REPORT OF THE 2020 PORBEAGLE SHARK STOCK ASSESSMENT MEETING
(Online, 15-22 June2020)

The results, conclusions and recommendations contained in this Report only reflect the view of the Sharks Species Group. Therefore, these should be considered preliminary until the SCRS adopts them at its annual Plenary meeting and the Commission revise them at its Annual meeting. Accordingly, ICCAT reserves the right to comment, object and endorse this Report, until it is finally adopted by the Commission.

1. Opening, adoption of agenda and meeting arrangements

The Chair opened the meeting by expressing his gratitude for attendees' interest and participation. He reminded the Group that the meeting's objectives were to assemble and review all available information on porbeagle sharks, assess the status of porbeagle sharks, and update any information from research projects. On behalf of the Executive Secretary the Assistant Executive Secretary welcomed the participants. The Group agreed to adopt the agenda (**Appendix 1**). The list of participants is included in **Appendix 2**. The list of papers and presentations is in **Appendix 3** and the abstracts provided by the authors are in **Appendix 4**.

Rapporteurs were assigned to the agenda sections as follows:

Sections	*Rapporteur*
Item 1	N.G. Taylor
Item 2	J. Carlson, A. Domingo, C. Palma, M. Ortiz, Y. Semba, R. Forselledo, C. Santos, R. Coelho, F. Mas
Item 3	E. Cortes, X. Zhang, H. Bowlby, L.G. Cardoso, and N.G. Taylor
Item 4	H. Bowlby, N.G. Taylor, E. Cortés, Y. Semba, E. Babcock
Item 5	A. Domingo, N. Duprey, and C. Brown
Item 6	E. Cortés
Item 7	R. Coelho
Item 8	N.G. Taylor

2. Summary of Available Data

2.1 Stock identity

The stock structure for porbeagle shark was addressed in 2009 at the joint ICCAT/ICES stock assessment. Data at that time supported the view of restricted movements between northeast and northwest Atlantic individuals. Therefore, it was concluded that in the North Atlantic there were two stocks. Regarding the South Atlantic, it was understood that there were two stocks, southwest and southeast, and that they both distributed up to 25° south latitude. At that time, the possibility was raised that both southern stocks would extend to bordering Oceans (Pacific and Indian), but that this possibility was not conclusive.

Since 2009, a number of mark-recapture, pop-off archival satellite tag (PSAT) studies have further examined the movements of porbeagle, particularly in the North Atlantic Ocean. Nearly all of the long-term satellite tagging (Campana *et al*., 2010a; Pade *et al*., 2009; Saunders *et al*., 2010; Biais *et al.,* 2017), conventional tagging (Kohler and Turner 2019) and survival tagging (J. Sulikowski, pers. comm.) support that porbeagle stocks in the northeast Atlantic are separate from the northwest, with the exclusion of a single tagged animal that moved from the NE to the NW (Cameron *et al.,* 2018). There is little tagging information from the South Atlantic. In addition to tagging studies, a study of genomic DNA from 224 individuals suggests there is strong genetic subdivision between the North Atlantic and Southern Hemisphere populations, but found no differentiation within these hemispheres (Testerman, 2014). New information derived from fishery and research data from the Atlantic, Pacific and Indian Oceans indicates that there is a continuous distribution of the species in the three oceans and that it ranges from 20° to 60° south latitude (Semba *et al.,* 2013).

Overall, recent satellite and long-term conventional tagging studies suggest that there are separate stocks in the eastern and western North Atlantic with limited mixing. While Testerman (2014) found no genetic evidence for differentiation between the eastern and western North Atlantic porbeagle stocks, it was noted that genetically there are only approximately 30 - 150 migrants per generation, or about 2 - 12 migrants per year, between the stocks. Testerman (2014) proposed that the Northern and Southern Hemisphere be managed as two separate, genetically distinct populations and, although no genetic differentiation was found between the northeast and northwest stocks, genetic recruitment between these areas is low and they should be considered as two stocks. There is insufficient data to define the appropriate number of stocks in the Southern Hemisphere.

