	19.5	21.3	18.1	18.5	19.4	18.3
3	18.9	20.4	22.5	18.8	20.1	20.1	19.0
4	19.7	21.3	22.6	19.1	20.8	20.1	20.0
5	20.3	22.2	22.5	20.0	21.4	20.5	21.0
6	21.7	22.5	23.2	22.2	22.5		
7			23.3		23.6		
8				23.8			
9							
10							
11							
12							

Table 8.2.5.2. Sardine 8c and 9a. Sardine Mean weight (kg) at age by quarter and by subdivision in 2021.

Age	First Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0							
1	0.022	0.038	0.036				0.029
2	0.041	0.050	0.048				0.030
3	0.042	0.059	0.056				0.033
4	0.054	0.069	0.071				0.031
5	0.061	0.070	0.074				0.034
6		0.069	0.079				
7		0.085					
8							
9							
10							
11							
12							

Age	Second Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0							
1	0.035	0.033	0.041	0.036	0.049	0.037	0.022
2	0.056	0.056	0.053	0.045	0.051	0.044	0.030
3	0.065	0.064	0.062	0.046	0.063	0.051	0.031
4	0.072	0.073	0.079		0.071	0.059	0.031
5	0.081	0.078	0.082		0.074	0.064	0.039
6	0.095	0.087	0.086		0.085	0.075	
7	0.090	0.092			0.094		
8					0.100		
9					0.097		
10							
11							
12							

Age	Third Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0	0.051	0.054	0.059	0.035	0.032	0.046	0.031
1	0.056	0.068	0.063	0.048	0.047	0.056	0.039
2	0.068	0.072	0.067	0.051	0.064	0.062	0.044
3	0.070	0.082	0.087	0.063	0.073	0.067	0.049
4	0.079	0.093	0.098		0.077	0.073	0.068
5	0.083	0.105	0.103		0.080		0.092
6	0.095	0.109	0.092		0.088		
7			0.120		0.097		
8					0.095		
9							
10							
11							
12							

Age	Fourth Quarter						
	8c-E	8c-W	9a-N	9a-CN	9a-CS	9a-S	9a-S-C
0	0.036	0.049		0.0	0.0	0.1	0.026
1	0.047	0.063	0.080	0.041	0.055	0.065	0.046
2	0.057	0.067	0.088	0.054	0.059	0.069	0.055
3	0.060	0.077	0.105	0.059	0.076	0.076	0.061
4	0.068	0.088	0.105	0.062	0.084	0.076	0.072
5	0.076	0.101	0.104	0.069	0.091	0.080	0.083
6	0.093	0.104	0.116	0.091	0.105		
7			0.116		0.120		
8				0.1			
9							
10							
11							
12							

Table 8.3.2.1. Sardine in 8c and 9a. sardine abundance in number (millions of fish) and biomass (tons) by age groups and ICES subdivision in PELAGO2022. Mean Weight in grams and Mean Length in cm.

AREA 9aCN										
AGE	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (ton)	60019	23262	140319	23661	6349	10494	1841			265946
%Biomass	23	9	53	9	2	4	1			100
Abundance (10 ³)	2046865	537287	2678367	377904	88489	128522	21128			5878562
%Abundance	35	9	46	6	2	2	0			100
Mean Weight (gr)	28.2	38.6	48.9	61.6	66.5	75.9	83.3			
Mean Length (cm)	15.8	17.5	18.8	20.2	20.7	21.6	22.2			

AREA 9aCS										
AGE	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (ton)	184806	19417	34709	64752	26242	47192	4324	631	116	382190
%Biomass	48	5	9	17	7	12	1	0	0	100
Abundance (10 ³)	5826360	432151	684641	1073836	422125	676634	54716	6954	1241	9178657
%Abundance	63	5	7	12	5	7	1	0	0	100
Mean Weight (gr)	30.0	42.9	48.2	57.8	59.6	67.0	76.2	87.7	90.5	
Mean Length (cm)	16.0	18.0	18.7	19.9	20.1	20.9	21.7	22.8	23.0	

AREA 9aS-ALG										
AGE	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (ton)	1418	17650	7889	24291	11483	9352	2090	54		74226
%Biomass	2	24	11	33	15	13	3	0		100
Abundance (10 ³)	40834	385762	161594	452181	202135	148867	33431	740		1425543
%Abundance	3	27	11	32	14	10	2	0		100
Mean Weight (gr)	33.2	43.8	46.8	51.6	54.6	60.5	60.1	71.0		
Mean Length (cm)	16.5	18.1	18.6	19.2	19.6	20.3	20.3	21.5		

