# 7 Sardine in Subarea 7

## 7.1 Population structure and stock identity

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

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

## 7.2 The fishery

### 7.2.1 Analysis of the catch

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

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

Annual landings (i.e. landings and BMS landings) have fluctuated between 6 157 and 29 287 t since 2002, being the highest values reported at the beginning of the reviewed time-series (Figure 7.2.1.2, Table 7.2.1.1). This large temporal fluctuation in landings is primarily explained by shifts in fleets activity and species targeted over the years (ICES, 2021). Sardine landings were dominated by France, followed by England, Netherlands, and Ireland in the 2000s. However, French landings decreased significantly since 2009 because of the closure of the fishery intended for human consumption in the Seine bay (Eastern Channel) due to PCB contamination. Landings remained lower than 10 000 t between 2009 and 2015 and increased again in 2016 due to a higher contribution from England, Netherlands, and Denmark. Landings from England remain quite stable since then (average English landings since 2016 is 8026t), whereas the contribution from the other countries has diminished. Landings in 2021 were 58% lower than in 2020, primarily because Danish landings have decreased from 3217t to 89t and UK landings have decreased from 9500t to 7074t.

The fleet and seasonality of the fishery has also changed over the years. The main fleet in the 2000s was midwater otter trawlers, which used to fish in 7d throughout the whole year (Figures

7.2.1.3, 7.2.1.4. Table 7.2.1.2). Currently it is a seasonal fishery, and most of the sardine landings are caught by purse-seiners in the third and fourth quarters, mainly from 7e. A detailed description of the temporal evolution of the fishery can be found in the stock annex. In 2021, the fishing activity of the Danish vessels was greatly reduced relative to 2020.

## 7.3 Biological data

### 7.3.1 Size composition of the catch

Historically, biological sampling of sardine from commercial catches has been almost non-existent. Dutch pelagic freezer trawlers operating in the English Channel provided length distribution in 1994, 1996 and annually from 2000; despite these vessels capturing substantial amounts of sardine, the species is not their main target, and the size composition of their catches may not be representative for the sardine population. Other countries have not provided regular length or age information due to the lack of national biological sampling scheme and no DCF (data collection framework) requirement regarding that species in Subarea 7.

In 2017, UK started a self-sampling programme involving the Cornish ringnet fleet, whose catches contribute to more than half of the total landings in recent years. Since fishing season 2017–2018, these vessels have recorded fishing trip information (haul locations, total catches, bycatch, discard, and effort) on dedicated logbooks. In addition, they were asked to collect individual lengths of a subsample approximately four times per month. In parallel, the main processors were asked to provide biological information (length and weight) for every catch.

Some of the data provided by the processors had to be discarded because part of their staff measured the samples with 1 cm precision instead of 0.5 cm, which created multiple peaks in the distributions. Figure 7.3.1.1 shows the combined size distribution provided by the fishing industry since 2018 after tidying up the data. The mean size of fish in the landings between 2018 and 2020 was consistently around 19.6 cm, however mean size in 2021 was lower (18.7 cm).

## 7.4 Fishery-independent information

### 7.4.1 The PELTIC survey

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

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

The time-series of biomass estimated in the Core area significantly increased between 2017 and 2019, reaching the highest biomass in 2019 with 273 708 tonnes of sardine (Figure 7.4.1.2, Table 7.4.1.1). Biomass dropped in 2020 and 2021 but they are still the second highest values of the time-series. The temporal series of the biomass in the total area (including French side of division 7.e) was very similar, although it showed a slight drop in 2018 compared to 2017 and a 32% decline in 2021 that was not found in the Core area (Figure 7.4.1.2, Table 7.4.1.1).

In 2022 the survey coverage for the PELTIC survey was severely reduced for technical reasons (see Figure 7.4.1.1c). In addition, a survey transect was not covered in the stratum in the west of the survey area. To account for this missing transect a new survey stratum was created, departing slightly from the standard strata used in previous years. The area covered in 2022 is termed the restricted area and constitutes <30% of the standard survey area adopted for the assessment. The area covered is the area where a large proportion of the stock has been found in previous years. The estimated biomass in this restricted area was 175 896t (CV=0.26).

There were a limited number of trawl hauls in this survey which limited the quantity of biological data available. However, the quantity of hauls was considered adequate. The most abundant age group in the survey was age 0 (2022 year class) with age 2 (2020 year class) at a higher abundance than the older of younger age group.

### 7.4.2 Estimation of biomass in the Total area

The Working Group decided to estimate the biomass that would have been in the total area based on the biomass estimated for the restricted area. The estimation involved two processes, raising the restricted area to the core area and then raising that estimate to the total area.

The raising factor for the restricted to core area used the average ratio of biomass (1.267) in the two areas for the years 2020-2021 (Table 7.4.2.1). The second step involved raising the core biomass to the total biomass using the average ratio of measured biomasses (1.509) for 2017 to 2021. This resulted in an estimated total biomass in the total area for 2022 of 336,306 t. This constitutes a 48% increase from 2021.

## 7.5 Stock assessment

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

### 7.5.1 SPiCT

As was done in 2021, a quarterly SPiCT model was run using the settings described in the stock annex. The input data included the time-series of landings (landings and BMS landing) from 2013 to 2021 and the biomass derived from PELTIC for the core area from 2013 to 2020 (Figure 7.5.1.1, Table 7.5.1.1). The 2021 PELTIC index was not included as it could not be fully estimated from the survey. The landing time time-series was shortened to cover only the period where biomass index was available to help model convergence and produce a reliable output (ICES,

2021). A prior on the initial depletion level was added to inform the model that the fishery was operating before the beginning of the input data to the model.

A summary of the SPiCT outputs is given in Figure 7.5.1.2 and Table 7.5.1.2. The model indicates that fishing mortality is likely to be below $F_{MSY}$ proxy and the biomass is above the reference $B_{MSY}$* 0.5 proxy. The confidence intervals of both reference points and the absolute values of biomass and fishing mortality remain high, as was the case when the model was run in the 2021 WGHANSA-2 meeting, and therefore these values are still not considered reliable.

