REPORT OF THE JOINT ICES-ICCAT BENCHMARK WORKSHOP IN ADVANCE OF THE NORTH-EASTERN ATLANTIC PORBEAGLE STOCK ASSESSMENT

To undertake the assessment of northeast Atlantic porbeagle stock, the ICES Working Group on Elasmobranchs (WKELASMO) and Shark Species Group (SHK SG) of the Standing Committee of Research and Statistics (SCRS) of the International Commission for the Conservation of Atlantic Tunas (ICCAT) held a series of meetings between late 2021 and April 2022. Between 28 November and 3 December 2021, the WKELASMO and SHK SG discussed data issues. CPUE standardization matters were discussed on 15 February 2022, whereas the assessment matters were tackled on a meeting held between 26 and 29 April 2022. Both ICES and ICCAT scientists agreed on the final decisions regarding data and base-case assessment model choice. The text below related to the North-eastern Porbeagle was extracted from the ICES report (Anon. 2022).

1. Introduction

The 2009 ICCAT-ICES WG carried out an initial analytical assessment of the Northeast Atlantic (NEA) porbeagle stock (ICCAT 2010). A Bayesian Surplus Production (BSP) model (Babcock and Cortes, 2010) was used, but the lack of CPUE data for the peak of the fishery was considered adding considerable uncertainty in identifying the status of the stock. In addition, an age-structured production model (Porch *et al.,* 2006) was used to provide contrast with the BSP model, but the fishing mortality estimated for the historic period was unrealistic. As a result, outputs of models were considered too uncertain for management advice to be based on them (ICES 2009).

As a result, the ICES assessment of the state of the stock in 2010 was based primarily on the observation that the northern fisheries had ceased and not resumed, indicating that the stock was probably depleted (ICES 2010). The subsequent 2012 assessment was unchanged (ICES 2012). In 2015, the stock status was considered unknown because previous perceptions of the stock were based largely on the historic decline in landings and changes in fishing patterns, but those factors other than fish abundance can also influence landings (ICES 2015). The stock size is still considered unknown in 2019 ICES advice for 2020-2023 (ICES 2019).

2. Stock Identity

Two WD (Biais *et al.,* 2022, Righton *et al.,* 2022) presented results from the large number of pop-up satellite archival tags (PSATs) deployed on porbeagle in the NE Atlantic from 2006 to 2019 (n=88 counting deployments > 8 days in length). Release areas were North Sea (n=1), Faroes Islands (n=1), North Ireland (n=20), Celtic Sea (n=12) and SW Celtic Sea and Bay of Biscay shelf edge (n=54). The plots of reconstructed tracks show limited number of daily positions in the northeast of Scotland, the North Sea and the Norwegian Sea (**Figures 15 and 16**).

The average percentage per month of daily positions in this area is estimated at 3% from March to July and at 26% from August to February for the porbeagle tagged in the Bay of Biscay and the South Celtic Sea in spring-summer. This low use of the north-eastern portion of their habitat by these porbeagle is associated with a frequent return to or near the tagging area in spring of the following year, with 76% of 22 tag deployments lasting over 11 months.

This migration pattern suggests a change in porbeagle distribution to explain past large catches in the North Sea and in the Norwegian Sea, or that the exploited biomass may be composed of several fractions which are not fully mixed on the main fishing areas due to their different areas and times of site fidelity. This latter possibility is supported by a preliminary genetic analysis based of mitochondrial DNA that suggest genetic differences between behavioural groups (Viricel *et al.,* 2021 WD). However, this analysis was based on a limited sample and must be confirmed by complementary genetic analysis on nuclear DNA.

Consequently, further studies must be encouraged to better appreciate the implications of the complexity of the stock structure and population structure of porbeagle in the NEA for stock assessment and fishery management. However, there is not yet sufficient information to consider another option than a single stock for porbeagle in the NEA. Tagging and catch data support the western limit of the stock area at 42°W but with its southern limit could be extended southward from 36°N to 5°N, to align with ICCAT (Ellis *et al.*, 2022).

3. Input data for stock assessment

3.1 Catch data

Porbeagle landings are assumed to be close to catches until 2009, as the high value of this species must have limited discards (ICES 2021). Since the EU zero TAC was introduced in 2010, reported landings are likely much less representative of catches, but there is no doubt that catches have been reduced by a very large proportion since 2010. Therefore, the use of landings to estimate catches may cause a limited underestimate of catches until 2009, as comprehensive landing data are available for the main fishing nations and discards limited. From 2010 onwards, discards are unquantified, and in the absence of such data, their level is assumed to be insufficiently large enough to distort the trend shown by the landings too much.

The 2021 WGEF landing data were revised using (**Figure 1**):

- landings submitted in response to the WKELASMO datacall (2005-2020 requested) by France, Germany, the Netherlands, Norway, UK-England and UK-Scotland. All these countries have previously reported landings to the annual WGEF datacalls. Now submitted landings were therefore crossed-checked for eventual updates against the 2021 WGEF landings table.

- ICCAT catch statistics provided to the WKELASMO. ICCAT Faroe Islands catches from 1953 to 1960 were included because it is assumed they were in the NEA before the porbeagle fishery began in the NWA. WGEF Spanish landing were replaced ICCAT catches, because WGEF landing were suspected of including landings of other shark species (no change from 1950 to 1987).

- Data base of the French Fisheries Directorate for the revision of the French landings from 1973 to 1987 and Ifremer data base (Harmonie) for the revision of the French landings from 1988 to 1999.

- Norwegian official statistic reports for the revision of the Norwegian catches for some limited differences (years 1971, 1973 and 1984) and conversion from gutted weight to live weight using the transformation coefficient (1.3) provided in Norwegian official statistic reports (years 1926 to 1972, except years 1958-1960, 1969, 1970 already in live weight).

3.2 CPUE series

Three longline CPUE series were made available for the NEA porbeagle stock benchmark, standardized by a GLM:

- A Norwegian longline CPUE series from 1950 to 1972, in number of fish by day, from personal logbooks of five vessels of the Norwegian directed fishery, in number of fish by day (Biais 2022 a and b);

- A French longline CPUE series from 1972 to 2009, in catch by trip, from logbooks of 19 vessels of the French directed fishery, a revision of the CPUE series already presented at the 2009 ICCAT-ICES assessment (Biais 2022 c and d);
- A composite survey CPUE series constructed by combining CPUEs of a French commercial vessel, from 2000 to 2009, with CPUEs of a survey carried out in 2018-2019, in number of fish by day and by ICES rectangle (Biais 2022 e, f and g).

In addition, a Spanish longline CPUE series has been available since the 2009 ICCAT-ICES assessment (ICCAT 2010; Mejuto *et al.,* 2010) that used it. This is a bycatch series of the surface longline targeting swordfish, in round weight per trip and per thousand hooks.

3.2.1 The Norwegian longline CPUE series

The Norwegian CPUE series was obtained from three handwritten logbooks for five longliners of the directed fishery (Biais 2022 a). Since this fishery ceased in the 1980s, these logbooks are now rare. Although limited in number, those obtained provided a sufficiently large database for further analysis, with 1683 daily catches in number per 1°x1° rectangle for the period 1950 to 1972 (years 1965-67 missing). First, considering that a vessel follows likely the porbeagle movement, the independence of pairs of catches in same or adjacent 1°x1° rectangles and taken at intervals varying from one to ten days was assessed using Kendall's rank correlations (p-value<0.05). Based on results, the CPUEs were selected if there are at least five days between successive catches when taken in same or contiguous rectangles. Otherwise, CPUEs were assumed to be independent observations, as it seems unlikely that a vessel may find again the same group of fish the next day by skipping a 1°x1° rectangle, given the variability in fish moves shown by SPAT deployments. This selection significantly reduced the number of daily catches that could be used from 1683 to 616, but it was considered necessary for obtaining unbiased abundance indices. Using this subsample, six subareas were defined based on mean CPUEs per rectangle and observed discontinuities. They extend along the Norwegian coast, south 69°N, to the North Scotland, also extending in the north and central part of the North Sea (**Figure 2**). This historic fishing area of the Norwegian fishery was supplemented by new areas to the west and south of Ireland in the 1960s. The CPUEs were standardized comparing three GLM approaches, all adapted to the presence of zero catch days in the CPUE series (negative binomial error distribution, Tweedie error distribution, delta-GLM approach combining a binominal error distribution with a Gamma error distribution) using CPUEs from the historic fishing area of the Norwegian fishery (Biais 2022 a). The year, the month, the subarea and the vessel were included in the GLM variables as well as the interactions between these effects. The selection of the model to retain was proposed on the basis on five folds cross validations, Akaike's Information Criteria and quantile residual plots. Following the presentation of this GLM comparison, the WKELASMO requested to complement the analysis by examining the effects of using all six defined spatial units (not excluding spatial units in west and southwest of Ireland) and quarter instead month as temporal variable to standardize the Norwegian longliner CPUEs, with GLMs using the negative binomial error distribution with a log link, given its relevance when CPUEs are integers and varies largely and its performances in comparison with GLMs using other distributions. Following the presentation of this supplement to previous analysis (Biais 2022 b), the GLM model involving the effects of the year, the month and the subarea and using a negative binomial error structure was selected as final model. The series of relative annual indices obtained with this model shows a downward trend in the second half of the 1950s, but this trend seems to have stabilized in the early 1960s, followed by a slight increase in the late 1960s and early 1970s (**Figure 3**).

To obtain a biomass index for doing a SPiCT assessment with indices and catch in weight, the Norwegian logbooks used to obtain the relative abundance index were also used. They provide catch by weight (gutted fish without head) for most landings. This allows the calculation of annual mean fish weights based on 92% of the daily CPUEs used in the GLM standardization for all years from 1950 onwards, except 1970 and 1972. For these two years, the mean weights were estimated by the average of the mean weights of the closest years (1969 and 1970, since the series ends in 1972). These mean weights were used to transform the abundance relative index in a biomass relative index series by multiplying each annual index by the corresponding annual mean weight (**Figure 11**).

3.2.2 The French longline CPUE series

CPUEs of longliners in the French directed fishery are available since 1972, the second year of the fishery, until it was stopped by a zero TAC in 2010 (Biais 2022 c and d). Its fishing area extends mainly on the shelf edge of the Bay of Biscay, but also in the Celtic Sea (**Figure 4**). In order to get the longest possible time series, these CPUEs are in weight per trip. This series was first presented to the 2009 ICCAT-ICES WG which used it for an exploratory assessment. As in 2009, the choice to select boats was made in order to avoid short participations and thus a better interannual comparability of abundance indices (19 vessels selected, all based in Yeu Island). In addition to this previous processing, the CPUE series was cleaned to limit the effects of sailing time to the fishing areas as well as to exclude some trips targeting tunas or whose values suggested an error in the reporting process. CPUEs were standardized with a GLM, using a Gamma error distribution with a log link. The variables considered were the year, the month, the area (ICES divisions 7 a & f-g, 7 h-j-k and 8), the vessel and their interactions. The selection of the final model was performed as for the Norwegian CPUEs. This model involves the four variables considered but not their interactions. The relative abundance index obtained decreases in the 1970s, but thereafter varies without trend (**Figure 5**).

3.2.3 The composite survey CPUE series

The composite survey CPUE series combines CPUEs of a French commercial vessel, from 2000 to 2009, with CPUEs of a survey carried out in 2018-2019. This was done to construct a series long enough to provide information on the trend in abundance since the cessation of the directed fishery in 2010, in the absence of any possibility of basing an assessment on commercial CPUE since the implementation of the regulations that stopped the French directed fishery and almost all porbeagle landings in European countries.