SCRS/2020/073 presented information on porbeagle size from the North and South Atlantic and sporadic observations were recorded in eastern areas between 20° North to 20° South. These rare catches, made in different years, could extend the range of distribution regularly considered for this species. On the other hand, in an exercise carried out during the meeting, the Secretariat presented the information from Task 2 Catch and Effort, which also shows catches reported by some countries in that area, particularly Japan, in the most recent years. However, the Japanese scientist noted that these results must be verified because they are not based on research and observer data, and thus a potential range extension based on these data must be more thoroughly discussed before being accepted. Although both sources of information may suggest the occurrence of this species in tropical areas and some rare events in those inter-tropical eastern areas, further investigation is required. The Group understood that this information was very important. The authors pointed out that those records had been previously verified because some of them come from areas with high SSTs. However, the authors also indicated that those records are probably related to colder temperatures in the deeper layers because of upwelling-coastal events in the western African coast and the effect of the cold currents flowing along those areas, which manifests itself when studying the temperature profiles in relation to depth, in addition to high food availability in those areas. Although the distribution of this species is regularly linked to high latitudes and cold waters, the authors cautioned that SST or latitude is just a simplification and should not be the only variable considered to explain these rare events, particularly in those eastern Atlantic regions affected by deep cold waters and cold currents, which can serve as cold-water corridors from higher latitudes so that some individuals can sporadically reach lower latitudes than those most frequently and regularly described.

2.2 Catches

The Secretariat presented to the Group the most up to date ICCAT nominal catches (T1NC: Task 1 nominal catches) on porbeagle (POR). The full POR catch series, historically classified geographically with three main Task 1 regions (NORT: North Atlantic; SOUT: South Atlantic; MEDI: Mediterranean Sea), was finally split into the four POR Atlantic stocks using the ICCAT billfish sampling areas (**Figure 1**) with the following association table:

POR stock	***Sampling areas (BIL only)***	***Task 1 area (optional)***
POR-NE (Atlantic Northeast)	BIL94B, BIL94C	NE, AZORES, CANA, CVER, ETRO
POR-NW (Atlantic Northwest)	BIL91, BIL92, BIL93, BIL94A	NW, GOFM, WTRO
POR-SE (Atlantic Southeast)	BIL97	SE
POR-SW (Atlantic Southwest)	BIL96	SW
**POR-MD (Mediterranean)*	BIL95	MEDI

*The Mediterranean catch series (mostly Italy and Malta) were left apart (outside the POR-NE stock), following the same approach used in shortfin mako (SMA) and blue shark (BSH).

For yearly catches without billfish sampling areas and having the already discontinued Task 1 areas "NORT" and "SOUT" (less than 2% of the entire catch series between 1926 and 2018, affecting in its majority the earliest years), the split into stocks was performed using proportions obtained from the closest year (NORT split into NE and NW, and, SOUT split into SE and SW). The BIL sampling area adopted on each split was the largest one: NE (BIL94B); NW (BIL94A); SE (BIL97); SW (BIL96). This allocation criterion should be revised in the future, or by the respective CPCs, or when more detailed and complete Task 2 (catch and effort) information containing POR catches is recovered.

No new SCRS documents with information on POR T1NC were presented to the Group. Therefore, the differences are minimal when comparing the current POR catch series with the catch series adopted at the SCRS 2019 Annual meeting. These modifications are majorly due to late reports of revisions made by ICCAT CPCs after September 2019.

Due to time constraints, the improvements made during the meeting to T1NC in terms of catch recoveries and gap completion were small and only limited to the two Atlantic western stocks (POR-NW and POR-SW).

Northwest stock:

As per request of the Group, the Secretariat used an alternative approach to the one used in Anon. (2009) to estimate non-reported catches (landings and dead discards) for CPCs that did not reported landings and or dead discards in the period 2008-2018, and that reported catches of porbeagle shark prior to 2008. The Group noted that reporting of dead discards continues to be very limited and some landings could remain unreported.