AREA 9aS-CAD										
AGE	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (ton)	32714	38355	5409	7736	1823	210				86247
%Biomass	38	44	6	9	2	0				100
Abundance (10 ³)	1136297	979141	117163	154762	33042	4216				2424621
%Abundance	47	40	5	6	1	0				100
Mean Weight (gr)	27.2	37.5	44.4	48.0	53.1	48.0				
Mean Length (cm)	15.6	17.4	18.5	19.0	19.7	19.0				

TOTAL PELAGO22										
AGE	1	2	3	4	5	6	7	8	9	TOTAL
Biomass (ton)	278957	98683	188325	120440	45898	67249	8256	685	116	808609
%Biomass	34	12	23	15	6	8	1	0	0	100
Abundance (10 ³)	9050357	2334341	3641764	2058682	745791	958239	109275	7694	1241	18907384
%Abundance	48	12	19	11	4	5	1	0	0	100
Mean Weight (gr)	30.8	42.3	51.7	58.5	61.5	70.2	75.6	89.1	93.6	
Mean Length (cm)	15.9	17.7	18.8	19.7	20.0	20.9	21.4	22.6	23.0	

Table 8.3.2.2. Sardine in 8c and 9a. sardine abundance in number (millions of fish) and biomass (tons) by age groups and ICES subdivision in PELACUS0422. Mean Weight in grams and Mean Length in cm.

AREA 8cE								
AGE	1	2	3	4	5	6	7	TOTAL
Biomass (ton)	1311	7303	24612	3360	1462	598	123	38768
%Biomass	3	19	63	9	4	2	0	100
Abundance (10³)	29120	147364	416747	50371	18015	7103	1384	670104
% Abundance	4	22	62	8	3	1	0	100
Mean Weight (gr)	42.8	47.4	56.6	63.8	78.0	81.2	85.4	55.1
Mean Lenght (cm)	17.5	18.2	19.3	20.1	21.5	21.8	22.2	19.1

AREA 8cW								
AGE	1	2	3	4	5	6	7	TOTAL
Biomass (ton)	608	4965	57657	9941	4748	1325	176	79420
%Biomass	1	6	73	13	6	2	0	100
Abundance (10³)	11076	89619	921339	145869	58901	15491	1971	1244266
% Abundance	1	7	74	12	5	1	0	100
Mean Weight (gr)	52.6	53.2	60.1	65.4	77.4	82.3	86.3	60.2
Mean Lenght (cm)	18.8	18.9	19.7	20.3	21.5	21.9	22.3	19.8

AREA 9aN								
AGE	1	2	3	4	5	6	7	TOTAL
Biomass (ton)	1651	13596	93716	14381	7441	2924	546	134254
%Biomass	1	10	70	11	6	2	0	100
Abundance (10³)	31736	257263	1534383	214201	90395	33339	5906	2167224
% Abundance	1	12	71	10	4	2	0	100
Mean Weight (gr)	51.7	52.7	60.8	66.7	81.7	87.3	92.2	61.5
Mean Lenght (cm)	19	19	20	20	22	22	22.77	19.84

TOTAL PELACUS22								
AGE	1	2	3	4	5	6	7	TOTAL
Biomass (ton)	3569	25864	175984	27681	13651	4847	845	252442
%Biomass	1	10	70	11	5	2	0	100
Abundance (10³)	71933	494246	2872468	410440	167312	55933	9261	4081593
% Abundance	2	12	70	10	4	1	0	100
Mean Weight (gr)	47.3	50.1	58.8	64.7	78.4	83.4	88.1	59.3
Mean Lenght (cm)	18.1	18.5	19.5	20.2	21.5	22.0	22.4	19.6

Table 8.3.5.1a. Sardine in 8c and 9a. Mean weights-at-age (kg) in the catch. Weights-at-age in 1978-1990 are fixed.

