6 Porbeagle in the Northeast Atlantic (subareas 1–14)

6.1 Stock distribution

WGEF consider that there is a single stock of porbeagle *Lamna nasus* in the Northeast Atlantic (NEA) that occupies the entire ICES area (subareas 1–14), extending southwards to 5° N.

The supporting information is provided in the Stock Annex.

6.2 The fishery

6.2.1 History of the fishery

Porbeagle has been exploited primarily in the NEA by four directed longline fisheries with the first notable landings in 1926 until applicable management largely reduced landings in 2010 (see Section 6.2.4). Norway first developed a directed fishery from 1926 to 1986, then Denmark from 1946 to probably the 1970s or in the early 1980s, followed by the Faroe Islands from 1953 to 1960, and finally France from 1971 to 2009. All together, these four countries contributed 98% of the total landings from 1926 to 2009. A detailed history of the fishery can be found in the Stock Annex.

6.2.2 The fishery in 2021

The 2021 WGEF estimated landings is 7 t in 2021 and since the zero TAC was implemented in 2010, the mean (2010–2021) WGEF estimate is 19 t per year (Table 6.1). However, since 2010 data must be considered as unrepresentative of removals, as dead discards are not quantified.

6.2.3 ICES advice applicable

The 2019 advice is valid for 2020–2023, and stated: "*ICES advises that when the precautionary approach is applied, there should be zero catch in each of the years 2020–2023*".

6.2.4 Management applicable

EC Regulation 1185/2003 prohibits the removal of shark fins and subsequent discarding of the body of this species. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

EC Regulation 40/2008 first established a TAC (581 t) for porbeagle taken in EC and international waters from ICES Subareas 1–12 and 14 for 2008. The TAC was reduced by 25% in 2009 and a maximum landing length of 210 cm (fork length) was implemented.

From 2010–2014, successive EC Regulations (23/2010, 57/2011, 44/2012, 39/2013 and 43/2014) had established a zero TAC for porbeagle in EU waters of the ICES area and prohibited EU vessels to fish for, to retain on board, to tranship and to land porbeagle in international waters.

Since 2015 it has been prohibited for EU vessels to fish for, to retain on board, to tranship or to land porbeagle, with this applying to all waters (Council Regulation (EU) 2015/104, 2016/72, 2017/127, 2018/120, 2019/124, 2020/123, 2021/92 and 2022/119). Fisheries consultations between the UK and the EU in 2021 and 2022 have also included porbeagle in the list of prohibited species in Union and UK waters[1].

It has been forbidden to catch and land porbeagle in Sweden since 2004; and in 2007, Norway banned all direct fisheries for porbeagle but bycatch could be landed up to 2011. Since that year, live specimens must be released, whereas dead specimens can be landed, but this was not mandatory. The species is therefore exempt from the general Norwegian landings obligation, and the payment is therefore withdrawn, except for 20% to cover the cost of landing.

In 2017, a regulation was issued to ban all targeted fishing in Icelandic waters for spurdog, porbeagle and basking shark and stipulating that all viable catch in other fisheries must be released.

6.3 Catch data

6.3.1 Landings

Landings of porbeagle in the Northeast Atlantic from 1926 to 2021 are shown in Table 6.1 and Figure 6.1 and 6.2.

These data were revised during the WKELASMO meeting (ICES, 2022a). The main changes from the WGEF landings tables in 2021 were: Faroe Islands landings added from 1953 to 1960 (from ICCAT database), French landings revised (mainly 1972 to 1977), conversion of Norwegian landings from gutted weight to round weight units (1926 to 1968, excepted 1958-60, and 1971), Spanish landings from 2008 (ICCAT landings series adopted). In addition to these revisions, 2021 landing figures were included (7t) and Danish landings were updated for the years 2005, 2006, 2007 and 2009 (one ton added each year), as these data were not previously provided in response to the 2021 WKELASMO data call. Since 2010, landings are below 50t and mainly occur in the Faroe Isles and Norway.

More detailed information on landings is presented in the Stock Annex.

6.3.2 Discards

Because of the high value of this species, it is likely that most specimens caught incidentally were landed prior to the zero quota from 2010. Analysis of at-sea observer programme for UK (E&W) fisheries confirms this (Silva and Ellis, 2019). Historical discards are consequently thought to be negligible.

Since the EU zero TAC was introduced in 2010, discards are likely a large proportion of the catches but they are unquantified. In recent years, the only discard estimate available was provided by France in 2018 (88 t). However, it should be noted that this may be an imprecise estimation as the underlying data relate to few observations and specimens. Anecdotal information suggests that French pelagic trawlers and tuna long liners discard porbeagle, but their total dead discards are unknown as are seasonal discards in some métiers (e.g. in the Celtic Sea (Bendall *et al.,* 2012a, b; Ellis and Bendall, 2015)). Porbeagle is also a regular bycatch in the Norwegian pelagic trawl fishery for blue whiting in the Norwegian Sea. All specimens are reportedly dead when caught.

This species is taken by recreational fishers in some areas, however the full extent of fish captured through this method has not been quantified. A time series of catch is only available for the UK

[1] Fisheries: consultations between the UK and the EU in 2021 and 2022 - GOV.UK (www.gov.uk, https://oceans-and-fisheries.ec.europa.eu /news/eu-and-uk-reach-agreement-fishing-opportunities-2022-2021-12-22_en)

catch and release fishery (Jones *et al.*, 2021). The porbeagle catches are largely incidental bycatch of blue shark recreational fisheries. Catches increased from zero between 199–2011 to 333 individuals between 2015 and 2020. Other recreational fisheries are known to occur in Ireland and the Faroe Islands, but no data are available. No data are available to estimate the post-release mortality of individuals caught and released in recreational fisheries.

More detailed information on discards is presented in the Stock Annex.

6.3.3 Quality of catch data

The quality of the catches from 1926 to 2009 can be considered good after the revisions made by the WKELASMO (ICES, 2022a).

Since the EU zero TAC / prohibited listing was introduced, discards have likely increased, but no estimates of discards are available.

More detailed information on quality of catch is presented in the Stock Annex.

6.3.4 Discard survival

Data on discard survival are too limited to estimate dead discards. Available data are presented in the Stock Annex.

6.4 Commercial catch composition

Only limited length data are available. However, length-distributions by sex are available for 2008 and 2009 for the French longline fishery that targeted porbeagle until 2009 (Hennache and Jung, 2010; Figure 6.3). These distributions are considered representative of international catches because during that period France was the major contributor to catch (Figures 6.1 and 6.2).

Catch data derived from the French longline fishery highlighted the dominance of porbeagle (89%) on the total catch. Other species included blue shark (10%), common thresher (0.6%) and tope (0.3%).

Additional information on commercial catch composition is presented in the Stock Annex.

6.4.1 Conversion factors

Length–weight relationships are available for different geographic areas and for time periods (Table 6.2). Relationships between alternative length measurements with total length in porbeagle are presented in the Stock Annex.

6.5 Commercial catch and effort data

Three commercial CPUE series are available for the NEA porbeagle stock, all 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, 2022a,b);
- A French longline CPUE series from 1972 to 2009, in weight by trip, from logbooks of 19 vessels of the French directed fishery (Biais, 2022c,d);

- A Spanish longline CPUE series from 1986 to 2007, in weight per thousand hooks by trip, from the surface longline targeting swordfish (Mejuto *et al*., 2010).

They are briefly presented in the following sections. Further information can be found in the Stock Annex as well as in the report of the WKELASMO (ICES, 2022a).

6.5.1 The Norwegian longline CPUE series

The Norwegian CPUE series was obtained from logbooks for five longliners of the directed fishery. This provided daily catches in numbers per 1°x1° rectangle for the period 1950 to 1972 (years 1965-67 missing) and for an area extending from 49°N to 69°N. To avoid autocorrelations, CPUEs were selected when there are least five days between successive catches when taken in same or contiguous rectangles, based on Kendall's rank correlations (p-value<0.05).

The CPUEs were standardized comparing three GLM approaches. On the basis on five folds cross validations, Akaike's Information Criteria and quantile residual plots, 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 abundance 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 6.4).

Relative biomass indices were derived from these abundance indices using mean catch weight calculated from landing weights available for most of the trips in the logbooks.

6.5.2 The French longline CPUE series

CPUEs of longliners in the French directed fishery are available from 1972 to 2009. These CPUEs are in weight per trip for a fishing area which extends mainly on the shelf edge of the Bay of Biscay, but also in the Celtic Sea. Nineteen boats were selected in order to avoid short participations. 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 6.5).

6.5.3 The Spanish longline CPUE series

The Spanish longline CPUEs are bycatch by trip (in weight per thousand hooks) of the surface longline fishery targeting swordfish in eastern Atlantic (East 20°W from 35°N to 55°N). Data are available from 1986 to 2007. The portion of this area north of 45°N comprises about half of these catches, although it is reported that traditional longline occurs in this area only sporadically during certain years and quarters, taking advantage of 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, area, quarter, bait, year*area, year*quarter). The relative abundance index obtained (Figure 6.6) includes higher values in the 2000s, with large interannual variations.

6.6 Recreational catch and effort data

CPUE (fish by trip) of the United Kingdom recreational porbeagle catches are available from 1960 to 2020 in Division 7e (Jones *et al.*, 2021). This fishery has been conducted on a catch and release basis since 1994, largely as an occasional bycatch of blue shark recreational fisheries. The data are collated from historical records of the Shark Angling Club of Great Britain (SACGB) from 34 different boats with additional data from 13 skippers. Since 2015, resulting CPUEs have significantly increased (Figure 6.7). Available length distributions indicate that this increase has been driven by the abundance of small fish in Division 7e (median length close to 100 cm).

Further information can be found in the stock annex.

6.7 Fishery-independent surveys

A composite CPUE survey series is also available for the porbeagle stock in the NEA. This series was thus named because it combines the CPUE of a French commercial vessel, from 2000 to 2009, with the CPUE of a fishery-independent survey carried out in 2018-2019. This was done to construct a series long enough to provide information on the trend in abundance in the absence of commercial CPUEs since the zero TAC/prohibited species listing on which an assessment could be based.

The survey was carried out for ~6 weeks in May-June 2018 and 2019, using a chartered longliner. The gear was a longline with 336 hooks. Two sets per day 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 of 16 ICES rectangles extending along the shelf edge of the Bay of Biscay and the southern Celtic Sea (Biais, 2022e).