The survey was carried out in May-June 2018 and 2019, during about one month and a half in both years, with a chartered longliner based in Yeu Island whose captain and crew were experienced in porbeagle longline fishing. The gear was a longline with 336 hooks, identical to gear used by the commercial directed fishery for the first set of the day. Two sets per day were planned, as usual in the commercial fishery, but with the same gear whereas a longline twice the length is generally used in commercial fishery for the second set of the day. The two daily sets were planned in the same ICES rectangle with one to three fishing days by statistical rectangle (but generally two) that must be at least 10 days apart. The survey area comprised 16 ICES rectangles extending along the shelf edge of the Bay of Biscay and the south Celtic Sea (**Figure 6**). Thus, the survey aimed to obtain systematic sampling of a core area of the former directed fishery in a time when this area is an important part of the porbeagle habitat as evidenced by PSAT deployments and commercial CPUEs. The positions of fishing stations were fixed and as far apart as possible. This sampling scheme and the daily change in ICES rectangle were intended to provide independent daily observations. This was verified by an analysis of the relationship between CPUEs on consecutive days when sets are made within 30 nautical miles of each other in contiguous statistical rectangles (Biais 2022 e).

The combination of CPUEs of this survey with commercial CPUEs required that the latter be detailed, including specific positions, numbers of fish caught and hooks by set. Mandatory declarative logbooks do not provide these data, but it was possible to get them for a vessel of the directed fishery of which the captain provided his personal diaries for years 2000 to 2009. This vessel contributed to total French landing for about 10% each year from 2000 to 2008. In an initial attempt for combining commercial and survey CPUEs, the commercial CPUEs were scaled to 336 hooks and a selection of sets was made to mimic the survey sampling plan, using only CPUEs from May-June and within the survey area. In its presentation, WKELASMO suggested an analysis of the possible difference in catchability between longline sets with 3 or 4 lines (252-336 hooks), usually in the morning, and sets with 9 or 10 lines (756-840 hooks), usually in the afternoon. The results of this analysis showed that scaling to the same number of hooks was insufficient to properly incorporate the difference between the two types of longlines.

Consequently, a GLM was considered to be a better method to combine all CPUEs, including the type of longline in the variables (Biais 2022 f). Nevertheless, in order to limit the number of types of longline to two (252-336 hooks or 756-840 hooks), given the number of commercial CPUE available (n=740), a scaling to the same number of hooks was kept, assuming that the catchability is not affected by a small difference in number of hooks within each type. To select independent observations, as the survey CPUEs are, due to its sampling design, an analysis based on Kendall's rank correlations was performed as for the Norwegian longline CPUEs. It shows that CPUEs are independent observations after one day when 252-336 hooks are used and after two days when 756-840 hooks are used. According to this result, it appears more difficult to track porbeagle in the Bay of Biscay and in the southern Celtic Sea than in northern European waters, but the reason remains speculative (fishing technique, environment, prey density, etc.).

When two consecutive CPUEs are 50 NM apart, they were considered independent observations because they are not in contiguous ICES rectangles, using the same rationale than for the Norwegian CPUEs. Consequently, two series of independent CPUEs were constructed based on the distance and number of days between sets, one for each type of long line. In addition, a final possibility of improvement of the consistency between survey and commercial CPUEs was investigated by examining the distribution per ICES rectangle of commercial CPUEs.

Because a systematic sampling plan is adopted for the survey, the number of statistical rectangles visited during the survey is independent of the porbeagle distribution. The fishing effort of a commercial vessel is naturally more limited on area of low porbeagle density. To investigate this possible relationship between

CPUEs and set distribution (Biais 2022 g), the series of independent CPUEs resulting from 252 or 336 hook sets was used because they form a longer series (n= 252) than the 756 or 840 hook CPUE series (n= 224), due to the selection to get independent observations. The survey area was divided in two parts: a northwestern subarea (North 47°N and west 7° W), which includes about half of ICES rectangles of the survey area, and the rest outside this NW subarea. Using the mean by ICES rectangle in May-June (survey months), to limit the effect of set distribution by rectangle, the mean CPUE was calculated by subarea (of the survey area) for every year. The proportion of ICES rectangles with longline sets in these subareas was also calculated in May-June every year. Then, the relationship between the proportion of set in the NW subarea and the mean CPUE outside this area in May-June was examined. As expected, there is a negative correlation between these two quantities (**Figure 7**). The relationship is linear with a slope significantly different from zero at alpha level of 0.05 (p-value<0.01). Therefore, the CPUEs outside the NW area provide a basis to estimate the number of ICES rectangles of the NW area where the commercial vessel would have set longlines in 2018 and 2019 with its usual fishing behaviour.

In these two years, the CPUE outside the NW area (i.e., in the southeastern part of survey area) are 5.3 and 4.4 porbeagle per set respectively, thus within the range of values used for estimating the linear relationship. They can therefore be used to estimate the proportion of ICES rectangles with sets in the NW area in 2018 (21%) and in 2019 (30%). These proportions and the number of rectangles with sets in the SE part of the survey area (7 in 2018 as in 2019) allow us to estimate that the number of rectangles in the NW area should have been 2 in 2018 and 3 in 2019 to have a distribution of sets by area similar to than that observed for the commercial vessel whose CPUEs are used to extend the survey series.

To obtain a consistent CPUE series, some ICES rectangles must consequently be selected among the rectangles with sets in 2018 (n = 9) or in 2019 (n = 8) in the NW area. The mean CPUEs in May-June outside the NW area can easily be grouped in two categories, depending on whether theirs mean CPUEs are above the mean or not, with large gap between the means of the two groups, with one having a mean CPUE nearly seven times higher than the other. The 2018 and 2019 CPUEs are obviously in the group of high CPUEs as they are about three times the 2000-2009 mean CPUE. Three years make up this group from 2000 to 2009: 2000, 2002 and 2009. In these years, the three ICES rectangles more frequented (by number of years) are 25D9, 25E0 and 24D9, in descending order of frequentation and priority to the easternmost rectangle in case of equality (25E0 and 24D9), considering that the vessel should navigate from east to west when exploring the NW area along the shelf edge. Therefore, only the CPUEs in these three ICES rectangles 25D9, 25E0 and 24D9 (25D9 and 25E2 in 2018, all three in 2019) must be selected to obtain a survey series comparable to the commercial series that complement it.

With regard to the commercial CPUEs, when independent observations are made using 252 or 336 hooks, they are comparable to the survey CPUEs (after scaling to 336 hooks when 252 hooks are deployed), considering that the fishing technique is identical, that the vessel in based on Yeu Island in both case, with the consequence that crew skill is similar and that the possible “skipper effect” is eliminated by the criteria set to obtain independent observations. A unique series can then be created to complement the survey CPUEs (including only those in selected ICES rectangles in the NW area) back to 2000 with comparable commercial CPUEs. The full CPUE series to standardize was formed by adding the CPUEs when 756 or 840 hooks are used, also scaled to the same number of hooks. This full CPUE series is referred as composite survey CPUE series later in the report.

The standardisation process was conducted with GLM using a Tweedie error distribution because data are continuous and include null values, with the usual choice of a log link. The model selection was done with the full series of survey CPUEs, because it was done before noticing the need to compare the spatial distribution of commercial and survey CPUEs. It was assumed that the removal of few CPUEs in two years (n=21 out of 535) has no consequence on the analysis previously performed to select the final model.

Four variables were considered for inclusion in the models tested: the year, type of longline (252-336 hooks or 756-840 hooks), month or period (February-April, May-June, July-September), to have periods before, during and after the survey, as an alternative to the month that limits the risk of over parametrisation, area (Celtic Sea north 48°30N, North Bay of Biscay from 45°N to 48°30N, South Bay of Biscay south 45°N) to catch the effect of the survey area (North Bay of Biscay), as the number of observations forces the ICES rectangle to be merged into larger spatial units. The selection of the final model was based on five folds cross validations, Akaike’s Information Criteria and quantile residual plots, like for the other GLM. This model involves the year, the type of longline and the area. The relative abundance index obtained shows a moderate increase of abundance of porbeagle in the Bay of Biscay and the southern Celtic Sea area from 2009 to 2019 (**Figure 8**).

To obtain a biomass index for doing a SPiCT assessment with indices and catch in weight, a mean weight series must be made available. A weight-length relationship based on landing data collected in 2008-2009 (Hennache and Jung, 2010) was used with length distributions from April to June of these two years (not available for each year separately) to calculate a mean weight for 2008-2009. Since the survey was carried out in May-June and that 80% of the commercial CPUEs selected to complement the survey are from April-June, the use of landing length distribution in these last three months (in Hennache and Jung, 2010) appeared relevant to provide biomass indices comparable to those of the survey and representative of the catch used to complement the survey CPUEs. The mean weight thus calculated is 59 kg.

This mean weight is above the values reported for May-June from 1980 to 1989 which are comprised between 42 and 53 kg (Lallemand-Lemoine, 1991), but the mean weight reported for July (61 kg) is greater than in 2008-2009 (44 kg). The higher July value in the 1980s likely indicates a sampling from the shelf edge when in July 2008-2009, the length distribution may have included samples from the Celtic Sea where the French fishery used to move in summer and where the fish are smaller. However, this shows that the mean weights do not appear to have changed much between the 1980s and 2000s. Given this observation, but also the low dynamic of porbeagle populations and the likely stability of the exploitation pattern in the absence of changes in fishing gears and practices in the French fishery in the 2000s, a stability of the length distribution of the exploitable population of porbeagle from 2000 to 2008 appear an acceptable assumption. That supports using the 2008-2009 mean weight from 2000 to 2009 to convert the composite survey abundance index into a biomass index.

The 2018 and 2019 mean weights were obtained using the available weight-length relationship and the length distributions of survey catches. They are respectively 78 and 72 kg, values in agreement with the observed shift to the right of the length distribution between 2008-2009 and 2018-2019 (**Figure 9**). The mean weights obtained were used to transform the composite survey abundance index in a biomass index by multiplying each annual abundance index by the corresponding annual mean weight (**Figure 11**).

3.2.4 The Spanish longline CPUE series

The Spanish longline CPUE series was presented at the 2009 ICCAT-ICES porbeagle stock assessments meeting (ICCAT 2010; Mejuto *et al.,* 2010). CPUEs were provided by trips (in kg round weight per thousand hooks) of the surface longline targeting swordfish in the whole North Atlantic, from 1986 to 2007. For 88% of the trips (n=15458) no porbeagle was found. At the request of the 2009 ICCAT-ICES Working Group, an analysis restricted to two zones (#4 and 5) in the eastern Atlantic (East 20°W from 35°N to 55°N) was carried out to be used in the assessment. 5844 trips were reported in this area from 1986 to 2007 for 5699 porbeagle caught. The portion of this area north of 45°N comprises about half of these catches, although it is reported that traditional longline appears in this zone only sporadically during certain years and quarters. Some of the trips carried out during 1980s in this area are also indicated to may have taken advantage of sporadic local concentrations of porbeagle. CPUEs were standardized using GLM procedures assuming a delta-lognormal distribution error. The final model was selected using Akaike's Information Criteria, Bayesian Information Criteria and the likelihood ratio test (variables included: year, zone, quarter, bait, year*zone, year*quarter). The relative abundance index obtained (**Figure 10**) includes higher values in the 2000s, with large interannual variations.

3.3 Life-history parameters

SPiCT model runs were carried out using 0.059 yr^{-1} as a prior for the intrinsic growth-rate (r). This value was computed for the western Atlantic porbeagle population (Cortes and Semba, 2020).

4. Stock assessment

For all SPiCT (Pedersen and Berg, 2017) runs presented at the WKELASMO, the acceptance was examined with the list of criteria recommended by Mildenberger *et al.,* (2020). Analyses were conducted in 3.6.3 (R Core Team, 2020) using the ellipse (Murdoch and Chow, 2020), SPiCT (Pedersen and Berg, 2017) and TMB (Thygesen *et al.*, 2017) packages.

Exploratory assessments with JABBA (Winker *et al.,* 2018) were also presented. This Bayesian state-space surplus production model framework provides a comprehensive toolbox to conduct model diagnostics to objectively evaluate the four model plausible criteria recommended in Carvalho *et al.,* (2021): (1) model convergence (2) fit to the data, (3) model consistency (retrospective pattern) and (4) prediction skill through hindcast cross-validation. More information on use of the 'JABBA' R package can be found in Ortiz *et al.,* (2022) and in Winker *et al.,* (2018).