Year	Age						
	0	1	2	3	4	5	6+
1990	0.020	0.039	0.054	0.060	0.066	0.073	0.090
1991	0.020	0.030	0.053	0.058	0.070	0.071	0.094
1992	0.018	0.044	0.052	0.061	0.066	0.077	0.089
1993	0.017	0.038	0.053	0.058	0.065	0.070	0.084
1994	0.020	0.036	0.057	0.060	0.067	0.072	0.089
1995	0.025	0.046	0.057	0.064	0.065	0.078	0.093
1996	0.019	0.037	0.048	0.054	0.062	0.070	0.082
1997	0.023	0.031	0.049	0.059	0.064	0.070	0.079
1998	0.024	0.041	0.055	0.061	0.064	0.067	0.073
1999	0.025	0.043	0.056	0.065	0.070	0.073	0.077
2000	0.025	0.037	0.056	0.066	0.071	0.074	0.077
2001	0.023	0.042	0.059	0.067	0.075	0.079	0.085
2002	0.027	0.045	0.057	0.068	0.074	0.079	0.082
2003	0.024	0.044	0.059	0.067	0.079	0.084	0.091
2004	0.020	0.040	0.056	0.066	0.072	0.082	0.089
2005	0.023	0.037	0.055	0.068	0.074	0.075	0.087
2006	0.031	0.042	0.056	0.068	0.073	0.078	0.082
2007	0.028	0.054	0.071	0.074	0.085	0.086	0.089
2008	0.025	0.043	0.066	0.074	0.075	0.083	0.085
2009	0.020	0.041	0.065	0.075	0.079	0.082	0.090
2010	0.026	0.046	0.061	0.075	0.082	0.084	0.081
2011	0.024	0.045	0.064	0.073	0.077	0.077	0.079
2012	0.031	0.056	0.065	0.078	0.083	0.086	0.090
2013	0.025	0.052	0.069	0.077	0.085	0.090	0.094
2014	0.030	0.046	0.061	0.076	0.080	0.089	0.093
2015	0.025	0.049	0.073	0.079	0.089	0.090	0.097
2016	0.018	0.046	0.062	0.074	0.084	0.092	0.098
2017	0.022	0.039	0.058	0.072	0.083	0.086	0.095
2018	0.031	0.047	0.062	0.080	0.088	0.094	0.099
2019	0.028	0.050	0.059	0.074	0.084	0.094	0.097
2020	0.031	0.042	0.057	0.065	0.075	0.084	0.095
2021	0.034	0.044	0.055	0.065	0.077	0.080	0.100

Table 8.3.5.1b. Sardine in 8c and 9a. Mean weights-at-age (Kg) in the stock. Weights-at-age in 1978-1998 are fixed (see Stock Annex).

Year	Age						
	0	1	2	3	4	5	6+
1978	0	0.027	0.041	0.050	0.059	0.060	0.063
1979	0	0.027	0.041	0.050	0.059	0.060	0.063
1980	0	0.027	0.041	0.050	0.059	0.060	0.063
1981	0	0.027	0.041	0.050	0.059	0.060	0.063
1982	0	0.027	0.041	0.050	0.059	0.060	0.063
1983	0	0.027	0.041	0.050	0.059	0.060	0.063
1984	0	0.027	0.041	0.050	0.059	0.060	0.063
1985	0	0.027	0.041	0.050	0.059	0.060	0.063
1986	0	0.027	0.041	0.050	0.059	0.060	0.063
1987	0	0.027	0.041	0.050	0.059	0.060	0.063
1988	0	0.027	0.041	0.050	0.059	0.060	0.063
1989	0	0.027	0.041	0.050	0.059	0.060	0.063
1990	0	0.027	0.041	0.050	0.059	0.060	0.063
1991	0	0.027	0.041	0.050	0.059	0.060	0.063
1992	0	0.027	0.041	0.050	0.059	0.060	0.063
1993	0	0.027	0.041	0.050	0.059	0.060	0.063
1994	0	0.027	0.041	0.050	0.059	0.060	0.063
1995	0	0.027	0.041	0.050	0.059	0.060	0.063
1996	0	0.027	0.041	0.050	0.059	0.060	0.063
1997	0	0.027	0.041	0.050	0.059	0.060	0.063
1998	0	0.027	0.041	0.050	0.059	0.060	0.063
1999	0	0.030	0.043	0.050	0.054	0.059	0.062
2000	0	0.027	0.041	0.050	0.059	0.060	0.063
2001	0	0.024	0.039	0.051	0.064	0.061	0.064
2002	0	0.022	0.037	0.052	0.069	0.062	0.066
2003	0	0.021	0.041	0.054	0.068	0.065	0.072
2004	0	0.020	0.045	0.056	0.067	0.068	0.079
2005	0	0.019	0.049	0.058	0.066	0.072	0.086
2006	0	0.024	0.052	0.060	0.067	0.072	0.084
2007	0	0.029	0.054	0.062	0.069	0.072	0.081
2008	0	0.033	0.057	0.064	0.070	0.072	0.079
2009	0	0.030	0.054	0.063	0.070	0.069	0.075
2010	0	0.027	0.051	0.062	0.070	0.067	0.072
2011	0	0.024	0.048	0.061	0.070	0.064	0.068
2012	0	0.027	0.048	0.062	0.068	0.068	0.073
2013	0	0.030	0.049	0.063	0.067	0.073	0.077
2014	0	0.032	0.049	0.065	0.066	0.077	0.081
2015	0	0.030	0.048	0.063	0.066	0.073	0.077
2016	0	0.029	0.046	0.062	0.065	0.070	0.072
2017	0	0.027	0.045	0.060	0.065	0.066	0.068
2018	0	0.027	0.044	0.056	0.063	0.066	0.071
2019	0	0.027	0.043	0.053	0.060	0.067	0.074
2020	0	0.027	0.042	0.050	0.058	0.068	0.078
2021	0	0.027	0.042	0.050	0.058	0.068	0.078