Combining the CPUE from this survey with a commercial CPUE was made possible by obtaining detailed data from personal logbooks provided by a vessel captain in the directed fishery for the years 2000 to 2009. This vessel contributed about 10% of the total French landings each year from 2000 to 2008. Sets with 252 or 336 hooks were considered comparable to the survey CPUEs (after scaling to 336 hooks when 252 hooks are deployed) because the same fishing gear and technique was used in both cases, assuming that catchability is not affected by a small difference in the number of hooks. Complementing this 2000-2009 commercial CPUE with the fishery-independent survey CPUE required a double selection for consistency. On the one hand, the commercial CPUE was selected to have independent observations of abundance, as was the survey CPUE due to the sampling plan, using the same process as for the Norwegian CPUE (Biais, 2022f). On the other hand, the survey CPUE was selected so that the spatial distribution was comparable to that of the commercial CPUE (Biais, 2022g).

The commercial and survey CPUE thus obtained were merged with "short" for longline type to form a CPUE series that was supplemented with the commercial CPUEs provided by 756 or 840 hooks, included with "long" for longline type, after scaling to the same number of hooks and selecting to have independent observation series. The resulting composite CPUE series was standardized with a GLM using a Tweedie distribution with a log link. The model involving year, type of longline and area was selected (Biais, 2022 f, g) based on five folds cross validations, the Akaike's Information Criteria (AIC), analysis of deviance tables and quantile residual plots. The relative abundance index series 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 6.8).

Relative biomass indices were derived from the abundance indices using 2008-2009 mean weight (from data provided by Hennache and Jung, 2010) for years 2000 to 2009, because available information supports the assumption that mean weights have not changed much in the 2000s. The

2018 and 2019 indices were calculated using the mean weights given by the weight-length relationship and the length distributions of survey catches.

Further information can be found in the stock annex.

6.8 Life-history information

Life-history information (including habitat description) is presented in the Stock Annex.

6.8.1 Movements and migrations

Migrations of three porbeagle tagged off Ireland with pop-up satellite archival tags (PSATs) in 2008 and 2009 are described by Saunders *et al.* (2011). One specimen migrated 2400 km to the northwest off Morocco, residing around the Bay of Biscay for about 30 days. The other two remained in off-shelf regions around the Celtic Sea/Bay of Biscay and off western Ireland. They occupied a vertical distribution ranging from 0–700 m and at temperatures of 9–17°C, but during the night they preferentially stayed at upper layers.

The UK (CEFAS) launched a tagging program in 2010 to address the issue of porbeagle bycatch and to further promote the understanding of porbeagle movement patterns in UK marine waters. Altogether, 21 PSATs were deployed between July 2010 and September 2011, and 15 tags popped off after two to six months. However, four tags failed to communicate. The tags attached to sharks in the Celtic Sea generally popped off to the south of the release positions while those to sharks off the northwest coast of Ireland popped off in diverse positions. One tag popped off in the western part of the North Atlantic, one close to the Gibraltar Straits and another in the North Sea. Several tags popped off close to the point of release (Bendall *et al*., 2012b).

From 2011 to 2019, France (IFREMER, with IRD and CEFAS in 2011; see Biais *et al*., 2017) deployed 60 PSATs that yielded 43 reconstructed tracks. They were used to map the spatiotemporal distributions by sex and length class of the exploitable fraction of the porbeagle stock present in the Bay of Biscay and the southern Celtic Sea in May-June (Biais *et al*., 2022). Quantitative estimates of area and period occupancy were derived. Based on 21 deployments that lasted more than 11 months (336 days), an estimated 76-86% of porbeagle exhibited annual return to the Celtic Sea and Bay of Biscay after frequent migrations far into the North Atlantic Ocean.

6.8.2 Reproductive biology

A research programme carried out by the NGO APECS (Hennache and Jung, 2010) provided information based on a large sampling (n = 1770) of the French catch in 2008–2009. Spatial sex-ratio segregations are documented and information is provided on the likelihood of a nursery ground in St. George’s Channel and of a pupping area in the grounds along the western Celtic Sea shelf edge. Further evidence of parturition close to the western European shelf was provided by the captures of 9 newborn pups on the Bay of Biscay shelf break in May 2015 and July 2016 (Biais *et al*., 2017) as well as by the captures of pregnant females during the 2018 and 2019 fishery-independent survey. Historic information (Gauld, 1989) indicated that parturition might be slightly later (summer or autumn) in more northern areas such as east Scotland and the Shetland Isles.

6.8.3 Genetic information

A first study of the genetic diversity (mitochondrial DNA haplotype and nucleotide diversities) was carried out by Pade (2009). This study was based on 156 individuals caught both on the

Northeast and Northwest Atlantic; the results obtained show no significant population structure across the North Atlantic. These findings were supported by another study which examined 224 specimens from eight sites across the North Atlantic and the Southern Hemisphere (Testerman, 2014). However, this study showed strong genetic difference between the North Atlantic and Southern Hemisphere, which indicates two genetically distinct populations.

Pade (2009) found also that while the mtDNA haplotype diversity was very high, sequence diversity was low, which suggests that most females breed in particular places, which also indicates the stock is likely to be genetically robust.

Viricel *et al*. (2021) observed also high levels of genetic diversity at the mitochondrial DNA control region in North Atlantic, using 49 individuals caught in the Bay of Biscay from 2013 to 2019, 6 individuals from the Indian ocean and 155 sequences obtained from Genbank from both North and South Atlantic. A significant genetic difference was found between individuals sampled in Norway and Denmark and others selected among samples from the Bay of Biscay and Celtic Sea, based on westward migrations. These results are considered preliminary, as they were obtained using a single locus and small sample sizes. They need to be complemented with Single Nucleotide Polymorphism (SNP) analysis, more robust for low sample sizes.

Further studies examining genetic structure of Mediterranean Sea porbeagle are still required.

6.9 Exploratory assessment models

6.9.1 Previous studies

The first assessment of the Northeast Atlantic stock was carried out in 2009 by the joint ICCAT/ICES meeting (ICCAT, 2009; ICES, 2009) using a Bayesian Surplus Production (BSP) model (Babcock and Cortes, 2009) and an Age-Structured Production (ASP) model (Porch *et al.*, 2006).

Using the French CPUE series as well as the Spanish CPUE series, stock projections based on the BSP model demonstrated that low catches (below 200 t) may allow the stock to increase under most credible model scenarios and that the recovery to B_{MSY} could be achieved within 25–50 years under nearly all model scenarios. More detailed results from these are detailed in the Stock Annex.

6.9.2 Benchmark

A total of 27 Surplus Production in Continuous Time (SPiCT) exploratory assessment runs (Pedersen and Berg, 2017) were submitted to WKELASMO (ICES, 2022a) with two additional JABBA exploratory assessments. For all assessments, the 1926-2020 landings, revised as part of the WKELASMO meeting were used for the catches. Considering that discards were negligible before 2010, but unknown afterwards, the standard deviation of the observed catches was multiplied by 5 from 2010 onwards. The biomass indices provided by standardizing the three available commercial CPUE series and the composite CPUE survey series were used (Figure 6.9), with the ratios of their standard errors from the GLMs to their respective means as input for the relative standard deviations of indices. The biomass was assumed close to the virgin state in 1926 as all available information shows that porbeagle were only caught incidentally in limited quantities by Norwegian fisheries in the absence of a local market (informative prior set for initial B/K= 0.99).

All the exploratory assessments set the median of the prior for the intrinsic rate of increase to 0.059, as per the 2020 ICCAT stock assessment (Cortes and Semba, 2020), and the shape parameter n to 2, which implies a Schaefer production model. The exploratory runs focused primarily on the effect of having informative (sd =0.2) or semi-informative (sd=0.5) priors for these parameters as well as on the inclusion of the Spanish longline biomass index in the assessment. When the sd of log (n) is 0.5, this n leads to a posterior n close to 1 which was in contradiction with a low prior for r. Therefore, the sd was set to 0.2 for log(n) for further exploratory assessments. For the prior for r, a sd set to 0.5 was retained because the acceptance criteria for a SPiCT assessment (ICES, 2020b) are met without restriction only for this input. After several sensitivity runs with different priors for the sd of the Spanish longline biomass index, it was incorporated with a large and informative prior for its sd (=1.1) in the final assessment, on the basis of acceptance criteria.

With respect to the comparison between the JABBA and SPiCT assessments, it should be noted that, despite some differences in model configuration, the two modelling approaches provided very similar outlooks of the status of the NEA porbeagle stock.

6.10 Stock assessment

The 2022 stock assessment was carried out using the SPiCT model with priors agreed for the final benchmark assessment (prior for B/K: median=0.99, sd of log(n)=0.2; prior for n: median=2, sd of log(n)=0.2; prior for r: median=0.059, sd of log(r)=0.5; priors for the sd_{Sp} of the Spanish longline biomass index: median=1.1, with sd of log(sd_{Sp})=0.1). The landings being updated but the biomass indices remain the same, because the survey was not carried out in 2020. In addition, the last release of the SPiCT package (version 1.3.6) was used. It includes some improvements in the management functionality and also in the retrospective function for time series that have missing values in the last years (such as this assessment).

The posterior n is the same as that of the final benchmark assessment (1.7). The model is thus close to a Schaefer model, with an inflection point of the production curve close to B_{MSY}/K=0.5. The posterior r is also the same as that of the final benchmark assessment (0.089). The exploited biomass decreases below B_{MSY} in the early 1950s (Figure 6.10). 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, but above $B_{trigger}$ (0.5 B_{MSY}; see section 6.13). Overfishing is no longer occurring, with the low values of current F consistent with the landing prohibition in effect since 2010 (Figure 6.11).

The retrospective patterns are consistent although the Mohn's rho of the relative F analysis is above 0.2 (Figure 6.12). This was not observed in the retrospective analysis made at the WKELASMO for the final assessment, but now occurs for this assessment when using the SPiCT package 1.3.6 with the same landings as during the benchmark. However, given the very low catches in recent years, a Mohn's rho of the relative F analysis slightly above 0.2 cannot be considered a relevant criterion for not accepting the assessment, as was agreed during the WKELASMO for some exploratory assessments.

6.11 Forecasts

The Benchmark Oversight Group (BOG) accepted the conclusions of the WKELASMO (ICES, 2022a). Therefore, the porbeagle stock in the NEA became an ICES Category 2 stock in 2022, as its status can be assessed with SPiCT. According to the ICES technical guidance for harvest control rules and stock assessments for stocks in category 2 (ICES, 2022 b), the default rule for the catch advice is to use the fractile rule with the 35th percentile of the predicted catch distribution.