The catch estimation focused only on longline fisheries for the period 2008-2018, using T1NC and EFFDIS (nominal effort distribution, Taylor *et al*., *in press*) datasets to:

i. Obtain yearly based average nominal catch rates for both landings (L) and dead discards (DD), respectively CPUE(L) and CPUE(DD).

ii. For CPUE(L), use only USA and Japan catches of POR as by-catch (excluded Canada as being a POR target fishery in the period 2008-2013).

iii. And for CPUE(DD), use Canada and USA.

iv. Each CPUE series was then multiplied by the estimated number of hooks (on all the 5x5 degree squares of POR-NW stock) of each longline fleet that has historical T1NC of POR for the NW stock.

v. The estimated series for flags with EFFDIS were:
   - L series: Barbados, Chinese Taipei, Japan, Korea Rep., and Venezuela
   - DD series: Barbados, Chinese Taipei, Japan, Korea Rep., and Venezuela

vi. No estimations were made for longline fleets without EFFDIS (Faroe Islands, France (SPM), Cuba, Norway). These fleets did not have EFFDIS possibly because they were not actively fishing between 2008 and 2018; Faroe Island is not an ICCAT CPC.

vii. For the 2 years of USA without reported DD (2009 and 2012), DD were estimated as the average of the two prior years for 2012, and the two subsequent years for 2009.

This approach assumes that longline fleets with historical catches prior to 2008 in the POR-NW stock would have catch rates of POR similar to the longline fleets of USA and Japan (non-target fisheries), and/or dead discards (Canada, USA) if actively fishing after 2008, unless proven otherwise. This approach is preliminary because the index of a fleet that occurs within POR habitat is multiplied by the effort of a fleet occurring outside POR habitat (e.g., Venezuela, Barbados, and some Chinese Taipei fishing grounds) and thus further improvement is necessary to estimate both non-reported landings and dead discards.

Southwest stock:

The Uruguayan T1NC longline series (1981-2001) reconstructed using the catch ratio approach (see report: WG-SHK 2019) and not included in 2019 was finally added to the Task 1 database. This series was already adopted by the Group at that meeting.

Overall:

The new estimates from non-reporting fleets are presented in **Table 1**. The final overall T1NC by stock, gear and year, are presented in **Table 2** and **Figure 2. Figure 3** shows differences in catches of POR-NW before and after the new estimations.

The Group adopted these new estimates (**Table 1**) as preliminary SCRS estimations for POR-NW and agreed that they represent the best SCRS scientific estimations for Atlantic POR total removals by stock within the timeframe allowed. By convention, all the SCRS preliminary estimations added to Task 1 should be replaced in the future by the corresponding official CPC estimates.

The Group also recognized that landings and dead discard estimates need to be further reviewed in the future to improve them due to the reasons described above. Due to time constraints it was not possible to perform this review at the meeting, highlighting the importance of holding Data Preparatory meetings, especially for stocks that have poor reporting of landings and/or dead discards such as pelagic sharks. It is therefore recommended that a Data Preparatory meeting be held for the next porbeagle assessment process in order to allow sufficient time to review and update total removal estimates.

The Group also recognized the importance of having post-release mortality of live releases of the POR-NW associated with fishing activities, particularly under the current management regulations [Rec 15-06 pg 1]. Previous and recent studies (Campana *et al.,* 2016, Anderson *et al.,* 2019) have reported post-release mortality rates to the order of 17% (ranging from 6.7% to 27.2%). The lack of official reports on live releases (DL) (only Canada has reported DL between 2015 and 2018) hindered the ability to estimate the post-release mortality component with reasonable confidence. However, the post-release mortality component should be considered in the future, particularly because discard amounts are expected to be higher than landings at present.