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

### 7.5.2 1-over-2 rule

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

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

where $C_y$ and $I_y$ represent the advised catch and the biomass indicator for year $y$, respectively. The first and third cases of the formula correspond to the application of an 80% symmetrical uncertainty cap. The last term in the equation refers to the biomass safeguard based on a trigger index value (Istat). If the biomass index falls below Istat, the advised catch will be reduced in proportion to the drop of the biomass index in relation to Istat. The biomass estimates derived from PELTIC in the total area were used as the biomass index and the Istat has been estimated as 120 751 t (see section 7.7).

An overview of the application of the 1-over-2 rule is shown in Table 7.5.2.1. The index is estimated to have increased by 20% and thus the uncertainty cap was not applied. The biomass was estimated to be above Istat and the biomass safeguard was not applied. The resulting catch advice for 2023 is 8 306 tonnes.

## 7.6 Short-term projections

No projections have been carried out for this stock.

## 7.7 Reference points

The table below summarizes the reference points for sardine in Subarea 7 and their technical basis. The Istat reference point represents the biomass safeguard trigger applied into the 1-over-2 rule and is estimated using the biomass index in the total area from 2017 to 2021. This reference point has been recalculated because the time-series is still too short and it was judged convenient to include all years now available for its estimate.

This year as the index value is just inferred from a restricted coverage, this rescaled index has not been included as input for the SPICT and therefore the relative status of the stock versus the MSY reference points has not been assessed (Table 7.7.1).

## 7.8 Quality of the assessment

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

As this is the second year of implementing the 1-over-2 rule the advised catch for 2022 is used to provide the advice for 2023.

The PELTIC survey in October 2022 only covered approximately 30% of the total area used for the estimation of sardine biomass due to technical issues. The total area accepted for use in the assessment has been sampled since 2017. The 2022 coverage was also slightly smaller than the 'core' area which has been sampled since 2013. An estimate of the biomass in the total area was undertaken by raising the area covered in 2022 to the 'core' area and then raising the core area estimate to the total area. This estimate utilized the available information to the WG and may be subject to change for next year after further examination, through the year, on the efficacy of the raising factors.

French catches from ICES rectangles 25E5 and 25E4 (Subarea 7) have been traditionally allocated to division 8.a, as they occur in the boundary between divisions, and are considered to be more closely associated with the sardine stock in divisions 8.a-b and 8.d. In 2021 the catches reallocated were larger than the remaining catches in Subarea 7. However, the boundary between sardine stocks in Subarea 7 and 8 is unclear and further studies are needed to support this procedure to allocate catches.

## 7.9 Management considerations

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

The 1-over-2 rule performs the best when there is no time-lag between the survey producing the biomass estimate and the TAC implementation (ICES, 2020a, ICES, 2020b). This is especially important for short-lived species, as part of the observed stock will not be available for the fishery when there is a large lag in time. The PELTIC survey is conducted in October and the biomass

estimate is already incorporated in the catch advice for the following year, with a time-lag of only two months. Since 2021 the catch advice is provided annually.

## 7.10 References

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

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

| | France** | UK | Nether-lands | Ireland | Germany | Denmark | Lithuania | Belgium | Spain | Poland | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 7315 | 2655 | 1106 | 28 | 0 | 4 | 0 | 0 | 0 | 0 | 11108 |
| 2008 | 8562 | 3470 | 2073 | 473 | 43 | 53 | 0 | 0 | 0 | 0 | 14674 |
| 2009 | 3918 | 2568 | 3406 | 65 | 0 | 0 | 0 | 0 | 0 | 0 | 9957 |
| 2010 | 706 | 2540 | 6645 | 50 | 62 | 13 | 0 | 0 | 0 | 0 | 10016 |
| 2011 | 237 | 3614 | 513 | 1966 | 5 | 3 | 0 | 0 | 0 | 0 | 6338 |
| 2012 | 372 | 4423 | 1637 | 16 | 587 | 40 | 0 | 0 | 0 | 0 | 7075 |
| 2013 | 1703 | 3722 | 1739 | 473 | 214 | 40 | 0 | 0 | 0 | 0 | 7891 |
| 2014 | 1100 | 3893 | 193 | 0 | 18 | 953 | 0 | 0 | 0 | 0 | 6157 |
| 2015 | 1208 | 4301 | 1171 | 555 | 1551 | 1011 | 0 | 0 | 0 | 0 | 9797 |
| 2016 | 925 | 9389 | 4697 | 464 | 1941 | 2286 | 1 | 1 | 0 | 0 | 19704 |
| 2017 | 820 | 7596 | 0 | 329 | 1475 | 2460 | 0 | 0 | 0 | 0 | 12680 |
| 2018 | 606 | 8143 | 811 | 89 | 758 | 263 | 0 | 1 | 0 | 0 | 10671 |
| 2019 | 671 | 7050 | 90 | 33 | 53 | 0 | 40 | 0 | 0 | 0 | 7937 |
| 2020 | 592 | 9500 | 185 | 58 | 0 | 3217 | 0 | 0 | 0 | 1 | 13553 |
| 2021 | 743 | 7074 | 111 | 509 | 0 | 89 | 0 | 0 | 0 | 743 | 8524 |

***Catch data prior 2002 has not been revised and they are not used in the assessment.**

****French catches from ICES rectangles 25E5 and 25E4 are not included.**

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

| | 7.d | 7.e | 7.f | 7.g | 7.h | 7.j | 7.a | 7.b | Unallo-cated |
|---|---|---|---|---|---|---|---|---|---|
| 2002 | 9756 | 18035 | 35 | 164 | 1253 | 44 | 0 | 0 | 0 |
| 2003 | 15478 | 6815 | 2 | 321 | 255 | 123 | 279 | 4 | 0 |
| 2004 | 10001 | 2450 | 158 | 552 | 90 | 36 | 856 | 346 | 0 |
| 2005 | 12561 | 3464 | 204 | 64 | 182 | 636 | 224 | 20 | 0 |
| 2006 | 14116 | 1950 | 395 | 250 | 394 | 786 | 78 | 24 | 0 |
| 2007 | 8480 | 1592 | 993 | 0 | 14 | 28 | 0 | 0 | 0 |
| 2008 | 9395 | 3225 | 1579 | 365 | 1 | 100 | 0 | 10 | 0 |
| 2009 | 6389 | 2568 | 932 | 0 | 2 | 63 | 0 | 2 | 0 |
| 2010 | 7123 | 1706 | 1083 | 0 | 55 | 36 | 14 | 0 | 0 |
| 2011 | 759 | 1639 | 1884 | 1394 | 89 | 129 | 443 | 0 | 0 |
| 2012 | 943 | 3609 | 1555 | 0 | 952 | 0 | 16 | 0 | 0 |
| 2013 | 2431 | 3549 | 1095 | 473 | 342 | 0 | 0 | 0 | 0 |
| 2014 | 1442 | 3018 | 1698 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2015 | 1476 | 6635 | 1604 | 10 | 66 | 6 | 0 | 0 | 0 |
| 2016 | 1478 | 9868 | 3026 | 163 | 169 | 301 | 0 | 0 | 4697 |
| 2017 | 3226 | 7421 | 1704 | 281 | 1 | 48 | 0 | 0 | 0 |
| 2018 | 1335 | 6013 | 2413 | 79 | 10 | 10 | 0 | 0 | 811 |
| 2019 | 888 | 5009 | 2007 | 34 | 0 | 0 | 0 | 0 | 0 |
| 2020 | 640 | 7615 | 3638 | 58 | 1601 | 0 | 0 | 0 | 0 |
| 2021 | 867 | 3737 | 3305 | 76 | 97 | 441 | 0 | 0 | 0 |