During the meeting, catch scenarios were established for two years, considering that a four-year advice as in 2019 was due to the zero-catch advice, but that if this is to change, an advice every two years would be more suitable for monitoring the exploitation of the porbeagle stock. However, there were some concerns raised by ICCAT scientists in the approach of applying the ICES default rule for the porbeagle catch advice when they may not have been tested on a long-lived species. This warning suggested making long-term projections (to 2053 to encompass two generations) with constant catch options to provide tables of probabilities p(B>BMSY), p(F<FMSY) and p (B>BMSY & F<FMSY), as required for ICCAT advice. This was considered useful to ensure consistency between ICCAT and ICES advice, although long-term projections are not required for ICES catch advice. A WebEX meeting has been agreed upon for mid-July to review the results of these long-term projections and possible additional catch scenarios to be considered for the catch advice for 2023 and 2024. Unfortunately, the results showed some inconsistencies for the early years of the long-term forecast with constant catches that could not be resolved quickly. However, these problems do not arise when making long-term projections for constant fishing mortalities, which are relevant for ICES advice because they allow estimation of F_{p05}, the fishing mortality that results in a less than 5% probability of SSB < Blim in the long term (ICES, 2022c). Given this interest, probability tables for constant fishing mortalities were sent in July by the stock coordinator to WGEF members, with the addition of probabilities p(B>Btrigger) and p(B>Blim) to include ICES biomass reference points (Table 6.3 a, b & c). The probability $p(B>B_{MSY})$ is above 0.5 in 2053 when $F=0.7F_{MSY}$. The probability $p(B>B_{Lim})$ is above 0.95 in 2053 when $F=0.3F_{MSY}$ ($F_{p0.5}$). The latter option was included in the catch scenario tables for 2023 and 2024 of the draft for the advisory advice.

6.12 Quality of assessments

In 2022, participants in WGEF included scientists involved in ICCAT shark assessments. Previously, several of them participated in WKELASMO, of which the chair of the 2020 ICCAT porbeagle assessment meeting was an external expert. Therefore, the porbeagle benchmark by the WKELASMO and the following assessment by the WGEF were conducted in cooperation with ICCAT scientists. It was the first time since the ICCAT 2009 Porbeagle Stock Assessments Meeting which was held as a joint meeting of WGEF and the ICCAT Shark species group (ICCAT, 2009; ICES, 2009). At this 2009 meeting, the lack of CPUE data for the peak fishery was highlighted as a major caveat to the quality of the assessment by a surplus production model. This issue has been resolved with the availability of the Norwegian longline CPUE series which begins in 1950, thus when catches were still above 3000t.

The 2009 request for an independent survey of the fishery was also taken into account with the organisation of two fishery-independent abundance surveys in 2018 and 2019. This generated a composite survey series combining commercial and survey CPUEs, obtained after successive improvements (Biais 2022 e-g). This work greatly benefited from the participation of members of the ICCAT shark species group at WKELASMO, as did the standardization of the Norwegian and French CPUE series (Biais 2022a-d). Members of the ICCAT shark species group provided also additional assessments using JABBA, with very similar results giving the same perception of the stock as the final accepted SPiCT assessment.

Treatments to avoid autocorrelation of CPUE addressed warnings about the potential for index hyperstability that searching for concentrations generates in directed fisheries (Biais, 2022a and f). It should also be noted that the standardization of the French longline CPUE series, already used in the 2009 exploratory assessment, is now documented (Biais, 2022c and d). The validity of including the Spanish longline index in the assessment was questioned during WKELASMO, due to its large variation and the area selected to build the CPUE series. Nevertheless, this index was used, but with a large standard deviation. An examination of the possibility of increasing the quality of this index would be of interest as well as its extension beyond 2007. Furthermore, the porbeagle subgroup of the WGEF indicated that any future WKLIFE meetings could be asked to examine the assessment of a lower productivity species such as porbeagle with a surplus production model.

The quality of porbeagle assessment would benefit from improved knowledge of stock structure. While there seemed to be strong indication of site fidelity and repeated migration routes, the genetic differentiation among different regions in the Northeast Atlantic was not strong, and based on a limited number of samples (ICES, 2022a). In its porbeagle subgroup, the WGEF held discussions on ongoing genetics and tagging studies and how collaborations and the sharing of materials can be developed to improve our understanding of the stock structure in the Northeast Atlantic. Any future joint ventures or assessments would benefit from a more coordinated approach with collaborative drafting of agendas, ToR and more advanced planning to ensure that the aims, expectations and results are as aligned as possible within the operational constraints of each organisation.

6.13 Reference points

SPiCT provides relative fishing mortality (F/F_{MSY}) and relative biomass (B/B_{MSY}) reference points. F_{MSY} and B_{MSY} are estimated directly from the SPiCT assessment model and, therefore, change when the assessment is updated.

For the MSY approach, the reference points are F_{MSY} and $B_{trigger}$= 0.5 B_{MSY} (ICES, 2021).

For the precautionary approach, the reference points are F_{lim} = 1.7 × F_{MSY} (ICES, 2017) and B_{lim}= 0.3 B_{MSY} (ICES, 2021).

6.14 Conservation considerations

The porbeagle shark subpopulation of the Northeast Atlantic was listed as Critically Endangered in the IUCN red list in 2015 (Ellis *et al*., 2015). In 2019, IUCN assigned the porbeagle to the vulnerable category in a global assessment of the species (Rigby *et al*., 2019a). This review was carried out using a Bayesian state space tool for each region where data were available (Rigby *et al*., 2019b). In the NEA, the results of the 2009 ICCAT-ICES meeting were used. The median population decrease over three generation was thus estimated to be 56% in 2009. As a result, the global assessment is based on a NEA population classified in the endangered category

In 2013, a renewed proposal to list porbeagle shark on Appendix II of CITES was accepted at the Conference of Parties (16) Bangkok, and it has been listed since September 2014.

6.15 Management considerations

A dedicated longline survey covering the main parts of the stock area is needed to monitor stock status appropriately. The surveys carried out by France in 2018 and 2019 have shown that a fixed stations survey design can provide consistent annual indices. Continuing this spring-summer survey with an expansion to other areas within the stock distribution would be advantageous, as this would provide the necessary sampling effort to take the large distribution of porbeagle into account in order to monitor stock size. This species has low population productivity, and is thus highly susceptible to overexploitation. Consequently, WGEF considers that target fishing should not proceed without a programme to monitor stock abundance feeding into regular updates of the NEA porbeagle stock assessment. The current fishing ban renders estimates of discards difficult to obtain, but they are considered to have increased in recent years in the Bay of Biscay as well as in northern part of the distribution area of the stock.

A maximum landing length (MLL) was adopted by the EC in 2009. It was considered a potentially useful management measure in targeted fisheries, as it could deter targeting areas with mature females. However, the fishery-independent survey data question both the efficacy and practicality of such a measure, and given the short time period of implementation prior to a zero TAC the effectiveness remains unevaluated.

Studies on porbeagle bycatch should be continued to develop operational ways to reduce bycatch, to decrease at-vessel mortality and to improve the post-release survivorship of discarded porbeagle.

All fisheries-dependent data should be provided by countries having fisheries for this stock, including countries targeting other species with longlines in the stock area.

During the WGEF, discussions were initiated regarding both the process and timeline of advice provision within ICES and similarly within ICCAT. The timelines to provide final advice, and management programmes of both organisations differ, with the ICES advice (scheduled for 4th October 2022) released after the ICCAT meeting of the Standing Committee on Research and Statistics (SCRS, scheduled for 26-30th September 2022) where the summary advice for porbeagle will be agreed (following the species group meeting scheduled for 20-21st September 2022). This has the potential to lead to inconsistent perceptions of the stock status and any associated catch advice. Consistency between the advice from each organisation is important and future alignment of process and outcomes may be facilitated by an MoU between ICES and ICCAT.

6.16 References

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Table 6.1 Porbeagle in the Northeast Atlantic. Working Group estimates of porbeagle landings data (tonnes) by country (1926–2021). Data derived from ICCAT, ICES data calls and national data. Note: blank when no catch,; '0' = < 0.5 t.

Year	Denmark	Faroe Islands	France	Germany	Iceland	Ireland	Netherlands	Norway	Portugal	Spain	Sweden	UK	Japan	Total
1926								363						363
1927								595						595
1928								794						794
1929								1082						1082
1930								1957						1957
1931								1438						1438
1932								2084						2084
1933								5049						5049
1934								4714						4714
1935								2591						2591
1936								3197						3197
1937								3647						3647
1938								3553						3553
1939								2877						2877
1940								135						135
1941								368						368
1942								374						374
1943								458						458
1944								417						417
1945								1206						1206
1946	1400							1414						2814
1947	3300							3671						6971
1948	2100							2490						4590
1949	1700							1626						3326
1950	1900							1765		4				3669
1951	1600							1013		3				2616
1952	1600							789		3				2392
1953	1100	100						927		4				2131
1954	651	300						772		1				1724
1955	578	100						1167		2				1847
1956	446							1132		1				1579
1957	561	100						1426		3				2090
1958	653	300						1080		3		7		2043
1959	562	600						1183		3		9		2357
1960	362	500						1929		2		10		2803
1961	425							1369		5		9		1808