2.3 Indices of abundance

SCRS/2020/084 presented the results of an indicator analysis for the western North Atlantic population of porbeagle based on Japanese longline observer data between 2000 and 2018. The analysis included the description of the spatio-temporal change in effort, CPUE (catch in number per 1,000 hooks), and gear deployment, the estimation of an abundance index, and the trend in size and sex ratio in a limited area. Longline sets targeting Atlantic bluefin tuna showed strong seasonality and inter-annual variability in the operation area. The estimated annual trend of abundance was close to that of the nominal CPUE and was stable between 2000 and 2014 at a low level of < 1.0 shark per 1,000 hooks, but showed an increasing trend from 2014 to 2018. Size data analysis suggested that juveniles dominated in both sexes and that sex ratios were approximately even throughout the years analyzed. Median and mean body length became smaller (<1m PCL) in recent years with increasing CPUE, compared to those in the preceding years. Although these trends were obtained based on limited geographic areas and thus careful consideration is necessary, the resulting time series suggests the possibility of increasing trends of abundance and young fish since the mid-2010s.

The Group commented that the Canadian fleets changed their area of operation, which affected where porbeagles were caught. Changes in oceanographic conditions as well as fleet behavior for vessels targeting swordfish have led to a substantial reduction of porbeagle CPUE from this fleet. However, a similar reduction in CPUE was not seen from the Japanese fleet targeting bluefin tuna. Also, the shift in operation area of the Japanese fleet was mainly due to increased efficiency of operations for Atlantic bluefin tuna, not to a shift in target species. The author noted that the effect of oceanographic conditions was not considered in the analysis. It was also clarified that the increase in the Japanese CPUE after 2015 was not only caused by large catches in a few sets, but also by constant catch in each set.

SCRS/P/2020/035 presented a standardized CPUE of porbeagle shark caught by Uruguayan longliners in the southwestern Atlantic Ocean between 1982 and 2012. The Uruguayan tuna fleet can be divided into two well-defined periods: 1982-1992 Japanese-style longline (deep sets) and 1993-2012 American-style longline (shallow sets). Standardization analyses were performed using Generalized Additive Mixed Models and splitting the time series in these two periods. Results of the GAMM models show the important effect of *Sea Surface Temperature* (*SST*) and *Latitude* on porbeagle catches. The first period presented higher standardized CPUE values, suggesting that fishing method factors such as set depth or bait type may have an effect on porbeagle catch rates.

Comments following the presentation were mainly related to the importance of environmental variables on porbeagle catches. The fact that *SST* and *Latitude* might be confounded variables was mentioned. This aspect was discussed before the analysis and the authors decided to use it either way as the environmental conditions of the area of fleet operation are very variable throughout the year, depending on the influence of the warm Brazil current and the cold Falkland/Malvinas current.

SCRS/P/2020/037 presented preliminary results and analyses of the Canadian fishery-independent longline survey directed at porbeagle. A spatially-implicit hurdle model that incorporated environmental effects suggested that porbeagle distribution has become more diffuse (less concentrated along the shelf edge) and that abundance has declined from 2007 to 2017. The strong abundance decline is contrary to predictions from the model used in the 2020 assessment (SCRS/2020/096), as well as the CPUE trends from Japan (SCRS/2020/084).Variability in catch rates was unacceptably high from this fixed-station design and catches may have been related to a predictor variable that was not considered. These results were provided as an example of why a survey may not index abundance for a pelagic shark like porbeagle.

After the presentation, some more operational details of the surveys were requested, such as a description of the gear, depth of operation, and time of year. For this last point, it was mentioned that there was a short time window to complete the surveys, due to operational issues, but that the campaigns started in mid-June and lasted 3 weeks. In response to a question regarding the population component of porbeagle sampled each year, the authors said that slight variations in size and sex composition were observed between surveys. In response to a question of whether other species captured on the survey showed the same decline, the authors mentioned that it was not possible to evaluate because captures of the other species were too low. The authors remarked that this presentation was given as information, and that there was no intention to use this as an abundance index or to include the results in the current assessment.