Table 8.4.1.1. Sardine in 8c and 9a. Parameters and asymptotic standard deviations estimated in the 2022 assessment model.

Label	Value	Parm_StDev	Phase	Min	Max	Init
SR_LN(R0)	16.844	0.038	1	1	20	16.00
Early_InitAge_4	0.063	0.537	2	-5	5	0.00
Early_InitAge_3	0.139	0.443	2	-5	5	0.00
Early_InitAge_2	0.355	0.289	2	-5	5	0.00
Early_InitAge_1	0.799	0.198	2	-5	5	0.00
Main_RecrDev_1978	0.965	0.164	2	-5	5	0.00
Main_RecrDev_1979	1.076	0.158	2	-5	5	0.00
Main_RecrDev_1980	1.173	0.148	2	-5	5	0.00
Main_RecrDev_1981	0.652	0.174	2	-5	5	0.00
Main_RecrDev_1982	-0.013	0.240	2	-5	5	0.00
Main_RecrDev_1983	1.515	0.112	2	-5	5	0.00
Main_RecrDev_1984	0.241	0.187	2	-5	5	0.00
Main_RecrDev_1985	0.111	0.180	2	-5	5	0.00
Main_RecrDev_1986	-0.035	0.192	2	-5	5	0.00
Main_RecrDev_1987	0.798	0.127	2	-5	5	0.00
Main_RecrDev_1988	0.184	0.160	2	-5	5	0.00
Main_RecrDev_1989	0.154	0.158	2	-5	5	0.00
Main_RecrDev_1990	0.217	0.155	2	-5	5	0.00
Main_RecrDev_1991	1.318	0.090	2	-5	5	0.00
Main_RecrDev_1992	0.868	0.101	2	-5	5	0.00
Main_RecrDev_1993	0.020	0.143	2	-5	5	0.00
Main_RecrDev_1994	-0.105	0.137	2	-5	5	0.00
Main_RecrDev_1995	-0.326	0.138	2	-5	5	0.00
Main_RecrDev_1996	0.050	0.112	2	-5	5	0.00
Main_RecrDev_1997	-0.369	0.132	2	-5	5	0.00
Main_RecrDev_1998	-0.045	0.116	2	-5	5	0.00
Main_RecrDev_1999	-0.310	0.135	2	-5	5	0.00
Main_RecrDev_2000	0.881	0.089	2	-5	5	0.00
Main_RecrDev_2001	0.300	0.110	2	-5	5	0.00
Main_RecrDev_2002	-0.264	0.144	2	-5	5	0.00
Main_RecrDev_2003	-0.481	0.161	2	-5	5	0.00
Main_RecrDev_2004	0.968	0.079	2	-5	5	0.00
Main_RecrDev_2005	-0.092	0.112	2	-5	5	0.00
Main_RecrDev_2006	-1.302	0.173	2	-5	5	0.00
Main_RecrDev_2007	-0.910	0.135	2	-5	5	0.00
Main_RecrDev_2008	-0.619	0.115	2	-5	5	0.00
Main_RecrDev_2009	-0.426	0.102	2	-5	5	0.00
Main_RecrDev_2010	-0.937	0.124	2	-5	5	0.00
Main_RecrDev_2011	-1.036	0.130	2	-5	5	0.00
Main_RecrDev_2012	-0.834	0.118	2	-5	5	0.00
Main_RecrDev_2013	-0.695	0.114	2	-5	5	0.00
Main_RecrDev_2014	-0.991	0.136	2	-5	5	0.00