Year	Denmark	Faroe Islands	France	Germany	Iceland	Ireland	Netherlands	Norway	Portugal	Spain	Sweden	UK	Japan	Total
1962	304							577		7		20		908
1963	173							157		3		17		350
1964	216							116		6		5		343
1965	165							265		4		8		442
1966	131							283		9		6		429
1967	144							397		8		7		556
1968	111							880		11		7		1009
1969	100							909		11		3		1023
1970	124							269		10		5		408
1971	311	1	550					208		11		7		1088
1972	523		1317					293		10		19		2162
1973	158	5	1350	6	2			209		12		27		1769
1974	170		967	3	2			165		9		15		1331
1975	265		1251	4	4			304		12	3	16		1859
1976	233	1	1373		3			259		9		25		1903
1977	289	5	1188		3			78		10				1573
1978	112	9	538					76		11	5			751
1979	72	25	703		1			106		8	1	1		917
1980	176	8	589		1			84		12	8	3		881
1981	158	6	451		1			93		12	5	2		728
1982	84	17	450		1			32		14	6	1		605
1983	45	12	517		1			33		28	5	2		643
1984	38	14	307		1			118		20	9	5		512
1985	72	12	200		1			79		23	10	12		409
1986	114	12	246		1			23		26	8	6		436
1987	56	33	223		1			25	3	30	5	3		379
1988	33	14	350		1			12	3	69	3	3		488
1989	33	14	357		1			27	2	42	3	15		494
1990	46	14	577		0			46	2	26	2	9		722
1991	85	7	292		0			34	1	47	2			468
1992	80	20	452		1			43	0	15	4			615
1993	91	76	632	1	3			24	1	21	3			852
1994	93	48	815		4			26	1	52	2			1041
1995	86	44	635		5			27	1	19	2	0		819
1996	72	8	442		3			28	1	41	1		3	599
1997	69	9	489		2			17	1	25	1		2	615
1998	85	7	428	2	3			27	1	25	1	1		580
1999	107	10	306	0	3	8		32	0	18	1	6		491

Year	Denmark	Faroe Islands	France	Germany	Iceland	Ireland	Netherlands	Norway	Portugal	Spain	Sweden	UK	Japan	Total
2000	73	13	385	17	2	2	0	23	15	13	1	7		551
2001	76	8	380	1	4	6		17	4	24	1	10		531
2002	42	10	528	3	2	3		14	11	54		7		674
2003	21	14	443	5	0	3	0	19	4	27		25		561
2004	20	5	423	6	1	0		24	57	11	5	24		576
2005	3	18	298	5	0	3	0	12		14	0	24		378
2006	3	21	223	0	1	4		27		34		12		325
2007	2	14	369	2	0	8	0	10		8	0	26		439
2008	2	10	319	2	1	7		12		41	0	15		409
2009	4	13	291		1	3		10		77		11		410
2010		14	7		1	0	0	12						34
2011	2	18	1		1			11						33
2012	3	25	2		1			17				0		48
2013		17	1		1			9						28
2014		15	1		0			5						21
2015		7			1		0	4						12
2016	0	3			2			6						11
2017	0	1	1		1			6						9
2018		1	1		1			3						6
2019	1	1	2		3			4						11
2020	0	1			3			3						7
2021		2						5						7

Table 6.2. Porbeagle in the Northeast Atlantic. Length–weight relationships of porbeagle from scientific studies.

Stock	L-W relationship	Sex	n	Length range	Source
NW Atlantic	W = (1.4823 x 10^{-5}) L_F 2.9641	C	15	106–227 cm	Kohler *et al.*, 1995
NE Atlantic (Bristol Channel)	W = (1.292 x 10^{-4}) L_T 2.4644	C	71	114–187 cm	Ellis and Shackley, 1995
NE Atlantic (N/NW Spain)	W = (2.77 x 10^{-4}) L_F 2.3958	M	39		Mejuto and Garcés, 1984
	W = (3.90 x 10^{-6}) L_F 3.2070	F	26		
NE Atlantic (SW England)	W = (1.07 x 10^{-5}) L_T 2.99	C	17		Stevens, 1990
NE Atlantic (Biscay / SW England/ W Ireland)	W = (4 x 10^{-5}) L_F 2.7316	M	564	88–230 cm	Hennache and Jung, 2010
	W = (3 x 10^{-5}) L_F 2.8226	F	456	93–249 cm	
	W = (4 x 10^{-5}) L_F 2.7767	C	1020	88–249 cm	

Table 6.3 a. Porbeagle in the Northeast Atlantic. Catch per year for each fishing mortality option (upper panel), probabilities (in %) of B>B$_{lim}$ (middle panel) and B>B$_{lim}$ and F<F$_{MSY}$ (lower panel) per year from 2023 to 2053 for fishing mortalities increasing from 0 to 1.2 F$_{MSY}$. Catch in 2022 corresponds to F status quo (8t).

Catch per F and Year	Year																														
Fishing mortality	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
F = 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F = 0.1 F_{MSY}	63	67	72	76	81	86	91	96	101	106	111	116	121	126	131	136	141	146	151	155	160	164	168	172	176	180	184	187	190	194	197
F = 0.2 F_{MSY}	126	133	142	150	159	167	176	185	194	203	213	222	231	240	249	258	267	276	284	292	300	308	316	323	330	337	343	350	356	361	367
F = 0.3 F_{MSY}	188	199	210	221	233	245	257	269	281	294	306	318	331	343	355	367	378	390	401	412	423	433	444	453	463	472	481	489	497	505	512
F = 0.4 F_{MSY}	250	263	277	291	305	319	333	348	362	377	392	406	421	435	449	463	477	490	503	516	529	541	553	565	576	587	597	607	617	626	635
F = 0.5 F_{MSY}	312	327	342	358	373	389	405	421	437	453	470	485	501	517	532	548	563	577	592	606	620	633	646	659	671	683	695	706	716	727	737
F = 0.6 F_{MSY}	373	390	406	423	439	456	473	490	507	524	540	557	573	590	606	622	637	653	668	682	696	710	724	737	750	762	774	786	797	808	818
F = 0.7 F_{MSY}	435	451	468	485	502	520	537	554	571	588	605	621	638	654	670	686	701	716	731	746	760	774	788	801	813	826	838	849	861	871	882
F = 0.8 F_{MSY}	496	512	529	546	563	580	596	613	630	646	662	679	694	710	726	741	756	770	784	798	812	825	838	851	863	875	887	898	909	919	929
F = 0.9 F_{MSY}	556	572	589	605	621	637	653	668	684	699	714	729	744	759	773	787	801	814	828	841	853	865	877	889	900	911	922	932	943	952	962
F = F_{MSY}	617	632	647	661	676	691	705	719	733	747	761	774	788	801	813	826	838	850	862	873	884	895	906	916	926	936	946	955	964	973	981
F = 1.1 F_{MSY}	677	690	703	716	729	742	754	766	779	790	802	814	825	836	847	857	868	878	888	898	907	916	925	934	942	951	959	966	974	981	989
F = 1.2 F_{MSY}	737	748	758	769	780	790	800	810	820	829	839	848	857	866	874	883	891	899	907	914	922	929	936	943	950	956	962	969	974	980	986

P(Bt>Blim)	Year																														
Fishing mortality	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
F = 0	81	83	85	87	89	90	91	92	93	94	95	96	96	97	97	98	98	99	99	99	99	99	100	100	100	100	100	100	100	100	100
F = 0.1 F_{MSY}	81	83	85	86	88	89	90	91	92	93	94	95	95	96	96	97	97	98	98	98	99	99	99	99	99	100	100	100	100	100	100
F = 0.2 F_{MSY}	81	82	84	86	87	88	89	90	91	92	93	93	94	95	95	96	96	96	97	97	97	98	98	98	98	99	99	99	99	99	99
F = 0.3 F_{MSY}	81	82	84	85	86	87	88	89	90	90	91	92	92	93	93	94	94	94	95	95	95	96	96	96	96	96	97	97	97	97	97
F = 0.4 F_{MSY}	81	82	83	84	85	86	87	88	88	89	89	90	90	91	91	91	92	92	92	92	92	93	93	93	93	93	93	93	93	93	93
F = 0.5 F_{MSY}	81	82	83	84	84	85	86	86	87	87	87	88	88	88	88	89	89	89	89	89	89	89	89	89	89	89	89	89	89	88	88
F = 0.6 F_{MSY}	81	81	82	83	83	84	84	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	84	84	84	84	84	84	83	83
F = 0.7 F_{MSY}	81	81	82	82	83	83	83	83	83	83	83	83	83	83	82	82	82	82	82	81	81	81	80	80	80	80	79	79	79	79	78
F = 0.8 F_{MSY}	81	81	81	81	82	82	82	81	81	81	81	80	80	80	79	79	79	78	78	78	77	77	76	76	76	75	75	75	75	74	74
F = 0.9 F_{MSY}	81	81	81	81	81	80	80	80	79	79	78	78	77	77	76	76	76	75	75	74	74	73	73	72	72	72	71	71	71	70	70
F = F_{MSY}	81	80	80	80	79	79	79	78	77	77	76	75	75	74	74	73	73	72	71	71	70	70	70	69	69	68	68	68	67	67	67
F = 1.1 F_{MSY}	81	80	80	79	78	78	77	76	75	75	74	73	72	72	71	70	70	69	69	68	68	67	67	66	66	65	65	65	64	64	64
F = 1.2 F_{MSY}	81	80	79	78	77	76	75	74	74	73	72	71	70	69	68	68	67	67	66	65	65	65	64	64	63	63	63	62	62	62	61

P(Ft>Fmsy & Bt>Blim)	Year																														
Fishing mortality	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
F = 0	70	72	74	76	78	80	82	83	85	86	87	88	89	90	91	91	92	92	93	93	94	94	94	95	95	95	95	95	96	96	96
F = 0.1 F_{MSY}	69	72	74	76	77	79	81	82	83	84	86	86	87	88	89	90	90	91	91	92	92	92	93	93	93	94	94	94	94	94	94
F = 0.2 F_{MSY}	68	70	72	73	75	76	77	79	80	81	82	83	84	84	85	86	86	87	87	88	88	89	89	89	89	90	90	90	90	91	91
F = 0.3 F_{MSY}	66	67	68	69	71	72	73	74	75	76	77	78	79	80	80	81	81	82	82	83	83	84	84	84	85	85	85	85	86	86	86
F = 0.4 F_{MSY}	62	63	64	65	66	68	69	70	71	71	72	73	74	74	75	76	76	77	77	77	78	78	79	79	79	79	80	80	80	80	80
F = 0.5 F_{MSY}	59	59	60	61	62	63	64	65	66	67	67	68	69	69	70	70	71	71	72	72	73	73	73	73	74	74	74	74	74	74	75
F = 0.6 F_{MSY}	55	56	56	57	58	59	60	61	61	62	63	63	64	65	65	66	66	66	67	67	67	68	68	68	68	68	68	69	69	69	69
F = 0.7 F_{MSY}	52	52	52	53	54	55	56	56	57	58	58	59	60	60	60	61	61	62	62	62	62	62	63	63	63	63	63	63	63	63	63
F = 0.8 F_{MSY}	48	48	49	50	50	51	52	53	53	54	54	55	55	56	56	56	57	57	57	57	58	58	58	58	58	58	58	58	58	58	59
F = 0.9 F_{MSY}	45	45	46	46	47	48	48	49	50	50	51	51	51	52	52	52	53	53	53	53	53	53	53	54	54	54	54	54	54	54	54
F = F_{MSY}	42	42	43	43	44	44	45	46	46	47	47	47	48	48	48	49	49	49	49	49	49	49	49	50	50	50	50	50	50	50	50
F = 1.1 F_{MSY}	39	39	40	40	41	42	42	43	43	43	44	44	44	45	45	45	45	45	45	46	46	46	46	46	46	46	46	46	46	46	46
F = 1.2 F_{MSY}	37	37	37	38	38	39	39	40	40	41	41	41	41	42	42	42	42	42	42	42	42	42	42	42	42	42	42	43	43	43	43

Table 6.3 b. Porbeagle in the Northeast Atlantic. Catch per year for each fishing mortality option (upper panel), probabilities (in %) of B>$B_{trigger}$ (middle panel) and B>$B_{trigger}$ and F< F_{MSY} (lower panel) per year from 2023 to 2053 for fishing mortalities increasing from 0 to 1.2 F_{MSY}. Catch in 2022 corresponds to F status quo (8t).