2.4 Life History

SCRS/2020/090 presented vital rates for the western North Atlantic population and the South Atlantic population of porbeagle shark, as well as several parameters of interest that can be used as inputs to other models like the intrinsic rate of population increase (r_{max}), the maximum lifetime reproductive rate ($\hat{\alpha}$), the spawning potential ratio at maximum excess recruitment (SPR_{MER}), and generation time. Values of these parameters were obtained deterministically through six methods and a stochastic simulation was performed with the Leslie matrix approach. For the western North Atlantic, the simulation scenario that considered an annual or biennial reproductive cycle as equally probable was deemed the most plausible, implying values of r_{max} = 0.059, $\hat{\alpha}$ = 3.22, and SPR_{MER} = 0.56. Information for the South Atlantic was very scarce and thus published values for the South Pacific had to be used for most life history inputs. As incorporation of those values in the simulation led to several estimated parameters being out of bounds/undefined, the deterministic scenario that assumed an annual reproductive cycle and a longevity obtained through bomb radiocarbon was deemed the most plausible, implying values of r_{max} = 0.059, $\hat{\alpha}$ = 3.253, and SPR_{MER} = 0.55.

It was noted that the methods used to derive estimates of r_{max} in this work were consistent with those used in the 2009 porbeagle stock assessment (Anon. 2010). It was also asked if the individual values for each parameter estimated in the stochastic simulation approach were available for potential use in the MSE analysis, in response to which it was noted that the original code had been modified for use in the ICM and the values were thus available. In all, the Group agreed to use the parameters recommended in SCRS/2020/090 for the western North Atlantic and the South Atlantic for the different assessment approaches.

2.5. Length compositions

SCRS/2020/097 presented information on size and sex distribution of porbeagle sharks collected by fishery observers from several longline fleets in the Atlantic (EU-Portugal, Canada, Japan, Namibia, South Africa, Uruguay and the USA). A total of 26,404 porbeagle shark records collected between 1992 and 2019 were compiled and analyzed, including region-specific size distributions and time series. Sex-ratios were also analyzed over regions and seasons.

The Group noted that in recent years the sample sizes (N) of measured specimens are small, so in those years the time series are not so representative. In the specific case of the SW, there is a large increase in sizes in recent years, but it was only due to low sample size in some of the years, while there are years without any measured specimens. For the NW, the authors pointed out that the sharp increase in sizes in 2019 was due to the catch of a few large-sized specimens close to the stock limit longitude in the North Atlantic.

Given such low sample size in some years, the Group recommended caution in interpretation and conclusions drawn from the size trends in the time series. Specifically, for the Southern Hemisphere this analysis was split into SW and SE areas, and it was mentioned that one idea could be to combine the time series of those two regions into one single series.

It was clarified that the data used in the paper comes from scientific observers on commercial longline vessels and scientific surveys. In the specific case of Canada, the majority of data collected prior to 2005 comes from sampling on vessels that were targeting porbeagle sharks, while for the other fleets it is mostly bycatch from longlines targeting tuna and tuna like species.

The Group noted the difference in sizes between the catches of USA and Canadian vessels that operate in a similar area, with Canada catches comprised by larger specimens compared to the USA. One possibility is related to differences in seasonality from the two components of the Canadian fishery; prior to 2013 when targeting POR, fishing used to take place from early spring until late October and tended to catch larger specimens. In more recent years, the catch comes mostly from bycatch in more coastal waters and tends to catch smaller specimens closer to the coast. Also, the Group questioned if the type of hook used in the USA and Canadian pelagic longline fisheries was similar, and it was clarified that both fleets operate with circle hooks.

It was further noted that gear configuration in Canada also changed from when the fishery was directed at porbeagle to more recent years when it is directed at swordfish. The fleet is still composed of the same fishing vessels operating in the same general region, but the fishing strategy changed over time and that could have contributed to having mostly smaller specimens in recent years. It was noted that for the SAFE analysis the data used was only from 2010 onwards (when several regulations started in multiple countries), so that approach uses mostly data from when most vessels were already targeting SWO.