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

| | Core Area | | | | Total Area | | | |
|---|---|---|---|---|---|---|---|---|
| | Biomass | | Abundance | | Biomass | | Abundance | |
| | Estimate | CV | Estimate | CV | Estimate | CV | Estimate | CV |
| 2013 | 48391 | 0.33 | 924300 | 0.18 | | | | |
| 2014 | 121171 | 0.32 | 3072930 | 0.23 | | | | |
| 2015 | 134907 | 0.22 | 3332244 | 0.41 | | | | |
| 2016 | 89918 | 0.34 | 2121684 | 0.23 | | | | |
| 2017 | 95298 | 0.11 | 4101091 | 0.13 | 174637 | 0.20 | 10163984 | 0.16 |
| 2018 | 123003 | 0.14 | 3317972 | 0.14 | 145514 | 0.12 | 4300528 | 0.12 |
| 2019 | 273708 | 0.21 | 11256581 | 0.18 | 374617 | 0.19 | 15409434 | 0.15 |
| 2020 | 178781 | 0.31 | 3713016 | 0.29 | 332098 | 0.20 | 6476230 | 0.18 |
| 2021 | 174375 | 0.28 | 5977676 | 0.28 | 227117 | 0.19 | 8714354 | 0.26 |
| 2022* | 222889 | | | | 336 306 | | | |

*Biomass estimate raised from the restricted area coverage for the 2022 PELTIC survey and uncertainty estimates are not available.

**Table 7.4.2.1. Sardine in Subarea 7. PELTIC survey biomass series. Raising factors and biomass estimates for the core and total area for 2022 are given.**

| Year | Survey biomass (t) in core area | Survey biomass (t) in full area | Survey biomass (t) in restricted area | Multiplier (average 2020-2021) for re-stricted area to core area | Multiplier (average 2017-2021) for core area to total area |
|---|---|---|---|---|---|
| 2013 | 48 391 | | | | |
| 2014 | 121 171 | | | | |
| 2015 | 134 907 | | | | |
| 2016 | 89 918 | | | | |
| 2017 | 95 298 | 174 637 | | | |
| 2018 | 123 003 | 145 514 | | | |
| 2019 | 273 708 | 374 617 | | | |
| 2020 | 178 781 | 332 098 | 157 799 | | |
| 2021 | 174 375 | 227 117 | 124 433 | | |
| 2022 | 222889* | 336 306* | 175 896 | 1.267 | 1.509 |

*Estimated values

**Table 7.5.1.1. Sardine in Subarea 7. Assessment summary. The high and low columns represent the 95% confidence intervals of the biomass index. All values are in tonnes.**

| Year | Biomass index (total area) | High | Low | Landings | Discards | BMS landing |
|---|---|---|---|---|---|---|
| 2002 | | | | 29287 | 190 | |

| Year | Biomass index (total area) | High | Low | Landings | Discards | BMS landing |
|---|---|---|---|---|---|---|
| 2003 | | | | 23276 | 10 | |
| 2004 | | | | 14488 | 737 | |
| 2005 | | | | 17354 | 377 | |
| 2006 | | | | 17994 | 785 | |
| 2007 | | | | 11108 | 15 | |
| 2008 | | | | 14675 | 51 | |
| 2009 | | | | 9957 | 40 | |
| 2010 | | | | 10017 | 4 | |
| 2011 | | | | 6337 | 275 | |
| 2012 | | | | 7075 | 342 | |
| 2013 | | | | 7891 | 91 | |
| 2014 | | | | 6157 | 0 | |
| 2015 | | | | 9783 | | 15 |
| 2016 | | | | 19634 | | 68 |
| 2017 | 176696 | 248358 | 105035 | 12662 | 28 | 18 |
| 2018 | 143845 | 178548 | 109141 | 10670 | 16 | 1 |
| 2019 | 358028 | 490975 | 225081 | 7317 | 111 | 620 |
| 2020 | 285564 | 402929 | 168200 | 12852 | | 701 |
| 2021 | 212772 | 292836 | 132707 | 8155 | | 370 |
| 2022 | 336306* | ** | ** | | | |

* Raised estimate.

** No uncertainty estimates were available.

**Table 7.5.1.2. Sardine in Subarea 7. Summary outputs of the SPiCT model.**

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 39.4218027
Euler time step (years):  1/16 or 0.0625
Nobs C: 36,  Nobs I1: 9

Residual diagnostics (p-values)
    shapiro   bias    acf   LBox shapiro bias acf LBox
 C   0.9573 0.5431 0.1950 0.3385       -    -   -    -
 I1  0.6275 0.4151 0.1706 0.3462       -    -   -    -