Prior to the development of a Norwegian directed fishery with first landing reported in 1926, all available information seems to show that porbeagle was only caught incidentally in limited quantities by Norwegian fisheries in the absence of a local market. No other fishery appears to have existed before 1946. There is therefore every reason to believe that the stock was very little exploited before 1926 and its biomass was close to the virgin state. The prior for the biomass ratio to the carrying capacity was consequently fix to 0.99 in all exploratory assessments carried with SPiCT, considering this prior informative (SD log (B/K)=0.2).

4.1 Exploratory assessments

Four sets of SPiCT exploratory runs were presented at the WKELASMO.

The first one (Biais 2022 h) did not include the Spanish longline index because the benefit of using it was discussed later. It included five runs (see below), starting with a Schaefer model as a reference run (informative prior for n set to 2). In subsequent runs, the prior for n remains set at 2, but with a different SD of log(n) in R3 to R5, and with no change in priors for B/K (or same basis of unfished biomass in 1926 when the starting year of the run is changed) and r:

- R1 Reference run with a Schaefer model (prior for n=2, SD of log(n)=0.2);
- R2 Robust estimation flag on catches to verify if this option could improve the diagnostics of the reference run in which the Shapiro test for normality of catch residuals fails to pass;
- R3 Semi-informative prior for n (SD of log(n)=0.5), because the posterior value below 2 seemed to indicate that a lower n could provide a less flat production curve;
- R4 Same as R3 but starting in 1950 to test whether the fit is improved when the run is restricted to years for which biomass indices are available;
- R5 Relative SD of catches five times that of 2010, due to the uncertainty in discards size since 2010, with a semi-informative prior for n.

This initial exploration of using the SPiCT model with new data presented to the WKELASMO suggested a better fit when using a semi-informative prior for n, implying a Fox model (posterior n close to 1), and a higher relative SD of catches from 2010 onwards (run R5), with no benefit from other options.

The parameter of the run R5 were selected for an exploratory assessment with JABBA that compared this run with an alternative scenario including the Spanish longline index (Ortiz *et al.*, 2022). Both scenarios are consistent with SPiCT run R5, with respect to B/B_{MSY} and F/F_{MSY} trends. The JABBA criteria for plausible model acceptance are met for both scenarios, but the incorporation of the Spanish index degrades the precision of the fit. Considering that both runs are plausible, Ortiz *et al.,* (2022 a) suggest selecting the scenario that incorporates all available indices.

A second set of SPiCT exploratory runs was also provided by Ortiz *et al.,* (2022 b). Like the JABBA exploratory assessment, it allows to compare run R5 of the set #1 with a run having the same priors but incorporating the Spanish index (Run Ref). Four additional sensitivity runs were added, all incorporating the Spanish index:

- S1 Terminal year 2010 = same as Run Ref, but end catch and index series in 2010.
- S2 Terminal year 2015 = same as Run Ref, but end catch and index series in 2015.
- S3 Higher r prior assumptions = increase the mean r prior by a factor of three (3*0.059) same standard error of 0.2 as Run Ref.
- S4 Low standard error for the Survey index = assuming a higher precision of the composite survey index (0.5 * se Index) compared to the fisheries dependent CPUE series.

Based on the results from these sensitivity runs, the Run Ref was proposed to be the final model. Comparison with the JABBA assessment incorporating the Spanish index again shows good consistency between the trends of two models, with JABBA B_{2020}/B_{MSY} being slightly above the SPiCT estimate (0.51 vs 0.47).

However, the choice of a prior for n leading to a posterior n close to 1 was pointed out as being in contradiction with a low prior for r. Indeed, this later implies a low productivity, as expected for a porbeagle stock, whereas n close to one implies a productive stock. Therefore, a third set of 8 exploratory SPiCT runs was presented, all with an informative prior for n set to 2 (SD log(n)=0.2), but with a comparison of runs when the prior for r (still set to 0.059) is informative (SD log(r)=0.2) or semi-informative (SD log(r)=0.5), whether the Spanish index is incorporated or not.

This set of runs incorporated the composite survey index whether the spatial distribution of survey observations in 2018 and 2019 is adjusted to that of the commercial vessel observations during 2000-2009 or not. It shows that B/B_{MSY} Mohn's rho are reduced with the adjusted series. The benefit of a more consistent series was thus confirmed. On other hand, the incorporating the Spanish index has larger consequences on acceptance criteria. Without this index, the runs with a semi-informative prior on r (SD log(r)=0.5) meet the all the acceptance criteria with a posterior r low enough to be considered realistic for the species; but, when the Spanish index is inserted, the runs with a semi-informative prior on r are not acceptable because a significant F/F_{MSY} retrospective pattern with peels in years 3 and 4 largely above the others in their terminal years. The solution of adding a prior on the SD of the Spanish index with a high value was tried, without changing the results much. Since the majority of WKELASMO members were in favour incorporating the Spanish index, the run with an informative prior on r was selected, although the F/F_{MSY} Mohn's rho was high (> 0.4). The presentation of results of these runs is available on the WKELASMO SharePoint (presentation folder). However, it was noted after the presentation that the index SD's should have been scaled to their means rather to their minima to allow the prior on the SD of the Spanish index to have the intended effect.

Therefore, a fourth set of 10 exploratory runs was provided to compare runs (**Tables 1 and 2**; Figures available on the WKELASMO sharepoint in presentation folder):

- when the Spanish index is not inserted (runs #1 and #2) or if it is (runs #3 to #10);

- when the SD's of the priors for log(r) is 0.2 (run #1 and runs #3 to #5) or if it is 0.5 (run #6 to run #10);

- when different priors are adopted for SD of the Spanish index. Three values were initially selected: 0.9, 1.2 and 1.8, considering that posterior SD of the composite survey index is about 0.6 in results of runs #1 and #2. Therefore, sensitivity runs with a prior for the SD of the Spanish index 1.5, 2 or 3 times higher seemed relevant. In addition, because the fit fails for more than 3 years in the retrospective analysis when SD of the priors for log(r) is 0.5 and prior for SD of the Spanish index is 0.9 (run #6), but not when this SD is 1.2 (run #9), the runs #7 and #8 were added to explore the effect of SD's of the Spanish index when it increases from 0.9 to 1.2.

As with set #3, the only runs that meet all the acceptance criteria without restriction are those with a semi-informative prior on r (SD for log(r) = 0.5). Theirs posterior r is again low enough to be considered realistic for the species (=0.09). However, the retrospective pattern is no longer an issue with SD for log(r) of 0.5 when inserting the Spanish index, considering higher uncertainty for this index (SD > 1).

As with set #3, the only runs that meet all the acceptance criteria without restriction are those with a semi-informative prior for r (SD for log(r) = 0.5). The retrospective pattern is no longer an issue when inserting the Spanish index, considering higher uncertainty for this index (SD > 1). As a result, there is now an advantage to use this index to meet the acceptance criteria. However, results are very similar whether the Spanish index is inserted or not when a semi-informative prior is used for r. The posterior r of these runs is again low enough to be considered realistic for the species (=0.09).

4.2 Final assessment

In the final set of exploratory runs, runs #8, #9 and #10 are very similar in terms of diagnostics, parameter point estimates and uncertainty. The Shapiro's p-values of the composite survey index differ slightly among these runs, with runs #8 and #9 showing values slightly below the 5% significance level (0.0426 for run #8 & 0.0458 for run #9); the p-value for run #10 is 0.0635. However, run #8 resulted in a lower number of failures when testing the influence of initial values on the parameter estimates (1 fit failed) compared to run #9 (7 fits failed) and run #10 (4 fits failed and 1 large distance), supporting accepting run #8 as the final assessment.

In the diagnostics of this run (**Figure 12**), the Shapiro test for the normality of catch residuals fails, as with other exploratory runs, because the decline in catches due to the second Word War and fishing regulations implemented since 2010. In addition to the Shapiro's p-value of the composite survey index (#3) just below 0.05, this test as well as the test for bias fail to pass for the Spanish longline index (#4). As for the catch residuals, this is due to one or two residuals and, therefore, these results are not considered to show a violation of assumptions that could invalidate the model run.

The production curve appears rather flat because substantial process error, but this is not unusual (**Figure 13**). The exploited biomass decreases below B_{MSY} in the early 1950s. Despite an increase in the 2010s due to the fishing restriction in place since 2010, B/B_{MSY} is well below B_{MSY} in 2020. The retrospective patterns are consistent (**Figure 14**).

4.3 Forecast

A forecast was made for information. The "manage()" function in the SPiCT R package was used with the scenario 8. The forecast was carried out using a target fishing mortality (F=0.03) which is the Fmsy reduced (since the estimated biomass is below MSY Btrigger) and followed the fractile rule proposed by WKMSYCat34 (ICES 2017). The corresponding catch are 324t, B/B_{MSY} is 0.49 [0.15,1.6] and F/F_{MSY} is 0.56 [0.05,6.28].

5. Future considerations/recommendations

Genetic studies for individuals from different regions (at least Bay of Biscay – Celtic Sea and North Sea - Norwegian Sea) should be continued or initiated, in order to confirm possible genetic differences between behavioural groups that may return to different spring-summer feeding areas each year. The need for appropriate sampling should be emphasized (small individuals, fish tagged with PSATS).

The PSAT deployments should be continued with attempts to obtain tracks in consecutive years. The planned PSAT deployments in northern European waters (by Norway) are welcomed to contribute to the knowledge of the stock structure by showing whether porbeagle in the Norwegian sea in summer have the same migration pattern than those tagged in the Bay of Biscay and the South Celtic Sea.

The difficulty of estimating discards should necessitate a specific at sea observer program if porbeagle landings continues to be banned in most European countries.

The continuation of the spring-summer survey in the Bay of Biscay and the southern Celtic Sea would be beneficial to follow the evolution of the exploited biomass with a fishery-independent index. This extension would allow the value of the investment made to carry out the survey in 2018 and 2019, but also to extend the two-year series obtained with commercial data to constitute a coherent series to evaluate the effect of the fishing limitation measures adopted since 2010. The extension of this survey to other regions and/or additional surveys in other regions should be considered.

The wide variations in the Spanish longline CPUE series should require an examination of the spatial distribution of trips that may be the cause. The possibility of obtaining an area and overwintering season index with this series should be investigated as well as its extension beyond 2007.

6. Reviewers report

6.1 Stock ID

Steve Cadrin, Christoph Stransky, David Murray and Zachary Whitener

New information on genetics (Viricel *et al.,* 2021 WD) and tagging (Biais *et al.,* 2022 WD, Righton *et al.,* 2022 WD) was considered in the context of previously available information (reviewed by Ellis *et al.,* 2022 WD and Haugen *et al.,* 2022 WD). Porbeagle have anti-tropical distributions throughout the North Atlantic and southern hemisphere, and analyses of mitochondrial DNA (mtDNA) indicate genetically distinct populations in each hemisphere (Kitamura and Matsunaga 2010, n=53) but no apparent genetic structure within the North Atlantic (n=40 from the northwest Atlantic, n=35 from northeast Atlantic; Testerman 2014). A recent analysis of mtDNA confirms two separate populations in the North Atlantic and southern hemisphere and no genetic structure within the North Atlantic (n=70 northwest Atlantic, n=99 northeast Atlantic, n=2 Mediterranean markets; González *et al.,* 2021). Life history information also suggests a relatively homogeneous population in the North Atlantic with only minor regional differences (Ellis *et al.,* 2022 WD, Haugen *et al.,* 2022 WD). Genetic and life history patterns suggest that there is sufficient reproductive connectivity to maintain a single genetic population in the North Atlantic, apparently including the Mediterranean. Information from tagging suggests a low rate of movement between the northeast and northwest Atlantic, with one porbeagle tagged in Irish waters and recaptured on the Grand Banks ten years later (Cameron *et al.,* 2018) from a total of 346 conventional tag recaptures (Ellis *et al.,* 2022 WD), and location estimates from several archival tag deployments that indicate movement across the ICES-NAFO boundary(42°W) from porbeagle tagged in the Bay of Biscay (**Figure 1**, Biais *et al.,* 2022 WD) and off the British Isles (Figure 2, Righton *et al.,* 2022 WD). Thermal preferences and temperature distributions also suggest that movement between the northeast Atlantic and the Mediterranean is limited (Ellis *et al.,* 2022 WD). Biais *et al.,* (2022 WD) reported two general movement patterns to the north and to the west from porbeagle tagged in the Bay of Biscay (**Figure 1**), and preliminary genetic analysis of one mtDNA character from a few individuals in each behavioural group (n=10 north, n=9 west) suggest genetic differences (Viricel *et al.,* 2021 WD).