Label	Value	Parm_StDev	Phase	Min	Max	Init
Main_RecrDev_2015	-0.370	0.116	2	-5	5	0.00
Main_RecrDev_2016	-0.180	0.122	2	-5	5	0.00
Main_RecrDev_2017	-1.071	0.165	2	-5	5	0.00
Main_RecrDev_2018	-0.321	0.144	2	-5	5	0.00
Main_RecrDev_2019	0.775	0.130	2	-5	5	0.00
Main_RecrDev_2020	-0.454	0.200	2	-5	5	0.00
Main_RecrDev_2021	-0.292	0.252	2	-5	5	0.00
Main_RecrDev_2022	0.216	0.455	2	-5	5	0.00
InitF_seas_1_flt_1purse_seine	0.395	0.057	1	-1	2	0.30
LnQ_base_Acoustic_survey(2)	0.293	0.096	1	-3	3	0.75
Q_extraSD_Acoustic_survey(2)	0.079	0.056	1	0	1	0.30
LnQ_base_DEPM_survey(3)	0.199	0.122	1	-3	3	0.26
Q_extraSD_DEPM_survey(3)	0.054	0.079	1	0	1	0.30
LnQ_base_Rec_survey(4)	-13.274	6.818	1	-30	3	0.00
Q_power_Rec_survey(4)	0.800	0.445	1	0	3	1.00
Q_extraSD_Rec_survey(4)	0.758	0.180	1	0	3	1.00
AgeSel_P2_purse_seine(1)	1.636	0.153	2	-3	3	0.90
AgeSel_P3_purse_seine(1)	0.738	0.137	2	-4	4	0.40
AgeSel_P4_purse_seine(1)	-0.254	0.169	2	-4	4	0.10
AgeSel_P7_purse_seine(1)	-0.694	0.437	2	-4	4	-0.50
AgeSel_P2_purse_seine(1)_BLK1delta_1988	-0.328	0.183	2	-4	4	0.90
AgeSel_P2_purse_seine(1)_BLK1delta_2006	0.093	0.138	2	-4	4	0.90
AgeSel_P3_purse_seine(1)_BLK1delta_1988	-0.002	0.167	2	-4	4	0.40
AgeSel_P3_purse_seine(1)_BLK1delta_2006	-0.187	0.133	2	-4	4	0.40
AgeSel_P4_purse_seine(1)_BLK1delta_1988	0.896	0.191	2	-4	4	0.10
AgeSel_P4_purse_seine(1)_BLK1delta_2006	-0.596	0.136	2	-4	4	0.10
AgeSel_P7_purse_seine(1)_BLK1delta_1988	-0.114	0.469	2	-4	4	-0.50
AgeSel_P7_purse_seine(1)_BLK1delta_2006	0.593	0.369	2	-4	4	-0.50

Table 8.4.1.2. Sardine in 8c and 9a. Fishing mortality-at-age estimated in the assessment. RefF is equal to $F_{\text{bar}(2-5)}$, the reference fishing mortality, corresponding to the average F of ages 2 to 5 years.