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

Model parameter estimates w 95% CI
            estimate        cilow        ciupp    log.est
 alpha  3.482069e+00    0.3497584 3.466623e+01  1.2476267
 beta   1.046500e+00    0.3060176 3.578753e+00  0.0454509
 r      2.108605e+00    0.2589977 1.716700e+01  0.7460265
 rc     1.220768e+00    0.2272336 6.558337e+00  0.1994801
 rold   8.590580e-01    0.1277162 5.778286e+00 -0.1519189
 m      1.451811e+04 8088.2668612 2.605943e+04  9.5831524
 K      3.941406e+04 5020.7169772 3.094116e+05 10.5818779
 q      4.952085e+00    0.5673832 4.322150e+01  1.5998088
 n      3.454555e+00    0.7057811 1.690885e+01  1.2396936
 sdb    8.951700e-02    0.0092624 8.651436e-01 -2.4133270
 sdf    3.695138e-01    0.1295738 1.053765e+00 -0.9955673
 sdi    3.117043e-01    0.1800924 5.394985e-01 -1.1657003
 sdc    3.866960e-01    0.2814888 5.312248e-01 -0.9501163
 phi1   1.940576e-01    0.0719572 5.233439e-01 -1.6396005
 phi2   2.666740e-02    0.0149176 4.767200e-02 -3.6243122
 phi3   1.087537e+00    0.4215446 2.805719e+00  0.0839151

Deterministic reference points (Drp)
           estimate        cilow        ciupp    log.est
 Bmsyd 23785.216373 2825.7609943 2.002068e+05 10.0768195
 Fmsyd     0.610384    0.1136168 3.279168e+00 -0.4936671
 MSYd  14518.114375 8088.2668612 2.605943e+04  9.5831524
Stochastic reference points (Srp)
           estimate        cilow        ciupp  log.est rel.diff.Drp
 Bmsys 2.355173e+04 2770.6600228 2.001992e+05 10.06695 -0.009913912
 Fmsys 6.064154e-01    0.1112378 3.305888e+00 -0.50019 -0.006544280
 MSYs  1.428120e+04 8039.7749760 2.536797e+04  9.56670 -0.016589005

States w 95% CI (inp$msytype: s)
                    estimate        cilow        ciupp    log.est
 B_2021.94      3.179737e+04 3322.4748664 3.043131e+05 10.3671389
 F_2021.94      2.464822e-01    0.0261756 2.320999e+00 -1.4004656
 B_2021.94/Bmsy 1.350108e+00    0.9847599 1.851001e+00  0.3001844
 F_2021.94/Fmsy 4.064576e-01    0.1599493 1.032876e+00 -0.9002756