Catch per F and Year	Year																														
Fishing mortality	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
F = 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F = 0.1 F_{MSY}	63	67	72	76	81	86	91	96	101	106	111	116	121	126	131	136	141	146	151	155	160	164	168	172	176	180	184	187	190	194	197
F = 0.2 F_{MSY}	126	133	142	150	159	167	176	185	194	203	213	222	231	240	249	258	267	276	284	292	300	308	316	323	330	337	343	350	356	361	367
F = 0.3 F_{MSY}	188	199	210	221	233	245	257	269	281	294	306	318	331	343	355	367	378	390	401	412	423	433	444	453	463	472	481	489	497	505	512
F = 0.4 F_{MSY}	250	263	277	291	305	319	333	348	362	377	392	406	421	435	449	463	477	490	503	516	529	541	553	565	576	587	597	607	617	626	635
F = 0.5 F_{MSY}	312	327	342	358	373	389	405	421	437	453	470	485	501	517	532	548	563	577	592	606	620	633	646	659	671	683	695	706	716	727	737
F = 0.6 F_{MSY}	373	390	406	423	439	456	473	490	507	524	540	557	573	590	606	622	637	653	668	682	696	710	724	737	750	762	774	786	797	808	818
F = 0.7 F_{MSY}	435	451	468	485	502	520	537	554	571	588	605	621	638	654	670	686	701	716	731	746	760	774	788	801	813	826	838	849	861	871	882
F = 0.8 F_{MSY}	496	512	529	546	563	580	596	613	630	646	662	679	694	710	726	741	756	770	784	798	812	825	838	851	863	875	887	898	909	919	929
F = 0.9 F_{MSY}	556	572	589	605	621	637	653	668	684	699	714	729	744	759	773	787	801	814	828	841	853	865	877	889	900	911	922	932	943	952	962
F = F_{MSY}	617	632	647	661	676	691	705	719	733	747	761	774	788	801	813	826	838	850	862	873	884	895	906	916	926	936	946	955	964	973	981
F = 1.1 F_{MSY}	677	690	703	716	729	742	754	766	779	790	802	814	825	836	847	857	868	878	888	898	907	916	925	934	942	951	959	966	974	981	989
F = 1.2 F_{MSY}	737	748	758	769	780	790	800	810	820	829	839	848	857	866	874	883	891	899	907	914	922	929	936	943	950	956	962	969	974	980	986

P(Bt>Btrigger)	Year																														
Fishing mortality	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
F = 0	50	55	59	63	66	69	72	75	77	80	82	83	85	87	88	90	91	92	93	94	95	96	96	97	97	98	98	99	99	99	99
F = 0.1 F_{MSY}	50	54	58	62	65	68	71	73	75	78	79	81	83	84	86	87	89	90	91	92	93	93	94	95	96	96	97	97	97	98	98
F = 0.2 F_{MSY}	50	54	58	61	64	67	69	71	74	75	77	79	80	82	83	84	85	87	88	88	89	90	91	92	92	93	93	94	94	95	95
F = 0.3 F_{MSY}	50	54	57	60	63	65	68	70	71	73	75	76	78	79	80	81	82	83	84	84	85	86	86	87	87	88	88	89	89	89	90
F = 0.4 F_{MSY}	50	54	57	59	62	64	66	68	69	71	72	73	75	76	77	77	78	79	79	80	81	81	81	82	82	82	83	83	83	83	84
F = 0.5 F_{MSY}	50	53	56	58	61	63	64	66	67	69	70	71	72	72	73	74	74	75	75	76	76	76	77	77	77	77	77	77	77	77	77
F = 0.6 F_{MSY}	50	53	55	58	59	61	63	64	65	66	67	68	69	69	70	70	71	71	71	72	72	72	72	72	72	72	72	72	72	72	72
F = 0.7 F_{MSY}	50	53	55	57	58	60	61	62	63	64	65	65	66	66	67	67	67	67	68	68	68	68	68	68	68	68	68	68	68	68	68
F = 0.8 F_{MSY}	50	52	54	56	57	59	60	61	61	62	63	63	63	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64
F = 0.9 F_{MSY}	50	52	54	55	56	57	58	59	59	60	60	61	61	61	61	61	61	61	62	62	61	61	61	61	61	61	61	61	61	61	61
F = F_{MSY}	50	52	53	54	55	56	57	57	58	58	58	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	58	58	58	58
F = 1.1 F_{MSY}	50	51	52	53	54	55	55	56	56	56	56	57	57	57	57	57	57	57	57	57	57	57	57	57	56	56	56	56	56	56	56
F = 1.2 F_{MSY}	50	51	52	53	53	54	54	54	54	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	54	54	54	54	54

P(Ft>Fmsy & Bt>Btrigger)	Year																														
Fishing mortality	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
F = 0	50	53	56	58	61	63	65	68	70	71	73	75	76	78	79	80	81	82	83	84	84	85	86	86	87	87	88	88	88	89	89
F = 0.1 F_{MSY}	50	53	55	58	60	62	64	66	68	70	71	73	74	76	77	78	79	80	81	82	82	83	84	84	85	85	86	86	87	87	87
F = 0.2 F_{MSY}	49	52	54	56	58	60	62	63	65	67	68	70	71	72	73	74	75	76	77	78	79	79	80	81	81	82	82	83	83	83	84
F = 0.3 F_{MSY}	48	50	52	53	55	57	59	60	62	63	64	66	67	68	69	70	71	72	73	74	74	75	76	76	77	78	78	79	79	79	80
F = 0.4 F_{MSY}	46	48	49	51	52	54	55	57	58	59	61	62	63	64	65	66	67	68	69	69	70	71	71	72	73	73	74	74	74	75	75
F = 0.5 F_{MSY}	44	45	46	48	49	50	52	53	54	56	57	58	59	60	61	62	63	64	64	65	66	66	67	68	68	69	69	69	70	70	70
F = 0.6 F_{MSY}	42	43	44	45	46	47	49	50	51	52	53	54	55	56	57	58	59	60	60	61	61	62	63	63	64	64	64	65	65	65	66
F = 0.7 F_{MSY}	40	40	41	42	43	44	46	47	48	49	50	51	52	53	53	54	55	56	56	57	57	58	58	59	59	59	60	60	60	61	61
F = 0.8 F_{MSY}	38	38	39	40	41	42	43	44	45	46	47	48	48	49	50	51	51	52	52	53	53	54	54	54	55	55	55	56	56	56	56
F = 0.9 F_{MSY}	35	36	36	37	38	39	40	41	42	43	44	45	45	46	47	47	48	48	49	49	50	50	50	51	51	51	51	51	52	52	52
F = F_{MSY}	33	34	34	35	36	37	38	39	40	40	41	42	42	43	44	44	45	45	45	46	46	46	47	47	47	47	47	48	48	48	48
F = 1.1 F_{MSY}	31	32	32	33	34	35	36	36	37	38	39	39	40	40	41	41	41	42	42	42	43	43	43	43	44	44	44	44	44	44	44
F = 1.2 F_{MSY}	30	30	30	31	32	33	34	34	35	36	36	37	37	38	38	38	39	39	39	39	40	40	40	40	40	40	41	41	41	41	41

Table 6.3 c. Porbeagle in the Northeast Atlantic. probabilities (in %) of B>B_{MSY} (upper panel), F<F_{MSY} (middle panel) and B>B_{MSY} and F<F_{MSY} (lower panel) per year from 2023 to 2053 for fishing mortalities increasing from 0 to 1.2 F_{MSY}. Catch in 2022 corresponds to F status quo (8t).

P(Bt>Bmsy)	Year																													
Fishing mortality	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
F = 0	12	16	19	23	26	30	33	36	40	43	46	48	51	54	56	59	61	63	66	68	70	72	74	75	77	79	80	82	83	85	86
F = 0.1 F_{MSY}	12	15	19	22	25	29	32	35	38	41	43	46	49	51	53	55	58	60	62	64	65	67	69	70	72	73	75	76	78	79	80
F = 0.2 F_{MSY}	12	15	18	22	25	28	31	34	36	39	42	44	46	48	50	52	54	56	58	59	61	62	64	65	66	68	69	70	71	72	73
F = 0.3 F_{MSY}	12	15	18	21	24	27	30	32	35	37	40	42	44	46	48	49	51	53	54	55	57	58	59	60	61	62	63	64	65	65	66
F = 0.4 F_{MSY}	12	15	18	21	24	26	29	31	34	36	38	40	42	44	45	47	48	50	51	52	53	54	55	56	57	58	58	59	59	60	60
F = 0.5 F_{MSY}	12	15	18	20	23	26	28	30	33	35	37	39	40	42	43	45	46	47	48	49	50	51	52	53	53	54	55	55	56	56	56
F = 0.6 F_{MSY}	12	15	17	20	23	25	27	30	32	34	35	37	39	40	42	43	44	45	46	47	48	49	49	50	51	51	52	52	52	53	53
F = 0.7 F_{MSY}	12	15	17	20	22	24	27	29	31	33	34	36	38	39	40	41	43	44	44	45	46	47	47	48	48	49	49	50	50	50	51
F = 0.8 F_{MSY}	12	15	17	19	22	24	26	28	30	32	34	35	37	38	39	40	41	42	43	44	44	45	46	46	47	47	48	48	48	49	49
F = 0.9 F_{MSY}	12	15	17	19	21	23	25	27	29	31	33	34	36	37	38	39	40	41	42	43	43	44	44	45	45	46	46	46	47	47	47
F = F_{MSY}	12	14	17	19	21	23	25	27	29	30	32	34	35	36	37	38	39	40	41	41	42	43	43	44	44	45	45	45	46	46	46
F = 1.1 F_{MSY}	12	14	16	18	21	23	25	26	28	30	31	33	34	35	36	37	38	39	40	41	41	42	42	43	43	44	44	44	45	45	45
F = 1.2 F_{MSY}	12	14	16	18	20	22	24	26	28	29	31	32	34	35	36	37	38	38	39	40	40	41	42	42	42	43	43	44	44	44	44