In summary, most information available supports the conclusion that porbeagle consist of a single genetic population in the North Atlantic, which is relevant for determining species conservation status (Curtis *et al.,* 2016). Preliminary results on genetic differences among behavioural groups in the northeast Atlantic (Viricel *et al.,* 2021 WD) will need confirmation with more samples and genetic characters (ideally nuclear characters), and investigation of spatial overlap of the two behavioural groups (e.g., in the Bay of Biscay) will need to be considered for stock identification. The observed movement rates between the Northwest, Northeast Atlantic, and Mediterranean appear to be low enough to consider separate spatial units for stock assessment and fishery management. Therefore, the information available supports the current ICES advisory unit (subareas 1-10, 12 and 14, the Northeast Atlantic and adjacent waters) extended southward to 5°N, the extent of the ICCAT North Atlantic fishing area (ICCAT 2010).

6.2 Stock assessment

Enric Cortés and *Jan Jaap*

The stock identity of porbeagle was extensively discussed. While there seemed to be strong indication of site fidelity and repeated migration routes, the genetic differentiation among different regions in the North-east Atlantic was not strong and based on a limited number of samples. Ultimately, it was decided to keep the current management units.

There were several potential relative abundance index series that could be used to inform a surplus production model. One of the issues with all abundance indices was that the sample size and spatial coverage of the indices were small compared to the size of the management unit.

SPiCT, a Bayesian surplus production model, was used to assess the status of the Northeast stock of porbeagle. Data inputs to the model included total catches (1926-2020) and three biomass indices: a Norwegian CPUE based on logbooks of longline vessels targeting porbeagle (1950-1972), a French CPUE also based on longline vessels targeting porbeagle (1972-2009), and a French CPUE based on the personal logbook of a commercial longliner targeting porbeagle (2000-2009) complemented with a survey biomass index conducted in the Bay of Biscay and the Celtic Sea in 2018-2019 (this index will be referred to as composite index). Additionally, a bycatch CPUE index from the Spanish pelagic longline fleet (1986-2007) was also available.

The assessment used the intrinsic rate of increase (rmax=0.059) used in the ICCAT (2020) stock assessment and set the prior for the shape parameter n to 2, which implies a Schaefer production model with an inflection point of the production curve of B_{MSY}/K=0.5. It was pointed out that the n corresponding to the value of r=0.059 is 3.4 (which corresponds to B_{MSY}/K=0.60 obtained from a relationship between the inflection point and the rate of increase per generation, rT) and thus that the priors of r and n were internally inconsistent. This was investigated by setting the prior of n to 1) 3.4 with SD=0.5 (uninformative) and 2) 3.4 with SD=0.2 (more informative). With SD=0.5, the posterior was still estimated at 1.3 and with SD=0.2, the assessment did not pass the acceptance criteria. Values of B_{MSY}/K <0.5 imply a more productive stock than predicted by life history characteristics, based on which the expectation would be a value >0.5Bmsy/K. This result may be due to the large interannual increases in the three biomass indices considered initially (especially the Norwegian index and some years for the composite index), which would conflict with the low productivity implied by the life history.

There was a question about the apparent concurrent trend in the indices and catches: a positive correlation between the decrease in catches and the Norwegian index from 1950 to 1972 and a positive correlation between the decrease in catches and the French index from 1972 to 2009. Further examination of the "plotspict.ci" plots from SPiCT showed that there were no positive increases in index at large catches that could indicate model violations.

There was also further discussion on the survey biomass index for 2018-2019. Rationale was presented as to why the index should be based on an analysis considering 10 statistical rectangles (reduced sampling area) with higher mean CPUE, including that there was an increase in R-squared of the index-effort relationship.

Several model configurations were trialled with 3 or 4 biomass indices, the composite index with or without a reduced area considered, and several assumptions about the SD of the priors of r and n. In general, there were retrospective patterns in F and F/F_{MSY}, which improved when the SD for r was set to 0.2. When using 4 indices, the Spanish index was not fit well owing to its very large interannual variability and the retrospective patterns improved when using SD=0.2 for r and a prior for the SD of variance was used ("logsdi" in SPiCT). It was recommended to run a sensitivity trial using very high or low values in the Spanish index to ensure that results would not be unduly affected by these changes. Another assessment using an alternative Bayesian production model (JABBA) was presented by the ICCAT Secretariat. Data inputs were the same as for the SPiCT assessment, with a few differences: the inflection point of the population growth curve/production curve was fixed at 0.37 (a Fox production model) implying a shape parameter n=1.01; initial depletion at the beginning of the model was 0.90 (vs 0.99 in SPiCT); and the standard error of the observation error variance for the indices was fixed at 0.25 (vs. using the actual observed values in SPiCT). An additional assessment using SPiCT was also presented by the ICCAT Secretariat with results similar to those run by the ICES WGEF.
There was extended discussion about the validity of the inclusion of the Spanish longline biomass index in the assessment. On one hand it was pointed out that the index was discussed during the 2009 ICCAT stock assessment and deemed appropriate for inclusion at the time, that it provides additional information on the relative abundance of the NE Atlantic stock of porbeagle east of 45° W, and that it is not based on a directed fishery that could lead to a hyperstable CPUE. On the other hand, there was concern that this this index provides information on porbeagle density further south than where the directed fisheries operated, in an area where PSAT deployments have shown that only a part of the exploited biomass migrates to and therefore raises questions about whether it provides better information on the abundance of the exploited biomass than the directed fisheries. Additionally, the validity of including this index in the base run was questioned because it shows interannual increases in abundance of 1 order of magnitude that are biologically impossible. It was recommended that at least, several of the peaks displayed by this index be down-weighted (i.e., increase the uncertainty of those data points) possibly by using robust estimation for those data points.

In all, despite some differences in model (JABBA and SPiCT ICES/ICCAT) configuration, both modeling approaches provided very similar outlooks of the status of the NE Atlantic porbeagle stock, pointing to a still overfished stock, but with overfishing no longer occurring, with the low values of current F consistent with the landing prohibition in effect since 2010. Despite the caveats about the Spanish index, the runs with 4 indices, prior for n=2 (SD=0.2), prior for r=0.059 (SD=0.2 or SD=0.5), and a prior for "logsdi" were deemed the most appropriate to assess the status of this stock. After further exploration a run that included a prior for n=2 (SD=0.2), prior for r=0.059 (SD=0.5), initial depletion=0.99 (SD=0.2), the four indices, but placing higher uncertainty in the Spanish index by setting a prior for logsdi=1.0, and scaling the se of each index to have a mean of 1 (vs. scaling it to the minimum value as initially done) was deemed to be the best run to determine stock status and provide catch advice. In conclusion, the data utilized in the assessment were the best available to the analysts and the assessment methods to determine stock status were adequate given the data available.

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Table 1. Results of NEA Porbeagle stock exploratory SPiCT runs (set #4).
Indices: NO = Norwegian longline index; FR = French longline index; SUR = composite survey index; SP = Spanish longline index.

Scenario (changes between runs highlighted in yellow)	Catch (years)	Indices		Priors: value and SD of log(value) between brackets			Acceptance	Estimates				Retropective : Mohn's rho		B2020.94/ B_{MSY}	F2020.94/ F_{MSY}	Stochastic reference points	
		List*	SD	n	B/K	r		n	K	r	B1950 /K	B/ B_{MSY}	F/ F_{MSY}			B_{MSY}	F_{MSY}
# 1 - Reference	1926-2020	NO + FR + SUR	Yes	2 (0.2)	0.99 (0.2)	0.059 (0.2)	Yes but	1.76 [1.15-2.68]	75398 [32588-174450]	0.063 [0.043-0.094]	38223/75398 = 0.51	0.09	0.46	0.41 [0.12-1.48]	0.02 [0-0.11]	28998 [12614-66667]	0.03 [0.01-0.07]
# 2 - identical to run #1 with with priors on SD r= 0.5	1926-2020	NO + FR + SUR	Yes	2 (0.2)	0.99 (0.2)	0.059 (0.5)	Yes but	1.75 [1.17-2.61]	61580 [26298-144197]	0.087 [0.038-0.202]	29647/61580 = 0.48	0.08	0.32	0.44 [0.14-1.42]	0.02 [0-0.09]	25404 [11413-56547]	0.05 [0.02-0.13]
# 3 - identical to run #1 with SPA index and prior on its SD c(log(0.9),0.1,1)	1926-2020	NO + FR + SUR +SP	Yes	2 (0.2)	0.99 (0.2)	0.059 (0.2)	Yes but	1.75 [1.14-2.66]	73175 [34621-154664]	0.064 [0.043-0.094]	36191/73175 = 0.49	0.11	0.36	0.38 [0.12-1.21]	0.02 [0-0.11]	29526 [13919-62632]	0.03 [0.01-0.07]
# 4 - identical to run #3 with prior on SD of SP index c(log(1.2),0.1,1)	1926-2020	NO + FR + SUR +SP	Yes	2 (0.2)	0.99 (0.2)	0.059 (0.2)	Yes but	1.74 [1.14-2.66]	73293 [34485-155774]	0.064 [0.043-0.094]	36311/73293 = 0.5	0.07	0.37	0.39 [0.12-1.25]	0.02 [0-0.11]	29485 [13833-62849]	0.03 [0.01-0.07]
# 5 - identical to run #3 with prior on SD of SP index c(log(1.8),0.1,1)	1926-2020	NO + FR + SUR +SP	Yes	2 (0.2)	0.99 (0.2)	0.059 (0.2)	Yes but	1.75 [1.15-2.67]	74126 [33748-162812]	0.063 [0.043-0.094]	37072/74126 = 0.5	0.05	0.40	0.4 [0.12-1.33]	0.02 [0-0.11]	29328 [13366-64352]	0.03 [0.01-0.07]
# 6 - identical to run #2 with SPA index and prior on its SD c(log(0.9),0.1,1)	1926-2020	NO + FR + SUR +SP	Yes	2 (0.2)	0.99 (0.2)	0.059 (0.5)	No	1.74 [1.17-2.58]	59894 [27919-128489]	0.089 [0.039-0.2]	28065/59894 = 0.47	0.27 (3 yrs)	-0.13 (3 yrs)	0.42 [0.14-1.27]	0.02 [0-0.09]	25534 [12271-53132]	0.05 [0.02-0.13]
# 7 - identical to run #4 with prior on SD of SP index c(log(1.0),0.1,1)	1926-2020	NO + FR + SUR +SP	Yes	2 (0.2)	0.99 (0.2)	0.059 (0.5)	Yes	1.74 [1.17-2.58]	59822 [27922-128169]	0.089 [0.04-0.199]	28025/59822 = 0.47	0.20 (4 yrs)	0.02 (4 yrs)	0.43 [0.14-1.28]	0.02 [0-0.08]	25508 [12270-53028]	0.05 [0.02-0.13]
# 8 - identical to run #4 with prior on SD of SP index c(log(1.1),0.1,1)	**1926-2020**	**NO + FR + SUR +SP**	**Yes**	**2 (0.2)**	**0.99 (0.2)**	**0.059 (0.5)**	**Yes**	**1.74 [1.17-2.58]**	**59837 [27875-128450]**	**0.089 [0.04-0.199]**	**28054/59837 = 0.47**	**0.16**	**0.11**	**0.43 [0.15-1.29]**	**0.02 [0-0.08]**	**25495 [12245-53084]**	**0.05 [0.02-0.13]**
# 9 - identical to run #4 with prior on SD of SP index c(log1.2),0.1,1)	1926-2020	NO + FR + SUR +SP	Yes	2 (0.2)	0.99 (0.2)	0.059 (0.5)	Yes	1.74 [1.17-2.58]	59903 [27798-129087]	0.089 [0.04-0.199]	28123/59903 = 0.47	0.16	0.11	0.43 [0.15-1.29]	0.02 [0-0.08]	25488 [12204-53232]	0.05 [0.02-0.13]
# 10- identical to run #4 with prior on SD of SP index c(log(1.8),0.1,1)	1926-2020	NO + FR + SUR +SP	Yes	2 (0.2)	0.99 (0.2)	0.059 (0.5)	Yes	1.74 [1.17-2.59]	60594 [27201-134985]	0.088 [0.039-0.2]	28754/60594 = 0.47	0.11	0.18	0.44 [0.14-1.34]	0.02 [0-0.08]	25481 [11887-54623]	0.05 [0.02-0.13]