Predictions w 95% CI (inp$msytype: s)
                  prediction        cilow        ciupp    log.est
 B_2023.00      3.250799e+04 3412.3777338 3.096872e+05 10.3892413
 F_2023.00      2.464823e-01    0.0231926 2.619526e+00 -1.4004652
 B_2023.00/Bmsy 1.380281e+00    0.9632868 1.977786e+00  0.3222869
 F_2023.00/Fmsy 4.064578e-01    0.1230850 1.342226e+00 -0.9002752
 Catch_2022.00  8.326637e+03 3965.3251430 1.748479e+04  9.0272150
 E(B_inf)       3.601612e+04           NA           NA 10.4917219
```

**Table 7.5.2.1. Sardine in Subarea 7. The basis for the catch scenarios*.**

| | |
|---|---|
| **Index A (2022)** | 336 306 tonnes |
| **Index B (2020–2021)** | 279 607 tonnes |
| **Index ratio (A/B)** | 1.20 |
| **Biomass safeguard (Istat)** | Not applicable |
| **Uncertainty cap** | Not applied |
| **Advised catch for 2022** | 6906 tonnes |
| **Discard rate** | Negligible |
| **Catch advice 2023 **** | 8 306 tonnes |
| **% advice change** | +20 % |

* The figures in the table are rounded. Calculations were done with unrounded inputs, and computed values may not match exactly when calculated using the rounded figures in the table.
**[Advice for 2022] x [Index ratio]

**Table 7.7.1. Sardine in divisions 8.a–b and 8.d. Reference points, values, and their technical basis.**

| Framework | Reference point | Value | Technical basis | Source |
|---|---|---|---|---|
| MSY approach | MSY $B_{trigger}$ | Not defined | | |
| | $F_{MSY}$ | Not defined | | |
| Precautionary approach | $I_{stat}$ | 120 751 tonnes | Geomean(Ihist) × exp(−1.645 × sd(log(Ihist)); Ihist is the available historical series of the abundance index (2017–2021) | (ICES, 2022b) |
| | $B_{lim}$, $B_{pa}$ | Not defined | | |
| | $F_{lim}$ | Not defined | | |
| | $F_{pa}$ | Not defined | | |
| Management plan | $SSB_{MGT}$ | Not defined | | |
| | $F_{MGT}$ | Not defined | | |

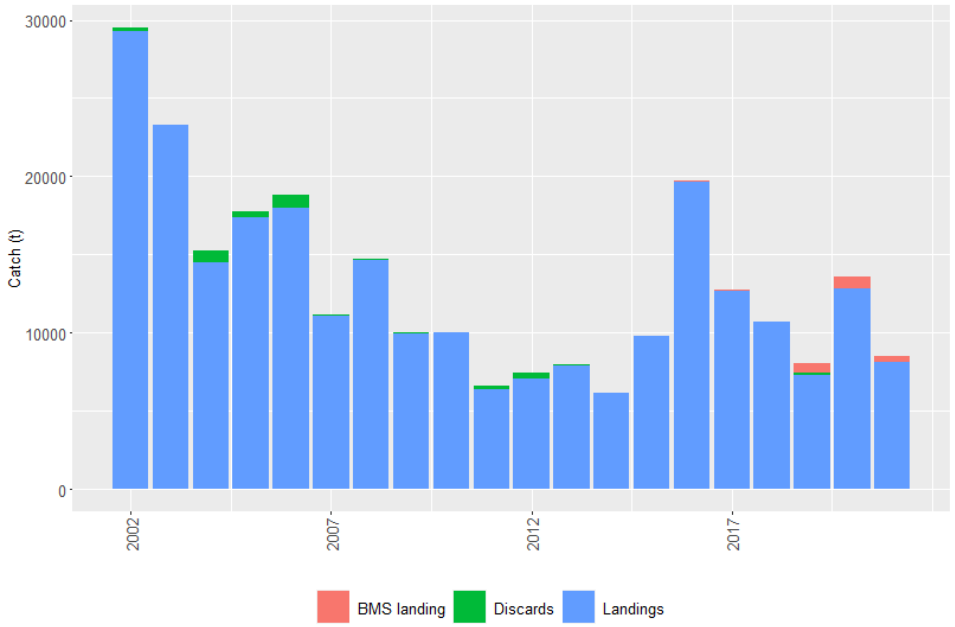


**Figure 7.2.1.1. Sardine in Subarea 7. Catches by category (tonnes).**

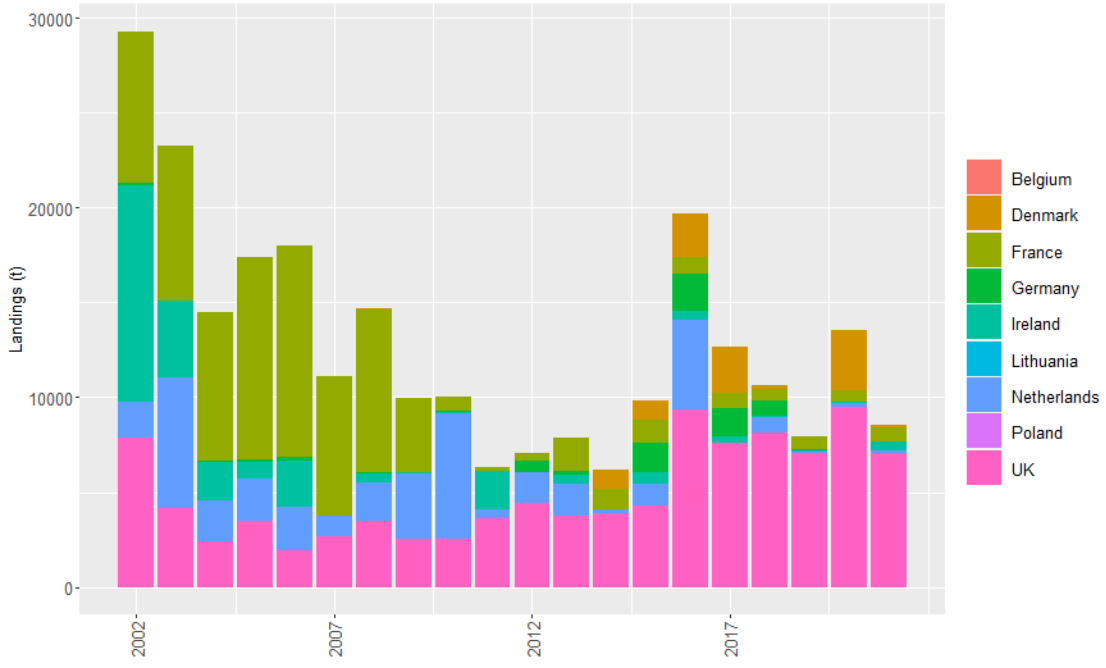