P(Ft<Fmsy)	Year																													
Fishing mortality	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
F = 0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
F = 0.1 F_{MSY}	98	97	95	93	92	90	89	88	87	86	85	84	83	82	81	81	80	79	79	78	78	77	77	76	76	76	75	75	75	74	74
F = 0.2 F_{MSY}	93	90	88	85	83	82	80	79	78	77	76	75	75	74	73	73	72	72	71	71	70	70	70	69	69	69	68	68	68	68	67
F = 0.3 F_{MSY}	87	83	81	78	77	75	74	73	72	71	70	70	69	68	68	67	67	67	66	66	66	65	65	65	64	64	64	64	64	63	63
F = 0.4 F_{MSY}	80	77	74	73	71	70	69	68	67	66	66	65	65	64	64	63	63	63	63	62	62	62	62	61	61	61	61	61	60	60	60
F = 0.5 F_{MSY}	74	71	69	67	66	65	64	64	63	63	62	62	61	61	61	60	60	60	60	59	59	59	59	59	58	58	58	58	58	58	58
F = 0.6 F_{MSY}	68	66	64	63	62	61	61	60	60	59	59	59	58	58	58	58	57	57	57	57	57	57	56	56	56	56	56	56	56	56	56
F = 0.7 F_{MSY}	63	61	60	59	59	58	58	57	57	57	56	56	56	56	55	55	55	55	55	55	55	55	55	54	54	54	54	54	54	54	54
F = 0.8 F_{MSY}	58	57	56	56	55	55	55	54	54	54	54	54	54	54	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	52
F = 0.9 F_{MSY}	54	53	53	53	53	52	52	52	52	52	52	52	52	52	52	52	52	51	51	51	51	51	51	51	51	51	51	51	51	51	51
F = F_{MSY}	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
F = 1.1 F_{MSY}	46	47	47	48	48	48	48	48	48	48	48	48	48	48	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
F = 1.2 F_{MSY}	43	44	45	45	46	46	46	46	46	47	47	47	47	47	47	47	47	47	47	48	48	48	48	48	48	48	48	48	48	48	48

P(Bt>Bmsy & Ft<Fmsy)	Year																													
Fishing mortality	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
F = 0	24	27	29	31	34	36	38	41	43	45	47	49	51	53	54	56	57	59	60	61	63	64	65	66	66	67	68	69	69	70	70
F = 0.1 F_{MSY}	24	27	29	31	33	35	37	39	41	43	45	47	49	50	52	54	55	56	58	59	60	61	62	63	64	65	65	66	67	67	68
F = 0.2 F_{MSY}	24	26	28	30	32	34	36	38	39	41	43	45	46	48	49	51	52	53	54	56	57	58	59	60	60	61	62	63	63	64	65
F = 0.3 F_{MSY}	24	26	27	29	31	32	34	36	37	39	40	42	43	45	46	48	49	50	51	52	53	54	55	56	57	58	59	59	60	61	61
F = 0.4 F_{MSY}	23	25	26	28	29	31	32	34	35	37	38	39	41	42	43	45	46	47	48	49	50	51	52	53	54	55	55	56	57	57	58
F = 0.5 F_{MSY}	23	24	25	26	28	29	30	32	33	34	36	37	38	40	41	42	43	44	45	46	47	48	49	50	50	51	52	53	53	54	54
F = 0.6 F_{MSY}	22	23	24	25	26	27	29	30	31	32	34	35	36	37	38	39	40	41	42	43	44	45	46	46	47	48	49	49	50	50	51
F = 0.7 F_{MSY}	21	22	23	24	25	26	27	28	29	31	32	33	34	35	36	37	38	39	39	40	41	42	43	43	44	45	45	46	46	47	47
F = 0.8 F_{MSY}	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	34	35	36	37	38	38	39	40	40	41	41	42	42	43	43	44
F = 0.9 F_{MSY}	20	20	21	21	22	23	24	25	26	27	28	29	30	31	31	32	33	34	34	35	35	36	37	37	38	38	39	39	39	40	40
F = F_{MSY}	19	19	20	20	21	22	23	24	25	26	26	27	28	29	29	30	31	31	32	32	33	33	34	34	35	35	35	36	36	36	37
F = 1.1 F_{MSY}	18	18	19	19	20	21	22	23	23	24	25	26	26	27	27	28	28	29	29	30	30	31	31	31	32	32	32	33	33	33	33
F = 1.2 F_{MSY}	17	17	18	18	19	20	21	21	22	23	23	24	24	25	25	26	26	27	27	27	28	28	28	29	29	29	29	30	30	30	30

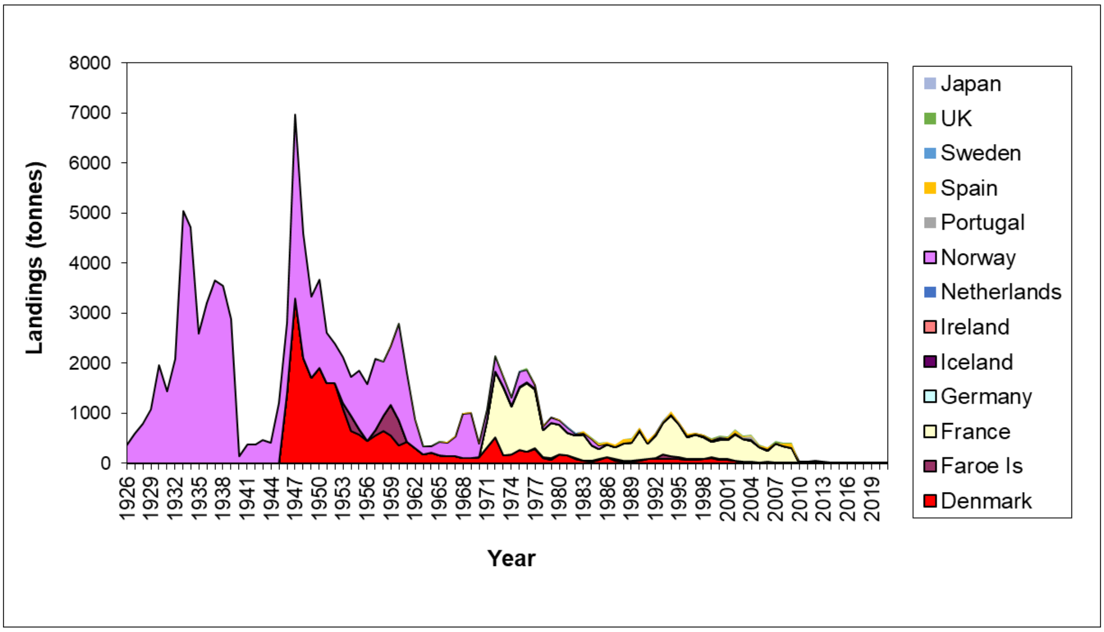

Figure 6.1. Porbeagle in the Northeast Atlantic. Working Group estimates of longer-term trend in landings of porbeagle in the Northeast Atlantic (1926–2021).

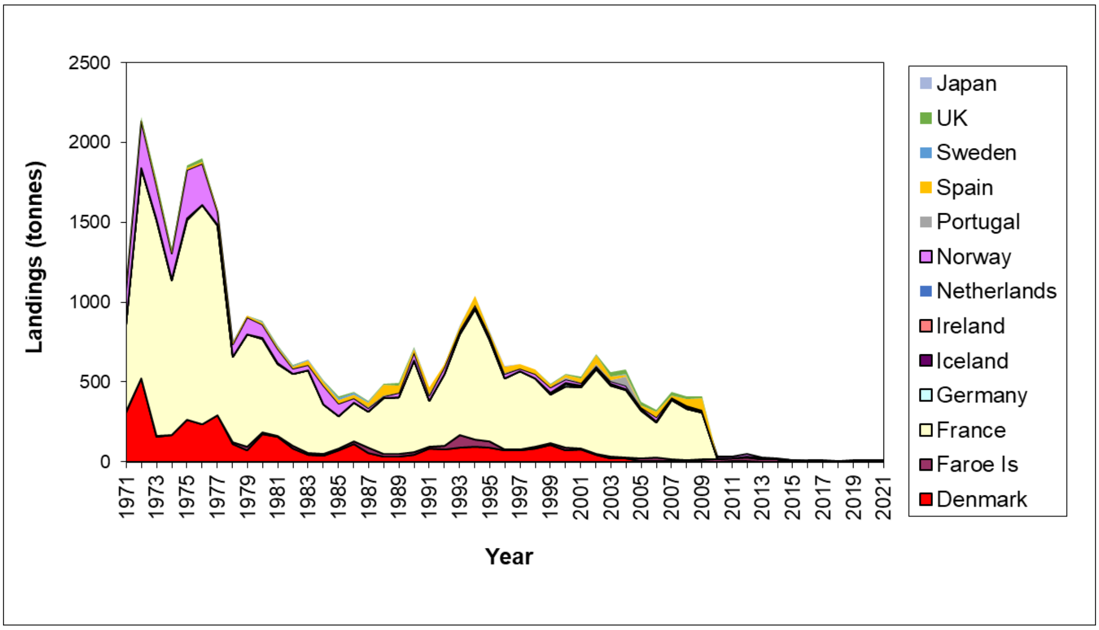

Figure 6.2. Porbeagle in the Northeast Atlantic. Working Group estimates of landings of porbeagle in the Northeast Atlantic for 1971–2021 by country.