Acceptance: see table 2.4.2 for criteria; Retrospective: Mohn's rho in red when rho > 0.2 or < -0.15

Table 2: Acceptance of NEA Porbeagle stock SPiCT runs presented at the WKELASMO online meeting.
Conclusion (bottom line) is Y (Yes) when all the acceptance criteria are met, "Y but" when criteria are not met for the order of magnitude of F/F_{MSY} (≤1) and its Mohn's rho (should –be comprised between -0.15 and 0.2), but the acceptance can be discussed considering that the very low catches since 2010 limit the quality of this criteria. Conclusion is No when B/BMSY Mohn's rho is not comprised between -0.15 and 0.2.
The results of the tests for normality of the capture residuals and bias or normality of the residuals of indices 3 and 4 are not considered as criteria that can prohibit acceptance of the series because the observed hypothesis violations are due to a small number of annual values.

# run	1	2	3	4	5
Convergence	Y	Y	Y	Y	Y
All variance parameters of the model parameters are finite	Y	Y	Y	Y	Y
No violation of model assumptions based on one-step-ahead residuals (bias, auto-correlation, normality)	No for normality of catch residuals	No for normality of catch residuals	No for normality of catch residuals and bias/normality residuals index 3 and 4	No for normality of catch residuals and bias/normality residuals index 3 and 4	No for normality of catch residuals and bias/normality residuals index 3 and 4
Consistent patterns in the retrospective analysis	Y for B/B_{MSY} but Mohn's rho F/F_{MSY} =0.46	Y for B/B_{MSY} but Mohn's rho F/F_{MSY} =0.32	Y for B/B_{MSY} but Mohn's rho F/F_{MSY} =0.36	Y for B/B_{MSY} but Mohn's rho F/F_{MSY} =0.37	Y for B/B_{MSY} but Mohn's rho F/F_{MSY} =0.40
Realistic production curve	Y	Y	Y	Y	Y
Assessment uncertainty	N OM B/B_{MSY} =1 OM F/F_{MSY} =2	Y	N OM B/B_{MSY} =1 OM F/F_{MSY} =2	N OM B/B_{MSY} =1 OM F/F_{MSY} =2	N OM B/B_{MSY} =1 OM F/F_{MSY} =2
No influence of initial values on the parameter estimates	Y	Y for 28/30 fits (1 fits failed)	Y for 28/30 fits (2 fits failed)	Y for 26/30 fits (4 fits failed)	Y for 27/30 fits (2 fits failed 1 large distance)
Conclusion	Yes but	Yes but	Yes but	Yes but	Yes but

Table 2 (continued): Acceptance of NEA Porbeagle stock SPiCT runs presented at the WKELASMO online meeting.
Conclusion (bottom line) is Y (Yes) when all the acceptance criteria are met, "Y but" when criteria are not met for the order of magnitude of F/F_{MSY} (≤1) and its Mohn's rho (should –be comprised between -0.15 and 0.2), but the acceptance can be discussed considering that the very low catches since 2010 limit the quality of this criteria. Conclusion is No when B/B_{MSY} Mohn's rho is not comprised between -0.15 and 0.2.
The results of the tests for normality of the capture residuals and bias or normality of the residuals of indices 3 and 4 are not considered as criteria that can prohibit acceptance of the series because the observed hypothesis violations are due to a small number of annual values.

# run	6	7	**8**	9	10
Convergence	Y	Y	**Y**	Y	Y
All variance parameters of the model parameters are finite	Y	Y	**Y**	Y	Y
No violation of model assumptions based on one-step-ahead residuals (bias, auto-correlation, normality)	No for normality of catch residuals and bias/normality residuals index 3 and 4	No for normality of catch residuals and bias/normality residuals index 3 and 4	**No for normality of catch residuals and bias/normality residuals index 3 and 4**	No for normality of catch residuals and bias/normality residuals index 3 and 4	No for normality of catch residuals and bias/normality residuals index 4
Consistent patterns in the retrospective analysis	Y for F/F_{MSY} (3 years) but Mohn's rho B/B_{MSY} =0.27	Y (4 years)	**Y**	Y	Y
Realistic production curve	Y	Y	**Y**	Y	Y
Assessment uncertainty	Y	Y	**Y**	Y	Y
No influence of initial values on the parameter estimates	Y for 25/30 fits (4 fits failed and 1 large distance)	Y for 23/30 fits (7 fits failed)	**Y for 29/30 fits (1 fit failed)**	Y for 23/30 fits (7 fits failed)	Y for 25/30 fits (4 fits failed and 1 large distance)
Conclusion	No	Yes	**Yes**	Yes	Yes

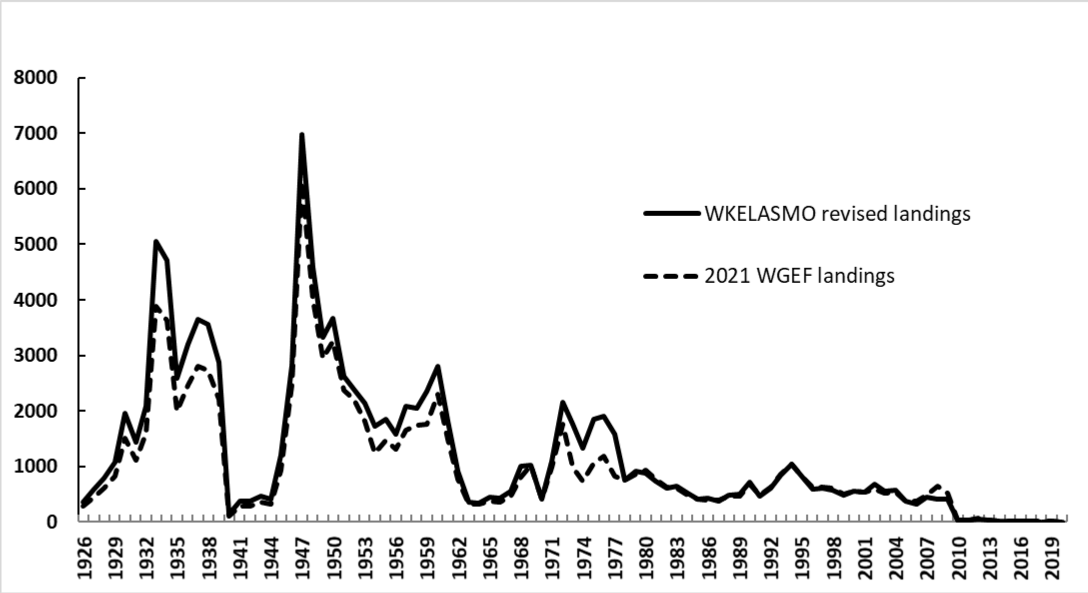


Figure 1. NEA Porbeagle total landings (tons).

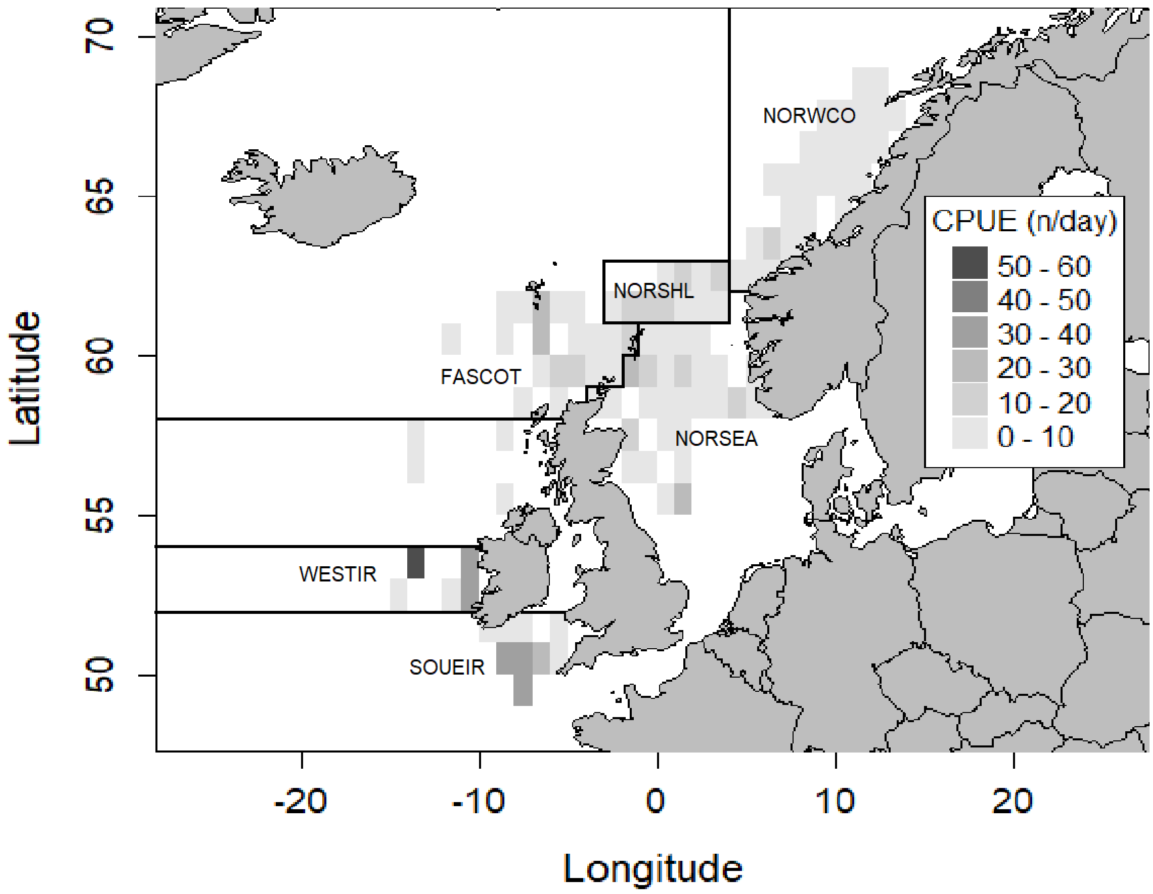


Figure 2. Mean number of fish per day and per 1°x1° rectangle caught by Norwegian longliners in the North East Atlantic from available logbooks (mean using only independent observations) for years 1950 to 1972, with delineations of the spatial units used in their analysis: WESTIR (west and southwest of Ireland), SOUEIR (southwest of Ireland), FASCOT (southwest to southeast Faroe and northwest Scotland), NORSHL (northern edge of the North Sea shelf), NORSEA (North Sea), NORWCO (Norwegian coast north 62°N).