**Figure 7.2.1.2. Sardine in Subarea 7. Landings reported by country (tonnes).**


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

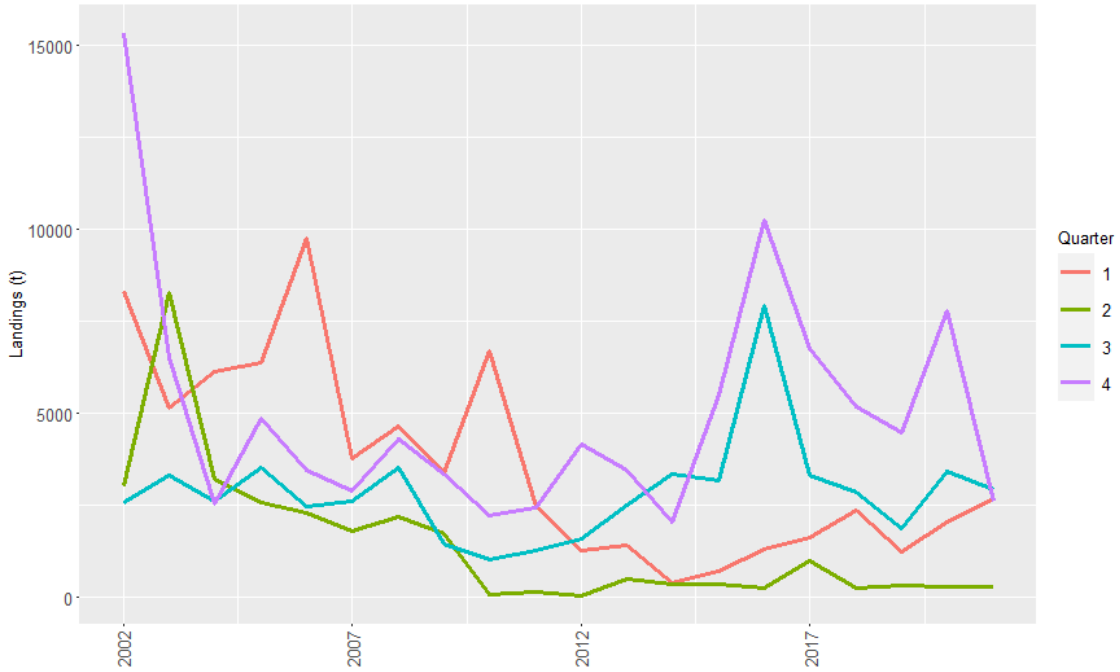


**Figure 7.2.1.4. Sardine in Subarea 7. Landings by quarter (tonnes).**

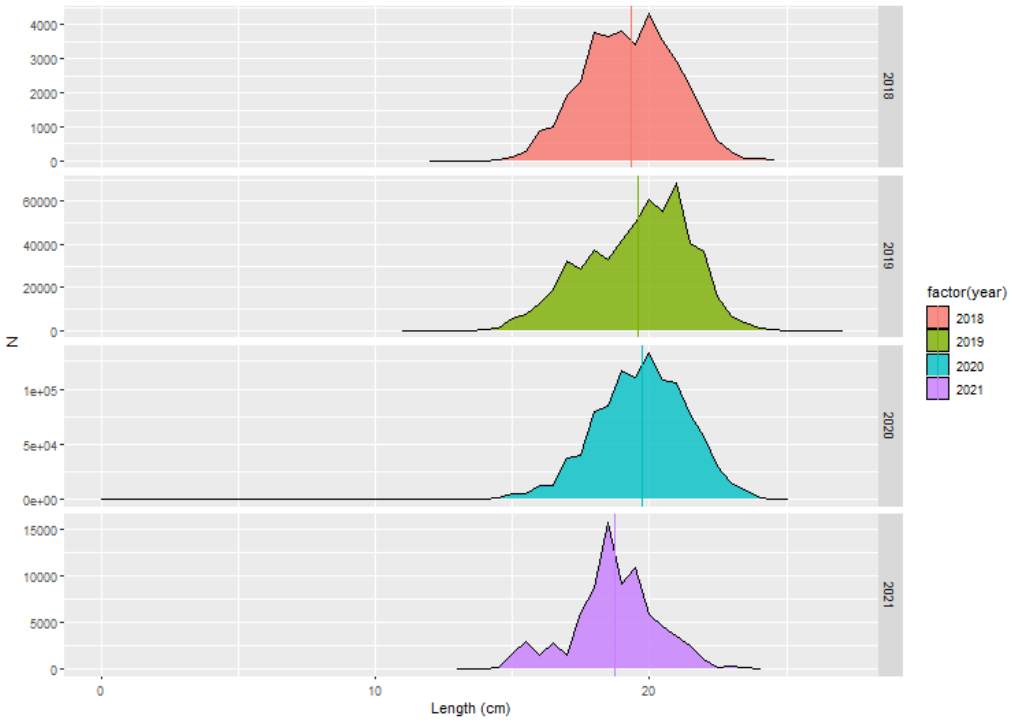


**Figure 7.3.1.1. Sardine in Subarea 7. Length distribution of landings provided by the English fishing industry.**

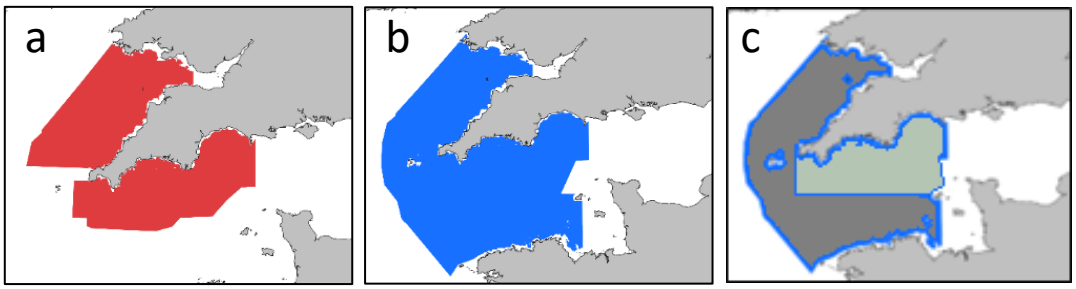


**Figure 7.4.1.1. Sardine in Subarea 7. PELTIC coverage of core area a. since 2013, b. total area since 2017 and c. in 2022.**


**Figure 7.4.1.2. Sardine in Subarea 7. Sardine biomass in tonnes estimated from PELTIC survey in the core area (red line), covering division 7.f and English waters of 7.e, in the total area (blue line), covering division 7.f and 7.e (also French side), and in the restricted area covered in 2022 (green line). Dashed red and blue lines are the estimated values.**

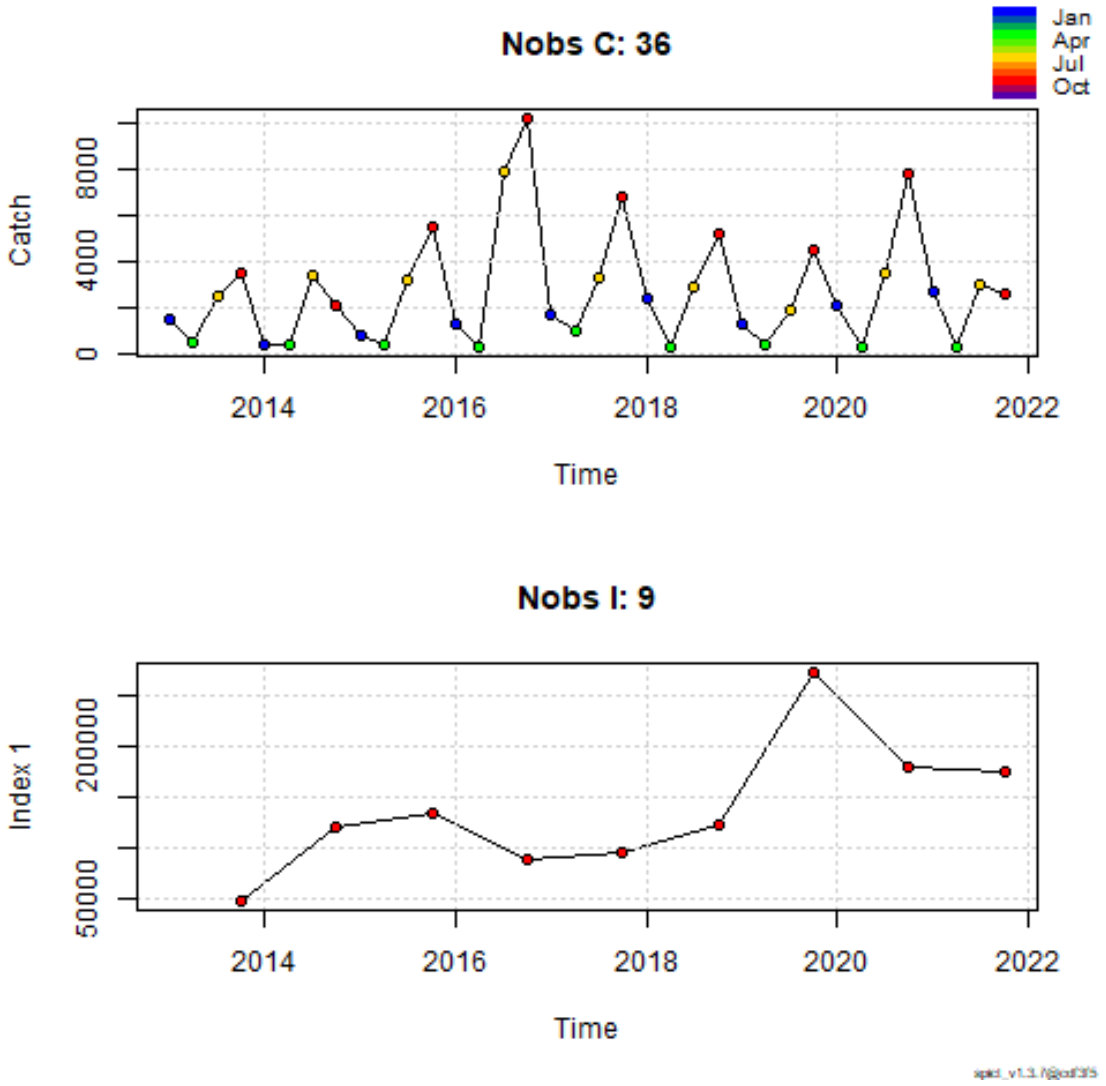