Year	RefF	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1978	0.267	0.030	0.153	0.320	0.249	0.249	0.249	0.124
1979	0.222	0.025	0.127	0.266	0.207	0.207	0.207	0.103
1980	0.227	0.025	0.130	0.272	0.211	0.211	0.211	0.106
1981	0.223	0.025	0.128	0.268	0.208	0.208	0.208	0.104
1982	0.222	0.025	0.128	0.267	0.207	0.207	0.207	0.103
1983	0.228	0.025	0.131	0.274	0.212	0.212	0.212	0.106
1984	0.231	0.026	0.133	0.278	0.216	0.216	0.216	0.108
1985	0.217	0.024	0.125	0.261	0.202	0.202	0.202	0.101
1986	0.283	0.032	0.162	0.340	0.264	0.264	0.264	0.132
1987	0.330	0.037	0.189	0.396	0.307	0.307	0.307	0.154
1988	0.401	0.031	0.114	0.239	0.455	0.455	0.455	0.202
1989	0.389	0.030	0.111	0.232	0.441	0.441	0.441	0.196
1990	0.423	0.033	0.121	0.252	0.480	0.480	0.480	0.214
1991	0.389	0.030	0.111	0.232	0.441	0.441	0.441	0.196
1992	0.286	0.022	0.082	0.170	0.324	0.324	0.324	0.144
1993	0.275	0.021	0.079	0.164	0.312	0.312	0.312	0.139
1994	0.231	0.018	0.066	0.138	0.262	0.262	0.262	0.117
1995	0.231	0.018	0.066	0.138	0.262	0.262	0.262	0.117
1996	0.312	0.024	0.089	0.186	0.354	0.354	0.354	0.158
1997	0.421	0.033	0.120	0.251	0.478	0.478	0.478	0.213
1998	0.477	0.037	0.136	0.285	0.542	0.542	0.542	0.241
1999	0.438	0.034	0.125	0.261	0.497	0.497	0.497	0.222
2000	0.391	0.030	0.112	0.233	0.444	0.444	0.444	0.198
2001	0.370	0.029	0.106	0.221	0.420	0.420	0.420	0.187
2002	0.309	0.024	0.088	0.184	0.351	0.351	0.351	0.156
2003	0.276	0.021	0.079	0.165	0.313	0.313	0.313	0.139
2004	0.306	0.024	0.087	0.182	0.347	0.347	0.347	0.155
2005	0.303	0.023	0.087	0.181	0.344	0.344	0.344	0.153
2006	0.178	0.024	0.099	0.172	0.180	0.180	0.180	0.145
2007	0.217	0.030	0.121	0.209	0.219	0.219	0.219	0.177
2008	0.346	0.047	0.193	0.334	0.350	0.350	0.350	0.282
2009	0.392	0.054	0.218	0.379	0.397	0.397	0.397	0.320
2010	0.488	0.067	0.272	0.471	0.494	0.494	0.494	0.398
2011	0.584	0.080	0.325	0.563	0.590	0.590	0.590	0.476
2012	0.467	0.064	0.260	0.451	0.472	0.472	0.472	0.381
2013	0.442	0.061	0.246	0.427	0.447	0.447	0.447	0.360
2014	0.282	0.039	0.157	0.272	0.285	0.285	0.285	0.230
2015	0.171	0.024	0.095	0.165	0.173	0.173	0.173	0.140
2016	0.168	0.023	0.093	0.162	0.170	0.170	0.170	0.137
2017	0.137	0.019	0.076	0.133	0.139	0.139	0.139	0.112
2018	0.073	0.010	0.041	0.071	0.074	0.074	0.074	0.060
2019	0.051	0.007	0.028	0.049	0.051	0.051	0.051	0.041
2020	0.062	0.008	0.034	0.060	0.063	0.063	0.063	0.050
2021	0.098	0.013	0.054	0.094	0.099	0.099	0.099	0.080

Table 8.4.1.3. Sardine in 8c and 9a. Numbers-at-age, in thousands, at the beginning of the year estimated in the assessment. Estimates of survivors in 2022 are also shown.

Year	Age						
	0	1	2	3	4	5	6+
1978	39924000	12539500	3708790	1309170	621151	315363	407647
1979	45898500	14313600	5822900	1666300	677221	334428	429344
1980	51643000	16578700	6829040	2769230	901317	381264	468276
1981	31102600	18689100	7890830	3231430	1492000	505427	518635
1982	15918800	11291600	8916270	3752380	1747800	839915	623320
1983	71747800	5795500	5392980	4249810	2033240	985701	882574
1984	20690500	26208400	2760320	2555550	2292270	1141450	1129750
1985	17986700	7568330	12465400	1304220	1375270	1283930	1375570
1986	15194700	6598260	3631020	5997970	711970	781397	1632220
1987	34003400	5535800	3052150	1618140	3082930	380884	1451130
1988	18512600	12313200	2493580	1286340	796063	1578580	1090640
1989	17706100	6725340	5965090	1226150	546117	351762	1348480
1990	18572000	6437420	3269930	2955520	528142	244829	960666
1991	55007800	6731770	3099410	1587290	1224320	227710	667528
1992	37396700	19998500	3272810	1535430	683495	548711	499732
1993	16273400	13706500	10013700	1724380	743481	344467	592479
1994	14164000	5969030	6884140	5309840	845198	379286	550829
1995	11099400	5212760	3035870	3747490	2736040	453286	560502
1996	15666800	4077980	2651530	1653020	1931870	1468020	607006
1997	10064600	5755660	2026780	1375470	777050	945196	1100780
1998	13343000	3633020	2772950	985176	571253	335891	1056150
1999	10160500	4819140	1722510	1303510	383896	231686	737404
2000	32028000	3677330	2310300	828661	530810	162709	526408
2001	19178800	11591200	1786530	1142780	355797	237212	385831
2002	10999600	6938160	5664090	894493	502146	162721	340954
2003	8854750	4009850	3449590	2940500	421104	246045	291485
2004	36781900	3224420	2012550	1826500	1437260	214228	309868