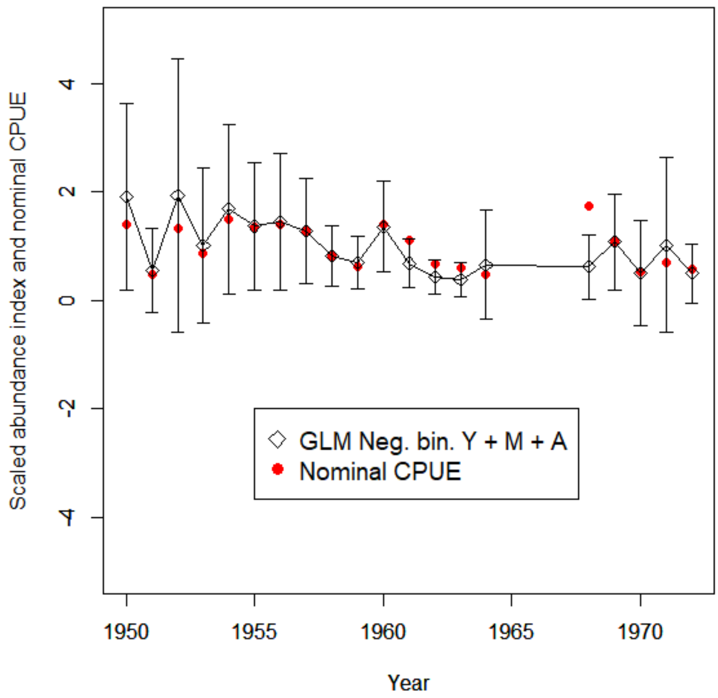


Figure 3. Relative annual indices (scaled by the mean) provided by the final GLM (negative binomial error distribution with a log link) selected by lowest five folds cross validation MSE (variables included: year, month and area) to standardize CPUEs of Norwegian longliners in the North East Atlantic, with the nominal CPUEs also scaled by the mean.

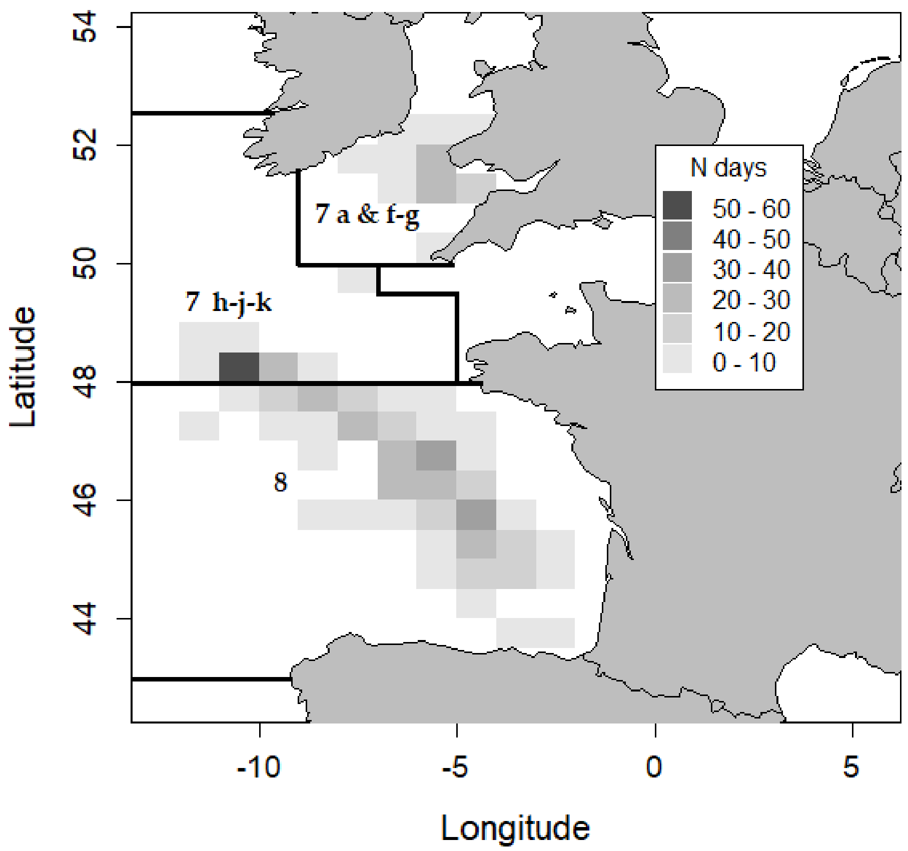


Figure 4. Fishing effort distribution by ICES rectangle of the French longliners whose CPUEs contribute to the French CPUE series with limits of areas used to standardize the CPUEs for years 1999 to 2009 (data not available by ICES rectangle prior to 1999).

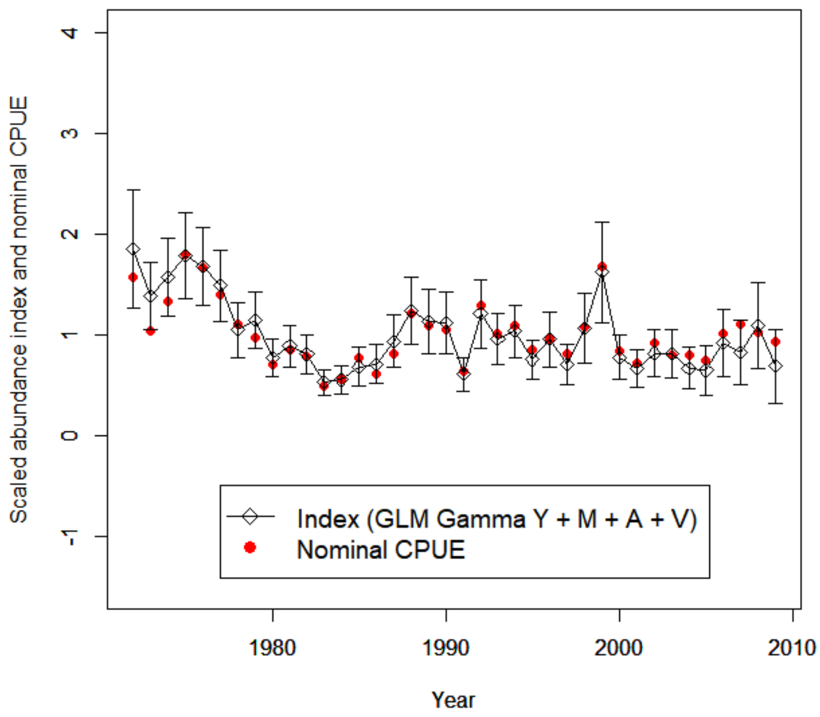


Figure 5. Relative annual indices (scaled by the mean) provided by the final GLM (Gamma error distribution with a log link) selected by five lowest folds cross validation MSE (variables included: year, month, area and vessel) to standardize CPUEs of the 19 longliners of the French tuning fleet targeting porbeagle in Northeast Atlantic, with the nominal CPUEs also scaled by the mean.

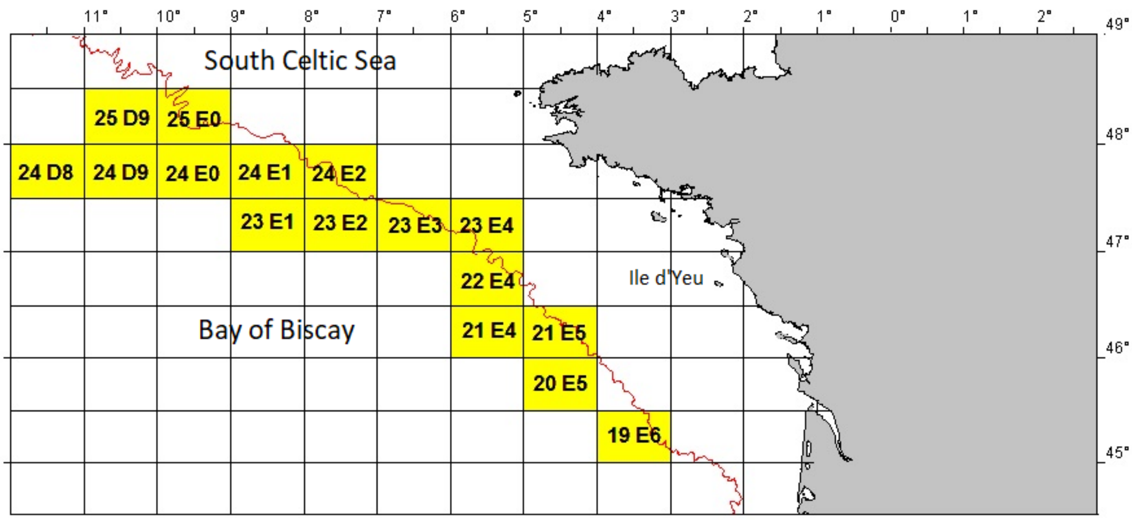


Figure 6. Statistical rectangles forming the French porbeagle survey area in the Bay of Biscay and the South Celtic Sea

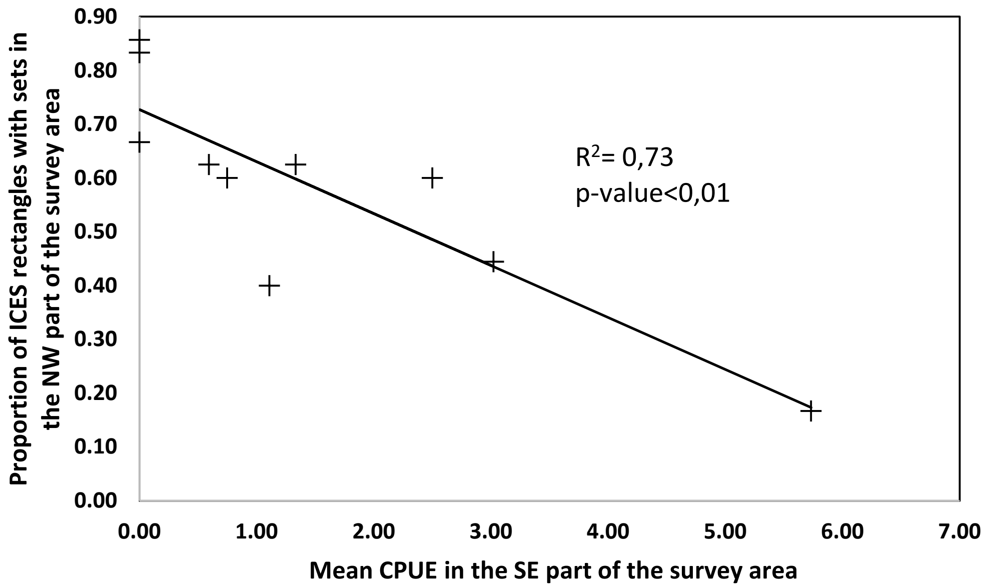


Figure 7. Porbeagle in the NEA – Relationship between the proportion of ICES rectangles with sets in the NW part of the survey area (North 47¨N and West 7°W) and the mean CPUE of ICES rectangles South 47¨N and East 7°W in the survey area in May-June.