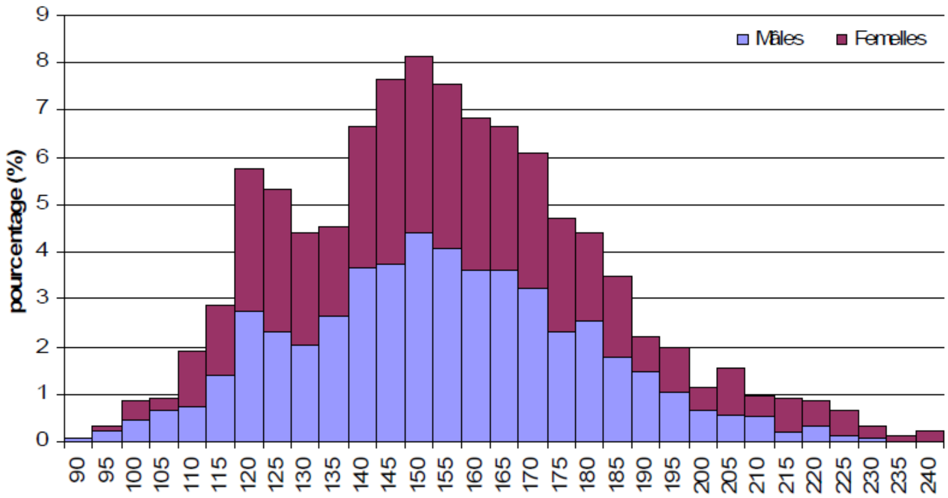

Figure 6.3. Porbeagle in the Northeast Atlantic. Length–frequency distribution of the landings of the Ile d'Yeu target fishery for porbeagle (2008–2009; n = 1769). Source: Hennache and Jung (2010).

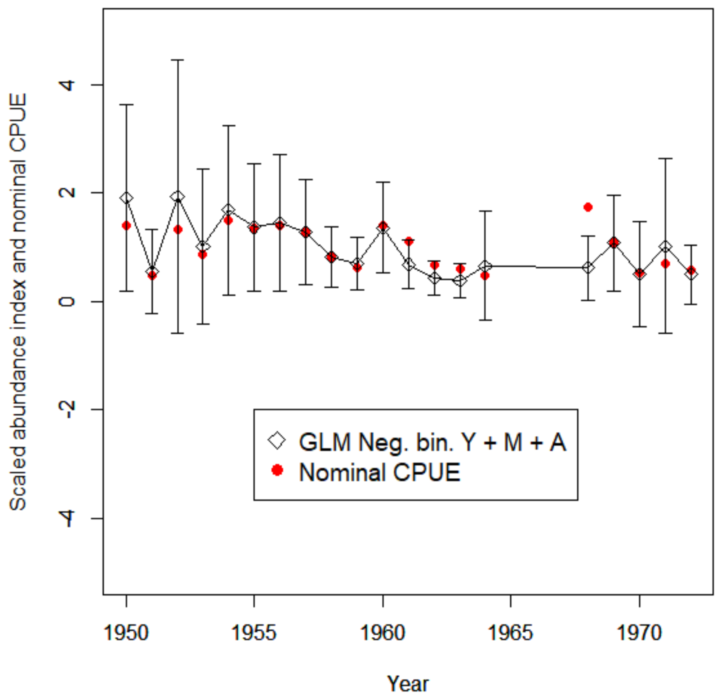

Figure 6.4. Porbeagle in the Northeast Atlantic. Relative abundance annual indices (± SE) provided by the standardization of CPUE of five longliners of the Norwegian directed fishery (with a GLM using a negative bi-nomial error distribution with a log link; variables included: year, month and area) with the nominal CPUEs (both scaled by the mean). Source: ICES 2022.

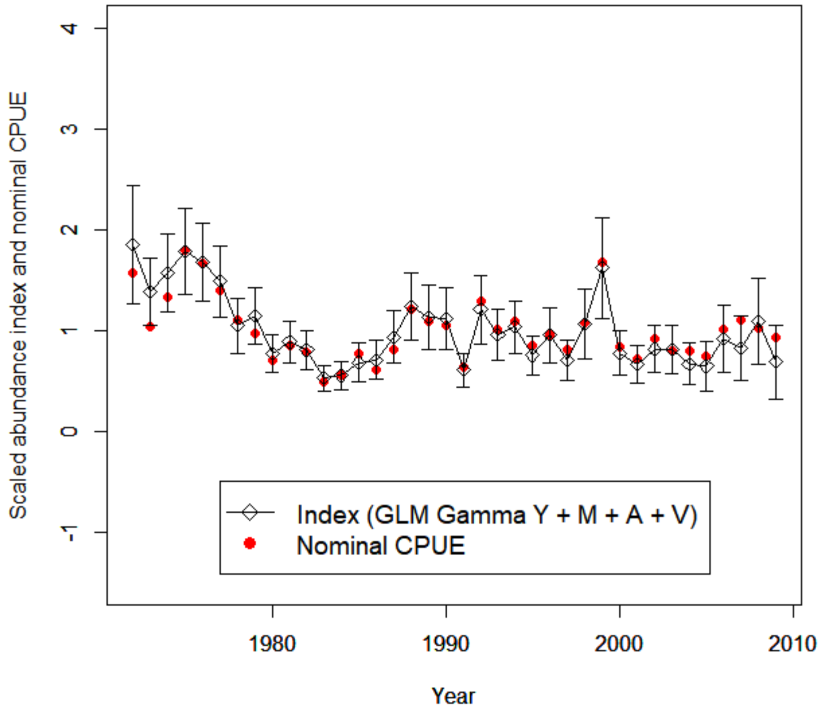

Figure 6.5. Porbeagle in the Northeast Atlantic. Relative abundance annual indices (± SE) provided by the standardization of CPUE of 19 longliners of the French directed fishery (with a GLM using Gamma error distribution with a log link; variables included: year, month, area and vessel) with the nominal CPUEs (both scaled by the mean). Source: ICES, 2022.

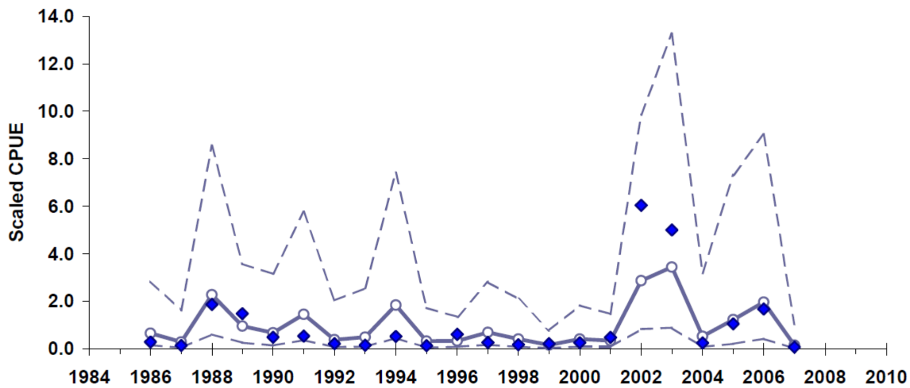

Figure 6.6. Porbeagle in the Northeast Atlantic. Relative abundance annual indices provided by the standardization of CPUE of the Spanish surface longline fishery targeting swordfish (with a GLM using delta-lognormal error distribution; variables included: year, zone, quarter, bait, year*zone, year*quarter) with confidence limits and the nominal CPUEs (blue rhombuses, scaled by the mean as the indices). Source: Mejuto *et al.*, 2009.

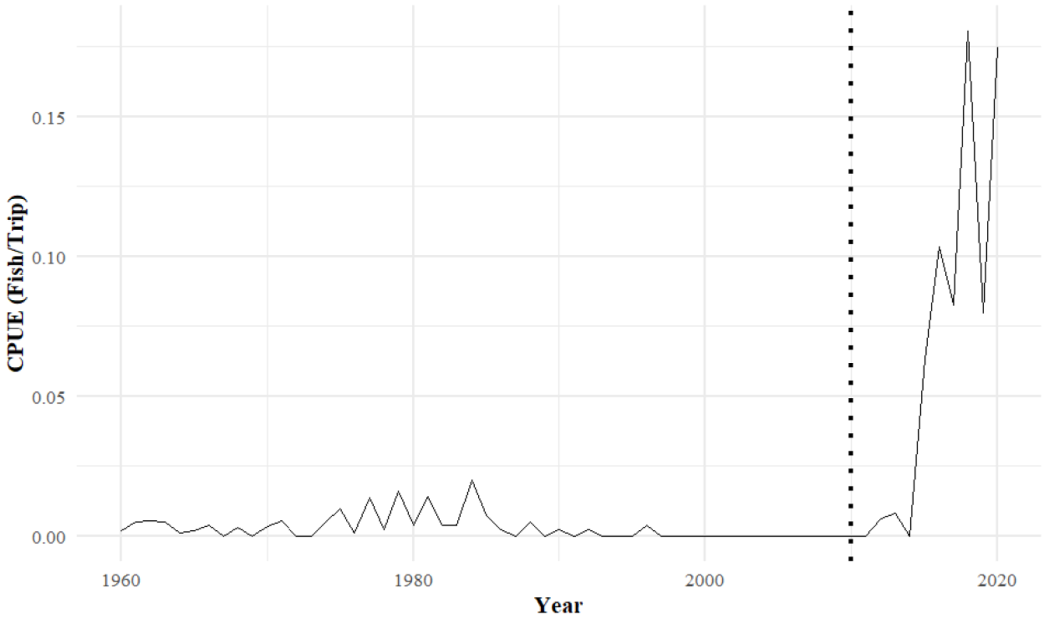

Figure 6.7. Porbeagle in the Northeast Atlantic. Temporal trends in CPUE (fish/ trip) of the UK recreational fishery in ICES Division 7e from 1960 to 2020 (n=478). Vertical dotted line represents imposition of zero TAC for the species by the EU. Source: Jones *at al.*, 2020.