Year	Age						
	0	1	2	3	4	5	6+
2005	13091800	13429800	1604300	1046370	862318	706246	298293
2006	4108130	4772860	6686980	835430	495494	425001	536625
2007	5917160	1492780	2343640	3522800	466016	287674	582366
2008	7554220	2145010	717994	1192280	1892650	260589	512617
2009	8587540	2696910	960005	323448	562077	928667	404829
2010	4929990	3018140	1175380	413510	145308	262816	647534
2011	4022290	1698870	1246100	462089	168396	61590	419872
2012	4372840	1364790	662354	444731	169596	64327	206142
2013	4847640	1492380	567324	263404	183358	72776	126763
2014	3684980	1642910	627431	229967	110854	80316	94079
2015	6671120	1258840	756528	296569	114163	57277	94791
2016	8974360	2306490	617902	398298	165318	66236	92378
2017	4020510	3021750	1133870	326153	222641	96181	96373
2018	8386620	1309080	1510450	615575	187911	133508	119757
2019	26171500	2842840	679865	874699	380144	120779	167760
2020	9054920	8209850	1496550	402820	553614	250420	196359
2021	10905000	3158530	4288170	875050	251351	359542	298400
2022	19424400	4038350	1734130	2912930	588645	182988	479151

Table 8.4.1.4. Sardine in 8c and 9a. Summary table of the WGHANSA 2022 assessment. Coefficient of variation (CV) are presented for SSB, Recruitment and Apical F (maximum F-at-age by year); biomass and landings in tonnes, recruits in thousand of individuals, F in year-1. Catches for 2022 are an assumption based on the Member States agreement.

Year	Biomass 1+	SSB	CV SSB	Recruits	CV Re- cruits	F (2- 5)	F Api- cal	CV F Api- cal	Land- ings
1978	657632	602823	0.170	39924000	0.178	0.266	0.320	0.200	145609
1979	817320	753199	0.169	45898500	0.169	0.221	0.266	0.190	157241
1980	994416	920241	0.160	51643000	0.157	0.226	0.272	0.177	194802
1981	1163880	1080280	0.149	31102600	0.180	0.223	0.268	0.166	216517
1982	1071120	1016550	0.149	15918800	0.246	0.222	0.267	0.155	206946
1983	841018	812261	0.159	71747800	0.109	0.228	0.274	0.151	183837
1984	1236710	1128930	0.112	20690500	0.187	0.232	0.278	0.146	206005

Year	Biomass 1+	SSB	CV SSB	Recruits	CV Re- cruits	F (2- 5)	F Api- cal	CV F Api- cal	Land- ings
1985	1035250	992492	0.108	17986700	0.179	0.218	0.261	0.112	208439
1986	825534	795550	0.108	15194700	0.192	0.283	0.340	0.142	187363
1987	656435	631291	0.111	34003400	0.122	0.329	0.396	0.145	177696
1988	712528	660845	0.097	18512600	0.160	0.401	0.455	0.125	161531
1989	628315	595410	0.097	17706100	0.159	0.389	0.441	0.122	140961
1990	564253	535183	0.099	18572000	0.157	0.423	0.480	0.121	149429
1991	518225	488135	0.105	55007800	0.088	0.389	0.441	0.124	132587
1992	858187	774769	0.082	37396700	0.100	0.286	0.324	0.114	130250
1993	971286	906336	0.072	16273400	0.144	0.275	0.312	0.107	142495
1994	818474	787660	0.072	14164000	0.136	0.231	0.262	0.092	136582
1995	678479	654551	0.073	11099400	0.139	0.231	0.262	0.086	125280
1996	543623	524598	0.076	15666800	0.110	0.312	0.354	0.091	116736
1997	480136	455142	0.076	10064600	0.133	0.421	0.478	0.093	115814
1998	382755	365364	0.082	13343000	0.115	0.478	0.542	0.101	108924
1999	365180	353794	0.083	10160500	0.137	0.438	0.497	0.106	94091
2000	310849	293789	0.091	32028000	0.086	0.391	0.444	0.109	85786
2001	470738	398969	0.076	19178800	0.110	0.370	0.420	0.105	101957
2002	479413	417749	0.075	10999600	0.144	0.310	0.351	0.106	99673
2003	453653	417926	0.078	8854750	0.161	0.276	0.313	0.097	97831
2004	396396	368346	0.084	36781900	0.072	0.306	0.347	0.095	98020
2005	532057	422579	0.071	13091800	0.108	0.303	0.344	0.091	97345
2006	625847	574013	0.063	4108130	0.173	0.178	0.180	0.099	87023
2007	492322	480934	0.064	5917160	0.132	0.216	0.219	0.077	96469
2008	383172	375980	0.066	7554220	0.109	0.346	0.350	0.078	101464
2009	289500	283127	0.068	8587540	0.095	0.392	0.397	0.090	87740
2010	244284	241230	0.066	4929990	0.122	0.488	0.494	0.101	89571
2011	175986	174256	0.076	4022290	0.130	0.583	0.590	0.113	80403
2012	130430	129037	0.097	4372840	0.127	0.466	0.472	0.128	54857
2013	120558	119019	0.113	4847640	0.135	0.442	0.447	0.151	45818
2014	124843	124843	0.131	3684980	0.165	0.282	0.285	0.167	27937
2015	118110	117315	0.147	6671120	0.151	0.171	0.173	0.173	20595
2016	150952	150952	0.146	8974360	0.163	0.168	0.170	0.175	22704
2017	193853	192643	0.152	4020510	0.198	0.138	0.139	0.180	21911
2018	186097	184440	0.161	8386620	0.179	0.073	0.074	0.178	15062
2019	215772	209539	0.158	26171500	0.163	0.050	0.051	0.164	13759