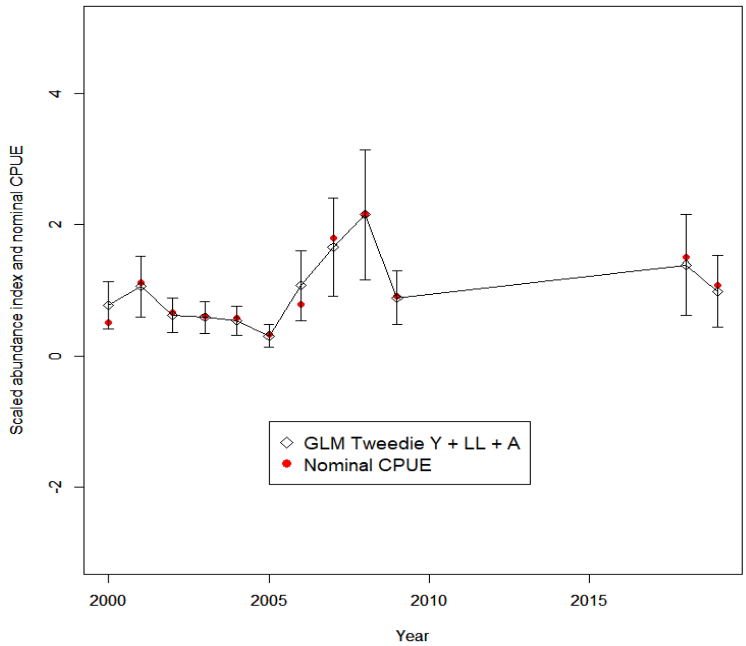
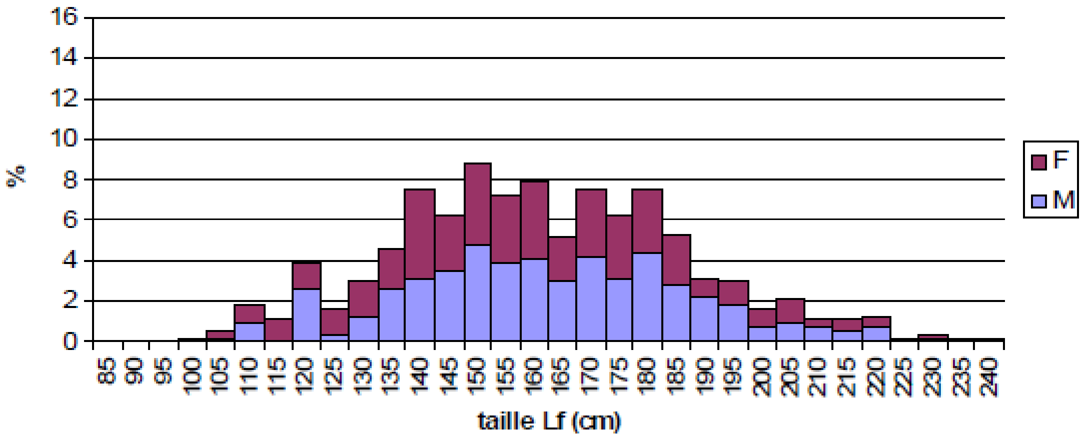
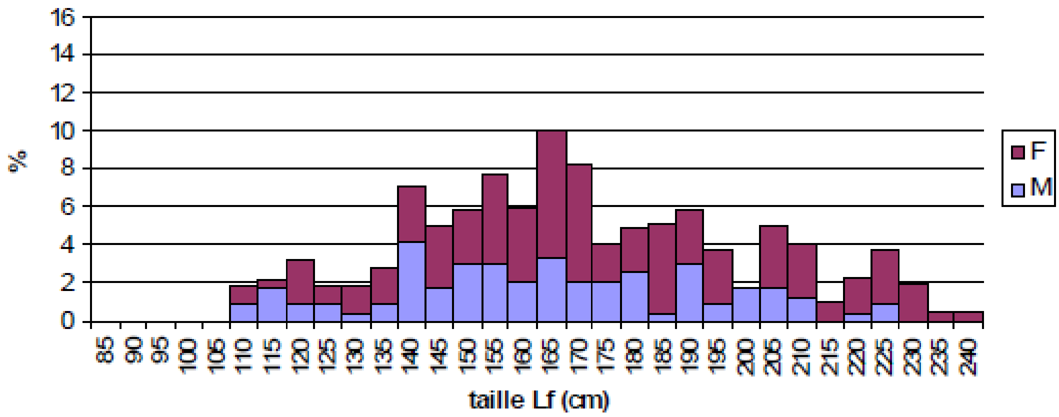


Figure 8. Relative annual indices (scaled by the mean) provided by the final GLM (Tweedie error distribution with a log link) selected to standardize the composite survey CPUEs (variables included: year, type of longline and area), with the nominal CPUEs scaled by the mean.

May 2008-2009 (n=570)



June 2008-2009 (n=237)



May-June 2018-19 (n=299)

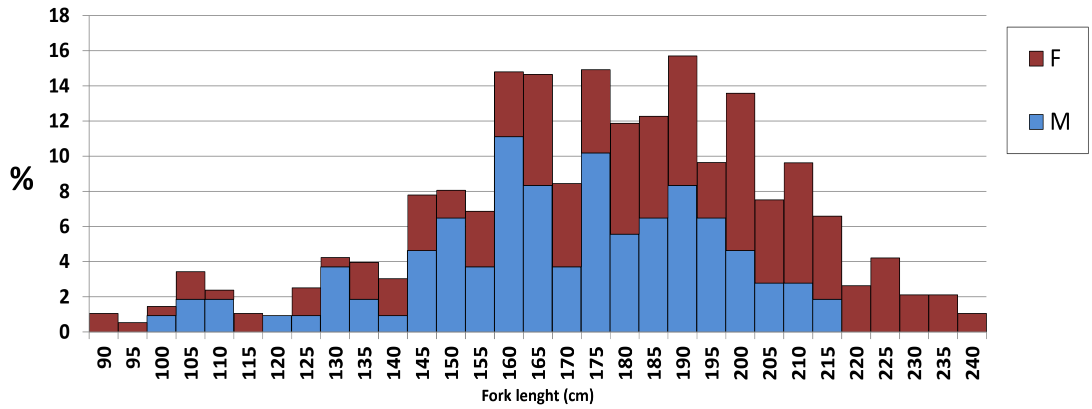


Figure 9. Comparison of the length distributions of the survey in 2018-2019 and in landings in the same months in 2008-2009 (source Hennache and Jung, 2010).

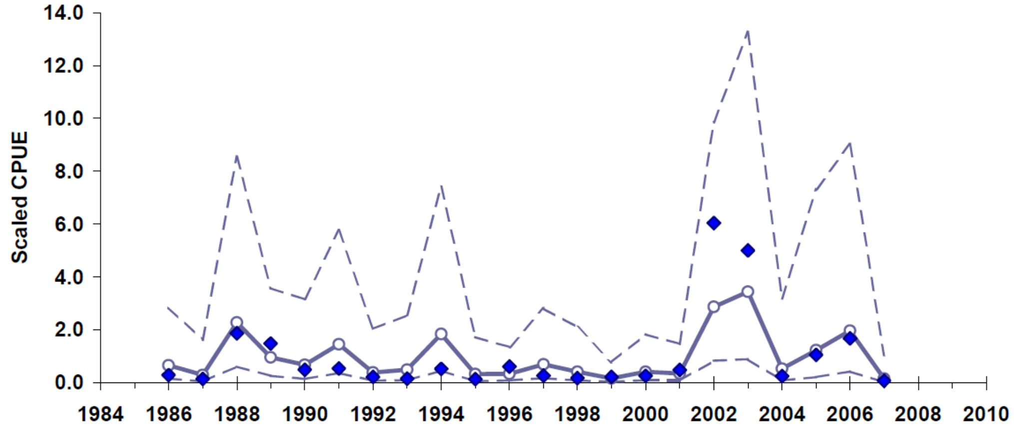


Figure 10. Standardized CPUE of porbeagle caught as by-catch of the Spanish surface longline fishery targeting swordfish, provided by the GLM selected (delta-lognormal distribution error; variables included: year, zone, quarter, bait, year*zone, year*quarter) with confidence limits and mean nominal CPUEs (blue rhombuses).

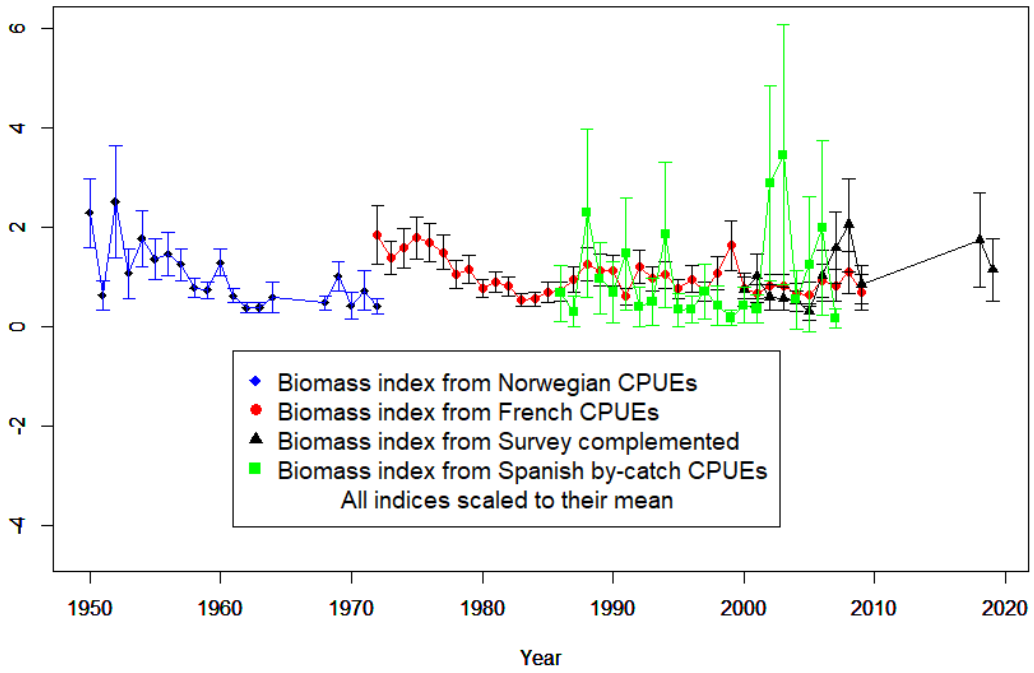


Figure 11. Biomass indices used in the porbeagle SPiCT runs provided by the standardization of the four available CPUEs series.

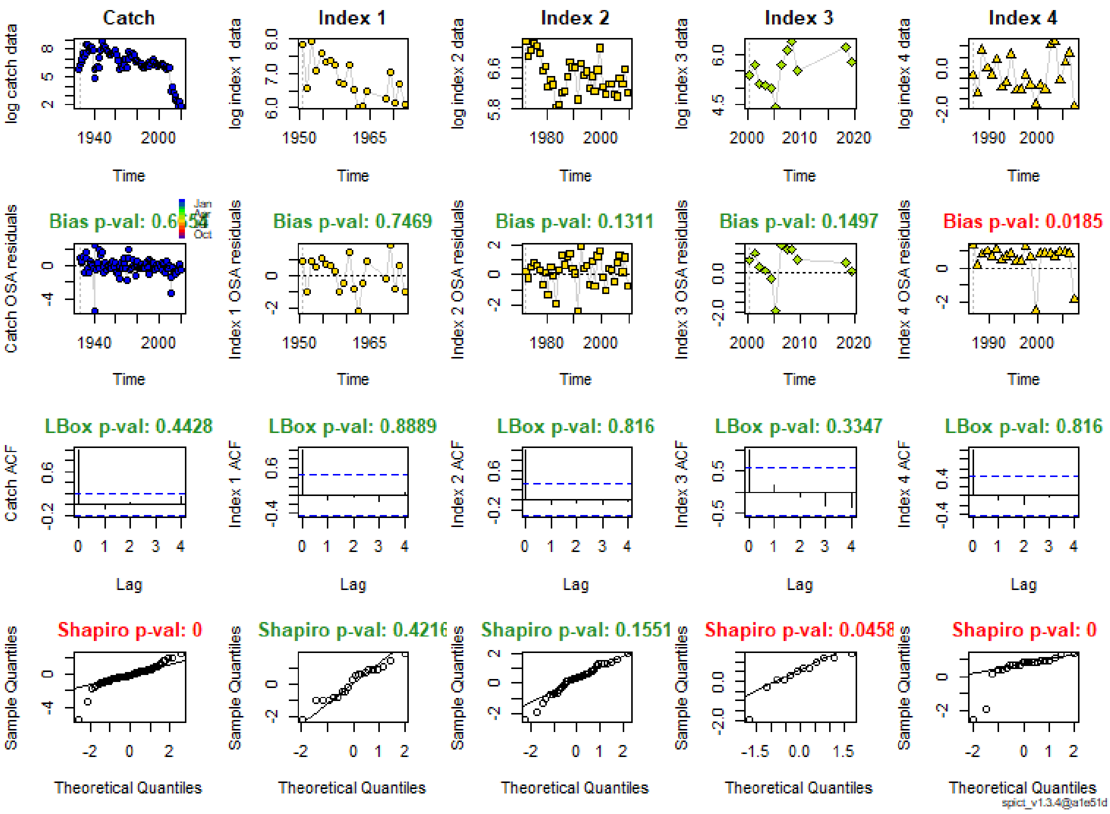


Figure 12. Diagnostics plots of the final assessment of NEA porbeagle stock (por.27.nea).