**Figure 7.5.1.1. Sardine in Subarea 7. Input data of the SPiCT model. Top: landings by quarter (2013-2021). Bottom: biomass estimates in the core area (2013-2021). Blue represents quarter 1, green represents quarter 2, yellow represents quarter 3, and red represents quarter 4.**

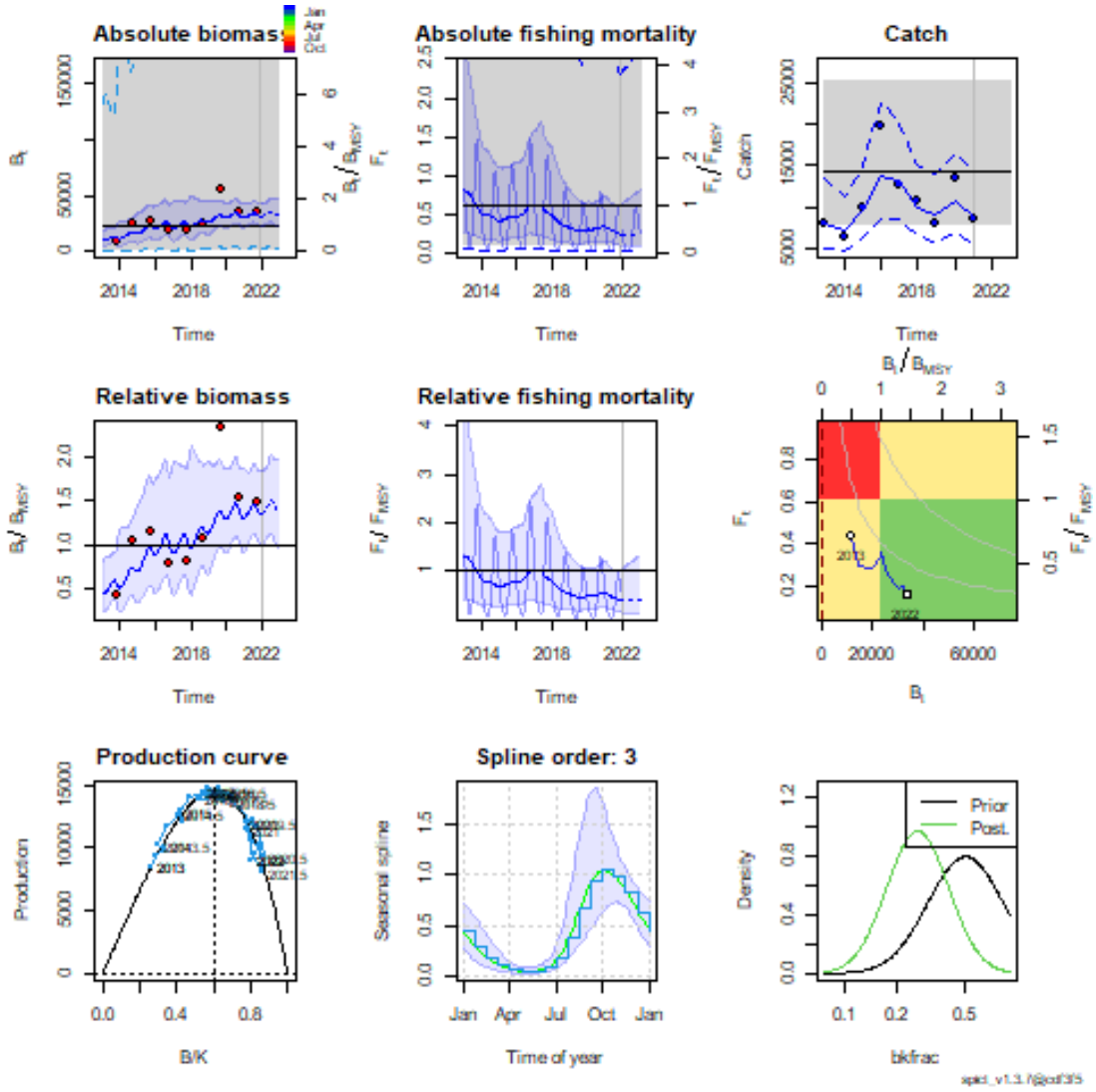


**Figure 7.5.1.2. Sardine in Subarea 7. SPiCT model results. Top row: absolute biomass, absolute F estimates, and fitted catch. Middle row: relative biomass and F, and a Kobe plot comparing biomass and F. The grey area in the Kobe plot represents the uncertainty in the relative biomass and F estimates.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

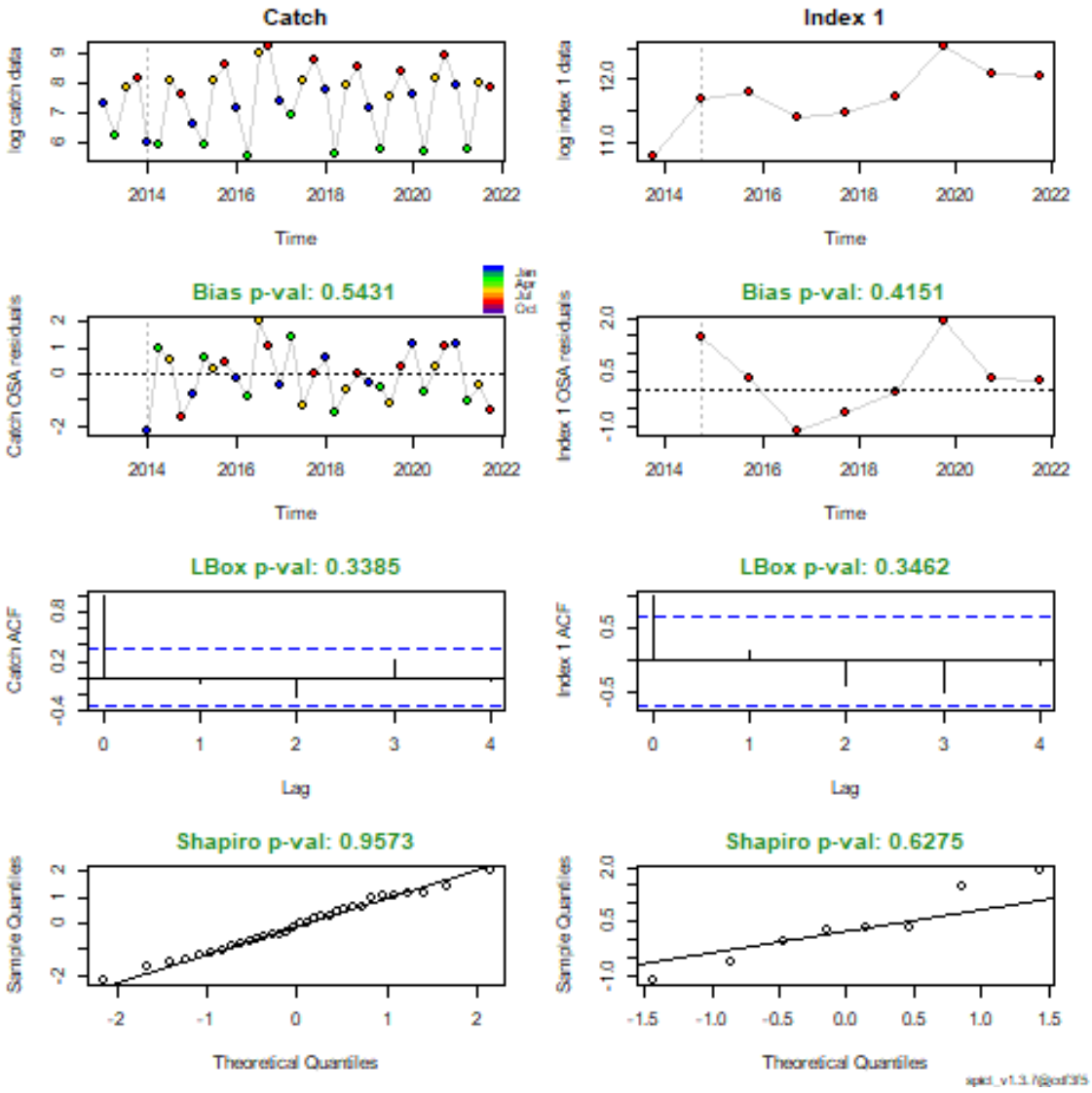


**Figure 7.5.1.3. Sardine in Subarea 7. SPiCT model diagnosis.**

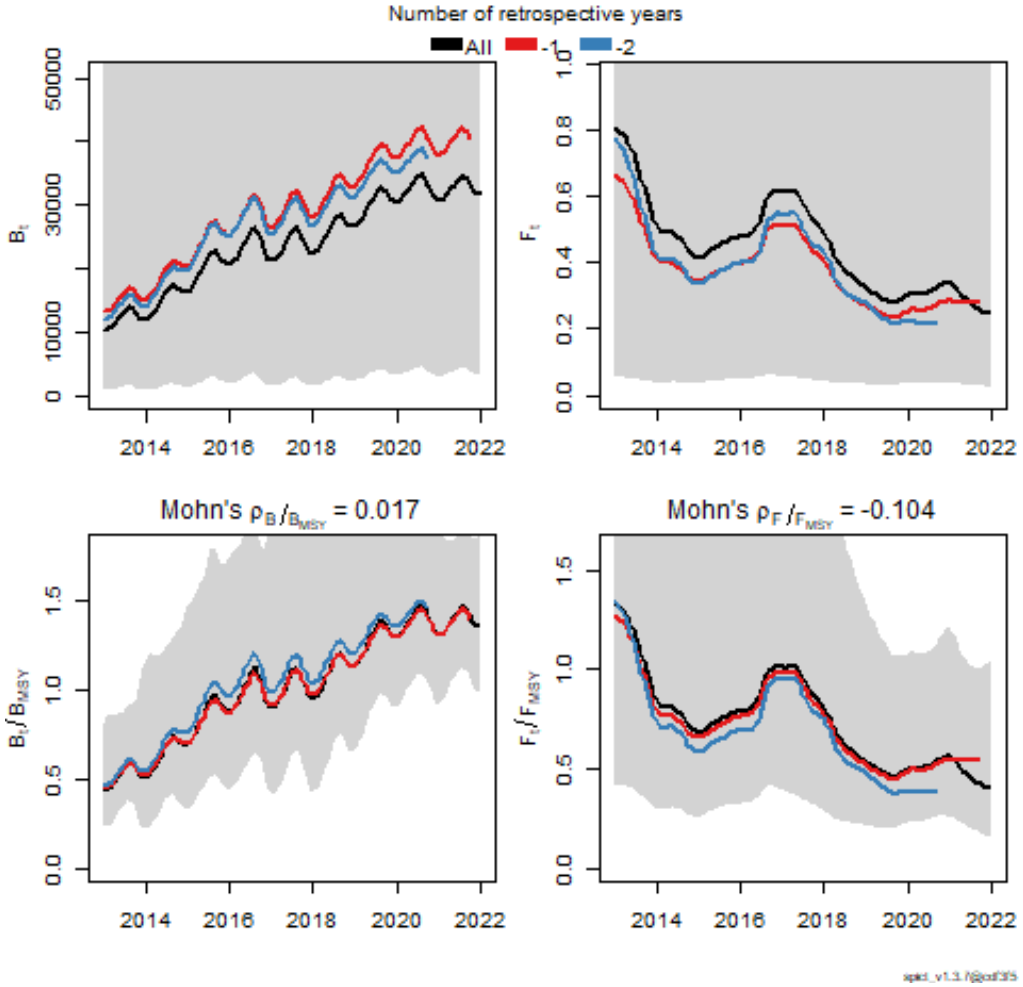


**Figure 7.5.1.4. Sardine in Subarea 7. Retrospective analysis of the SPiCT model. Top row: absolute biomass and absolute F; bottom row: relative biomass and relative F.**