Year	Biomass 1+	SSB	CV SSB	Recruits	CV Re- cruits	F (2- 5)	F Api- cal	CV F Api- cal	Land- ings
2020	426676	407167	0.148	9054920	0.220	0.062	0.063	0.162	22143
2021	424514	417774	0.149	10905000	0.274	0.098	0.099	0.166	40686
2022	432379	428340	0.164	19424400	0.470	-	-	-	44262

Table 8.6.1. Sardine in 8c and 9a. Input data for short-term catch predictions. Number-at-age for 2022 and recruitment for 2023. Input values for stock weight, catch weight, natural mortality (M) and fishing mortality (F) at-age. Input units are thousands and kg.

Year = 2022						
Age	Numbers	Stock weights	Catch weights	Maturity	M	F
0	7860940	0.000	0.030	0.000	0.98	0.015
1	3158530	0.028	0.046	0.988	0.61	0.060
2	4288170	0.045	0.059	0.989	0.47	0.102
3	875050	0.058	0.073	1.000	0.40	0.109
4	251351	0.063	0.082	1.000	0.36	0.109
5	359542	0.068	0.091	1.000	0.35	0.109
6	298400	0.073	0.097	1.000	0.32	0.093
Recruitment in 2023 = 13 330 753						
Stock weights, catch weights, maturity and mortality are the same as in 2022						

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

B1+ 2023 = 423 378 tonnes; Catch 2022 = 44 262 tonnes ; F 2022 = 0.101					
F (2023)	Catch (2023)	Biomass 1+ (2024)	Catch2024	% Biomass 1+ change ¹	% Catch change ²
0.092	43841	515423	45960	2	8
0.093	44301	515100	46413	2	9
0.094	44761	514777	46865	2	10
0.095	45221	514455	47316	1	11
0.096	45680	514132	47766	1	12
0.097	46139	513810	48215	1	13
0.098	46598	513488	48663	1	15
0.099	47056	513167	49110	1	16
0.100	47514	512846	49556	1	17
0.101	47972	512525	50001	1	18
0.102	48429	512204	50446	1	19
0.103	48886	511883	50889	1	20
0.104	49343	511563	51332	1	21
0.105	49799	511243	51773	1	22
0.106	50255	510924	52214	1	24
0.107	50711	510604	52654	1	25
0.108	51166	510285	53093	1	26
0.109	51621	509966	53531	1	27
0.110	52076	509647	53968	1	28
0.111	52530	509329	54404	0	29
0.112	52984	509011	54839	0	30
0.113	53438	508693	55273	0	31
0.114	53891	508375	55706	0	32
0.115	54344	508058	56139	0	34
0.116	54797	507741	56570	0	35
0.117	55249	507424	57001	0	36
0.118	55701	507107	57431	0	37
0.119	56153	506791	57860	0	38
0.120	56604	506475	58288	0	39
1.390	437165	252523	238275	-50	974
1.960	530585	196334	241559	-61	1204
0.260	116651	464655	110108	-8	187
0.062	30000	525149	30000	4	-26
0.073	35000	521633	35000	3	-14
0.084	40000	518120	40000	2	-2
0.095	45000	514610	45000	2	11
0.105	50000	511102	50000	1	23

¹Biomass 1+ in 2024 relative to Biomass 1+ in 2023 (506 858 tonnes). ²Advised catches in 2023 compared to 2022

B1+ 2023 = 423 378 tonnes; Catch 2022 = 44 262 tonnes ; F 2022 = 0.101					
F (2023)	Catch (2023)	Biomass 1+ (2024)	Catch2024	% Biomass 1+ change ¹	% Catch change ²

catches (44 262 tonnes) .