Index 1: Norwegian longline biomass index
Index 2: French longline biomass index
Index3: Composite survey biomass index
Index4: Spanish longline biomass index

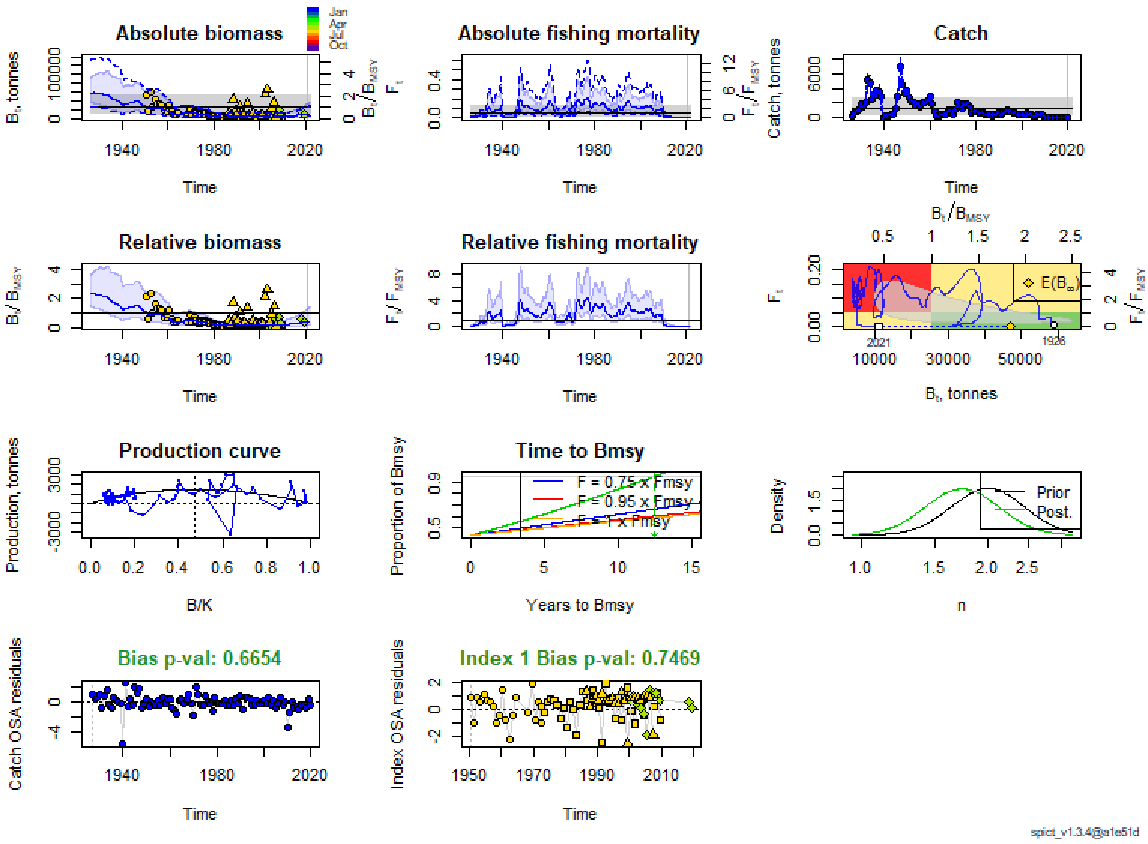


Figure 13. Result plots of the final assessment of NEA porbeagle stock (por.27.nea).

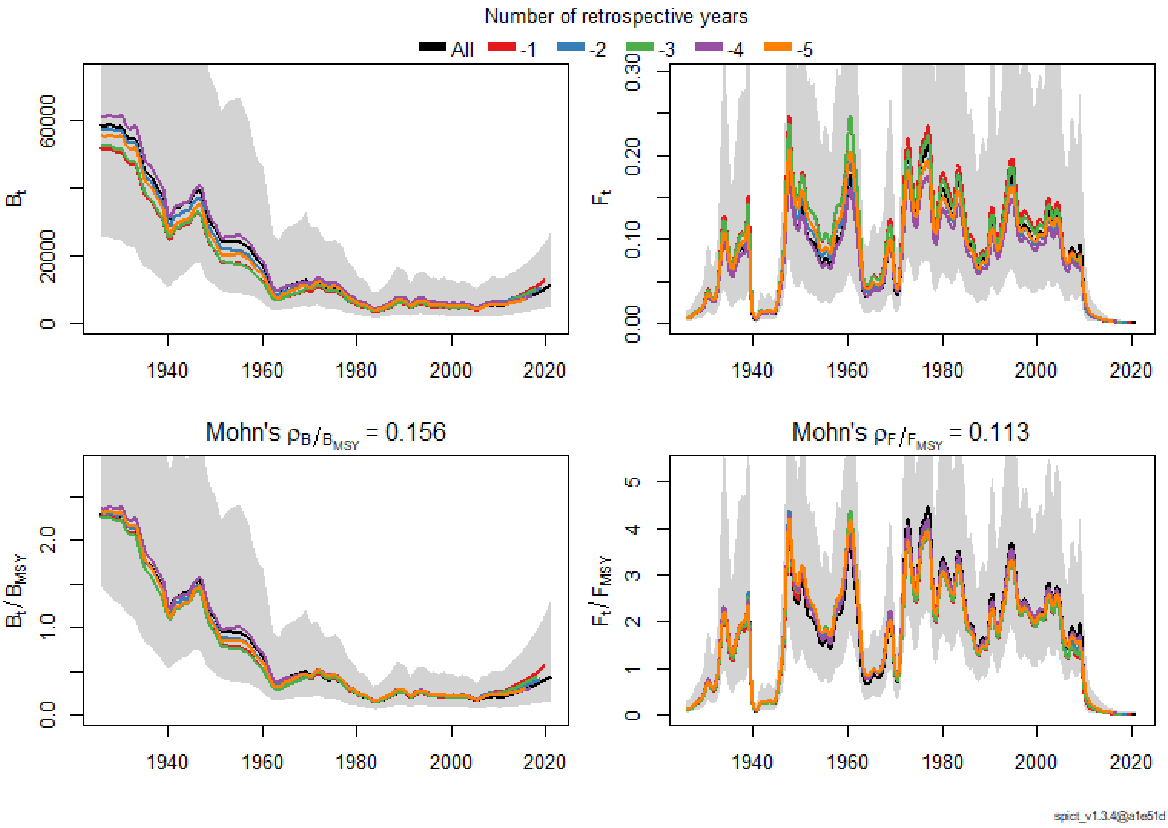


Figure 14. Retrospective plots of the final assessment of NEA porbeagle stock (por.27.nea).

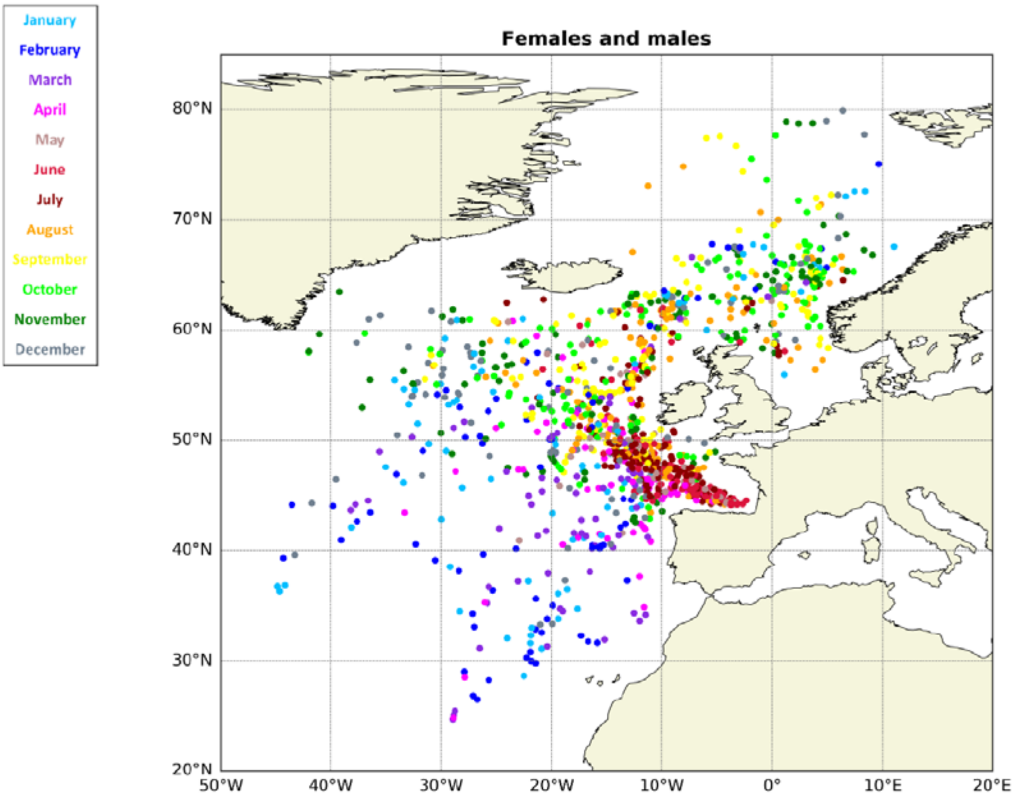


Figure 15. Estimated daily positions (coloured dots are 10 days apart) of 43 porbeagle tagged in the Bay of Biscay between May and July in 2011-2019 (from Biais *et al.,* 2022 WD).

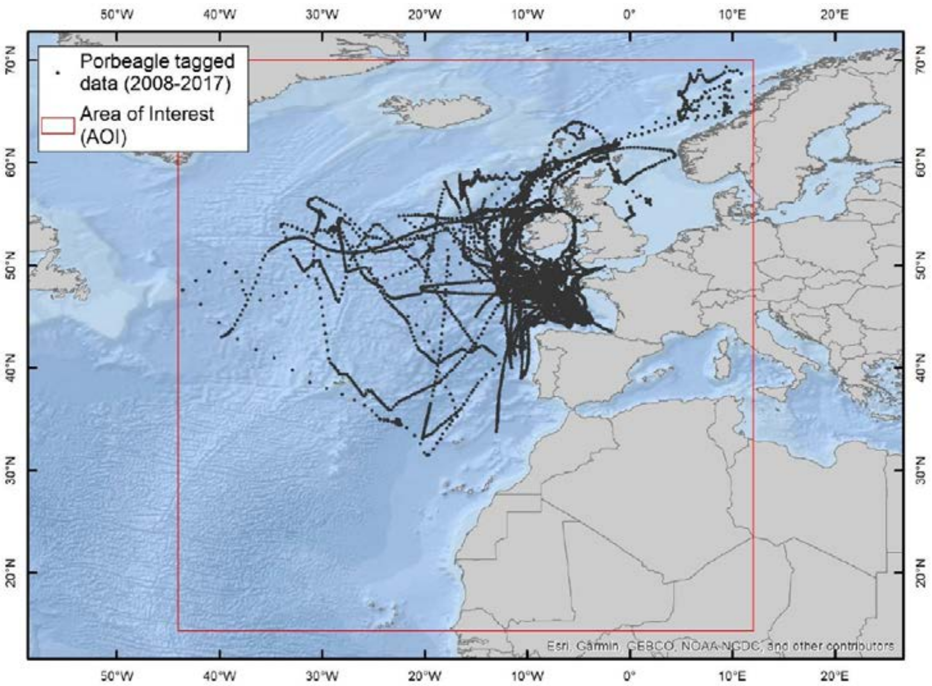


Figure 16. Positional estimates from all PSAT datasets > 8 days in length. Each symbol shows a daily estimate. Positional estimates were derived from bespoke algorithms suited to the transmitted or archived data received from Microwave Telemetry or Wildlife Computers PSAT tags.