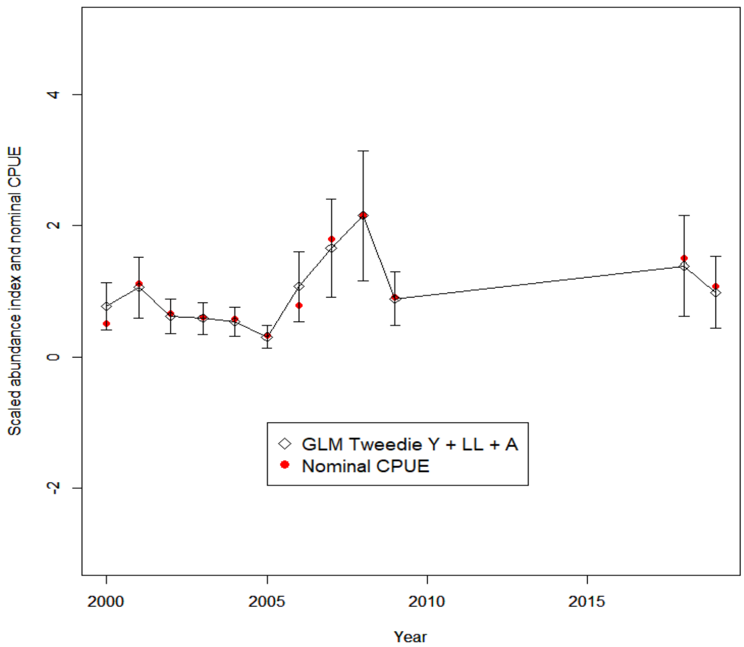

Figure 6.8. Porbeagle in the Northeast Atlantic. Relative abundance annual indices (± SE) provided by the standardization of CPUE of the composite survey CPUEs (with a GLM using Tweedie error distribution with a log link; variables included: year, type of longline and area) with the nominal CPUEs (both scaled by the mean). Source: ICES, 2022.

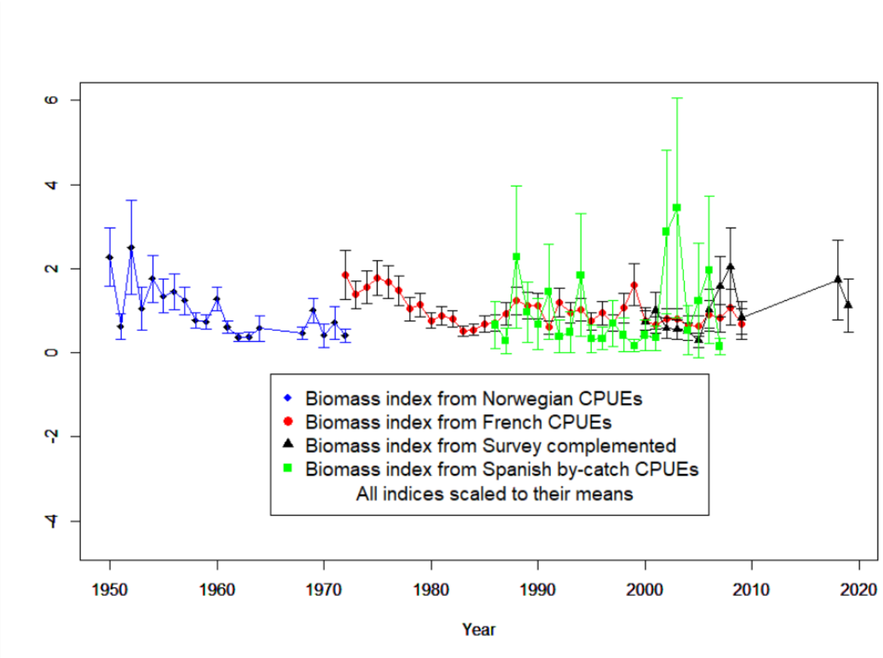

Figure 6.9: Porbeagle in the Northeast Atlantic. Relative biomass indices used in the porbeagle SPiCT assessments provided by the standardization of the four available CPUEs series. Source: ICES, 2022.

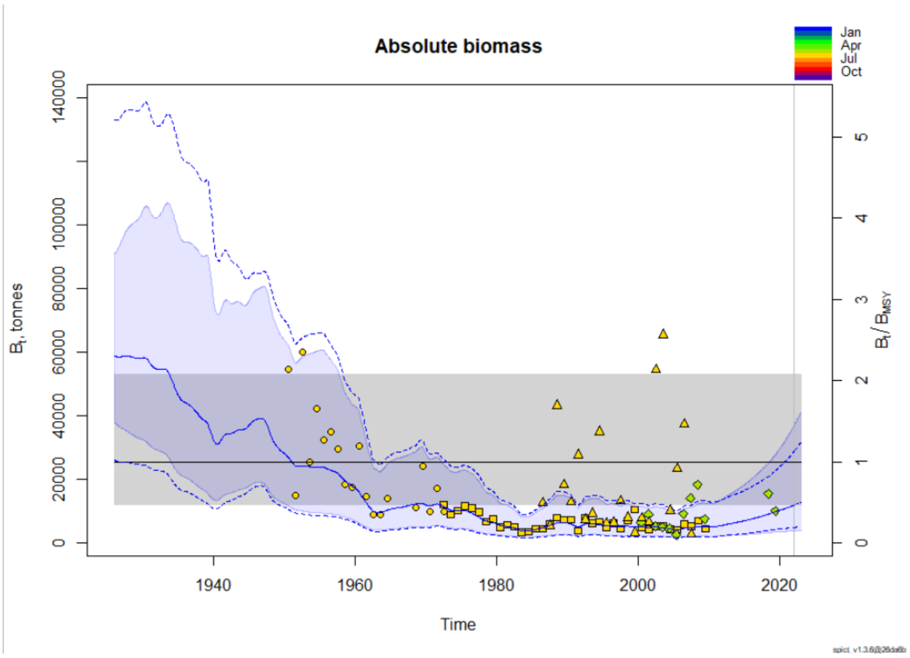

Figure 6.10: Porbeagle in the Northeast Atlantic. Absolute and relative biomasses from the SPiCT assessment.

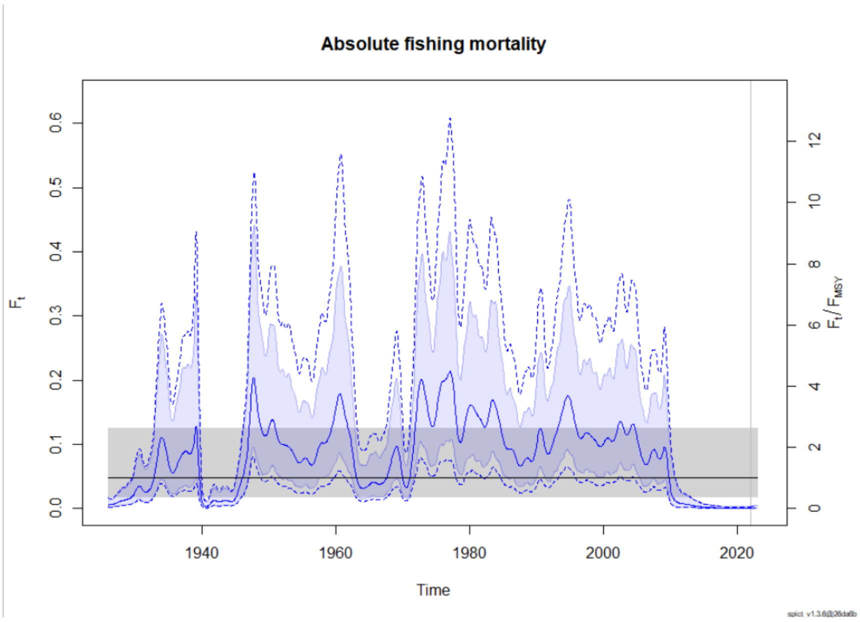

Figure 6.11: Porbeagle in the Northeast Atlantic. Absolute and relative fishing mortalities from the SPiCT assessment.

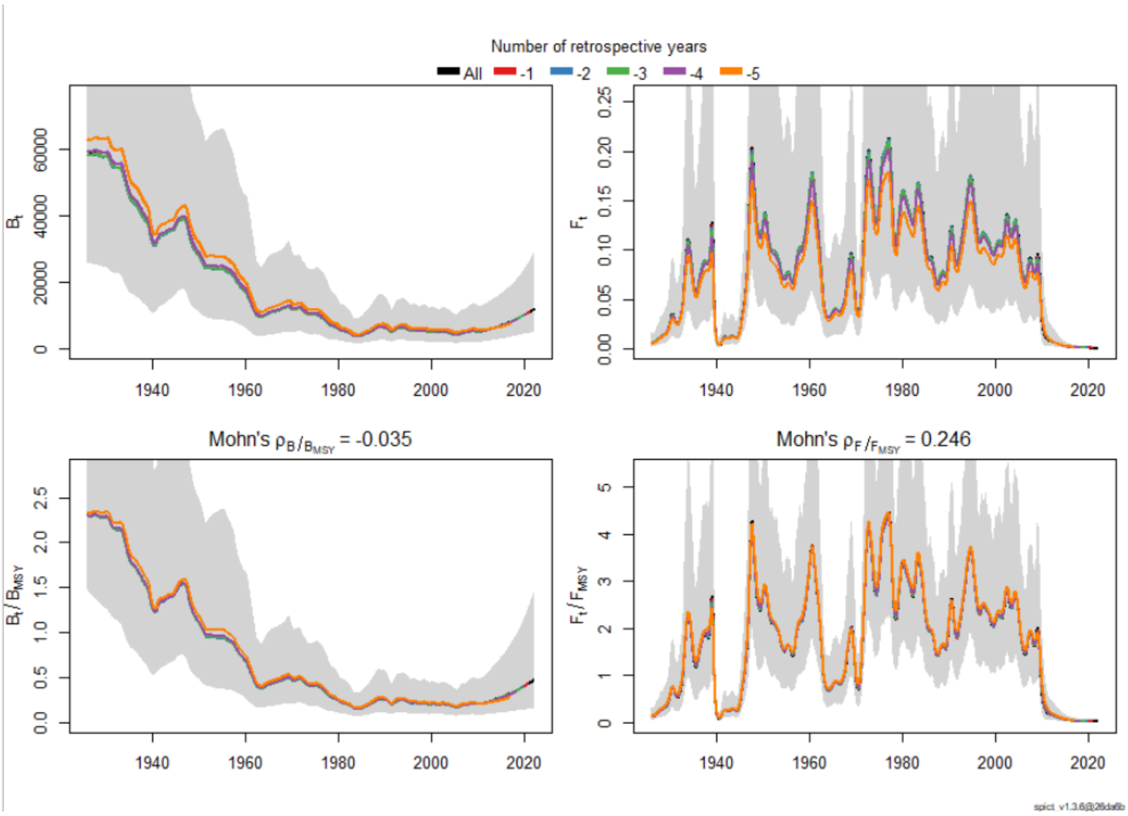

Figure 6.12: Porbeagle in the Northeast Atlantic. Retrospective plots from the SPiCT assessment.