The Group also noted that in the specific case of Canada where there was this change in target, it could be interesting to explore the size distribution of those two components of the fleet separately. Results were subsequently presented to the Group from a comparison of the size distribution by decade (1990s, 2000s and 2010 onwards) from the two components of the fleet. No differences in the size distribution of captures was evident.

SCRS/2020/073 provided size observations of porbeagle recovered from scientific records in the Spanish longline fishery targeting swordfish in the Atlantic Ocean for the period 1987-2017. For the northern zones, the analysis of data showed stability of mean length throughout the time series, a very stable range of mean values and very few differences between sexes. The data suggest that a small fraction of the individuals is available in the oceanic areas where this fleet regularly fishes and that some individuals could sporadically reach some intertropical areas of the Atlantic.

The authors clarified that the Spanish longline fleet where this data comes from targets swordfish and operates year-round, not just in a specific seasonal pattern. This fleet has sporadically caught some porbeagle as a very low bycatch.

The Group noted that there are some sporadic catches between 20°S and 20°N, in areas that might represent an extension of the POR distribution range. It was also noted that most of the sizes between 20°S and 20°N are from specimens with undetermined sex over different years.

The Secretariat split and showed the catch and effort data by region and showed that there are some records of catches between 20°N and 20°S in the ICCAT CE database. It was noted that in some cases those catches would be close to the 20°N or 20° S limits, but there are also some data closer to the equator. A further request was made for the Secretariat to produce a map between 20°N and 20°S at 5° x 5° resolution showing POR presence information from ICCAT databases.

It was noted that when POR are very small, species identification is problematic and there is a possibility of confusing POR with shortfin makos. It was further noted that while the ICCAT CE data is likely mostly coming from logbooks, size data is mostly coming from observer data with a much higher degree of reliability for species ID. After the Group requested that records close to the equator be further scrutinized, the scientists from EU-Spain clarified that the data used in SCRS/2020/073 were collected in different years and reported from different sources, such as highly qualified onboard scientists and also some collaborative skippers. The authors dismissed potential misidentification of porbeagle individuals as shortfin makos after a thorough review of the data from the different sources.

2.6 Other Relevant Data

SCRS/P/2020/034 presented information regarding porbeagle shark hooking mortality on longline fishing vessels operating in the southwestern Atlantic. Data used in the analysis came from scientific observers onboard Uruguayan longline fishing vessels and also Japanese longliners operating within the Uruguayan EEZ. A Generalized Additive Mixed Model (GAMM) was fitted considering biological, environmental, and operational covariates. Results showed that deep longline sets had lower hooking mortality compared to shallow sets. Size, sea surface temperature and sex were also significant covariates, with hooking mortality increasing with size and temperature, and being lower in females compared to males. The authors suggested that the differences observed in hooking mortality between deep and shallow sets could be related to the length of the branch lines. Japanese vessels have longer branch-lines that could provide a less restricted movement for caught individuals. On the other hand, the shorter branch-lines of the Uruguayan fleet could restrict movement to an extent that might limit the individual's capacity to ventilate properly, ultimately decreasing their chances of survival. Even though the authors acknowledge that soak time was an important variable to be included, they discussed the issues associated with using the available soak time data and how it affected the model performance and rendered inconsistent results. Finally, the authors mentioned some alternatives that could be incorporated in future work in order to include this variable in a more meaningful way (i.e. hook timers, temperature depth recorders).

3. Assessment Methods and Results

3.1. Sustainability Assessment for Fishing Effects (SAFE)

SCRS/2020/100 described how distribution information for the northern and southern porbeagle stocks was evaluated relative to fishing effort to determine the extent of geographical overlap between the species with commercial longline fishing activity. The amount of overlap is called 'availability' and is one of the inputs to the Sustainability Assessment for Fishing Effects (SAFE) quantitative ecological risk assessment (ERA). To describe porbeagle distribution in the previous assessment, spatial information for the North and South Atlantic came from the IUCN. For this assessment, the distribution of porbeagle in the northwest Atlantic was extended using substantial new information on occurrences from commercial catch data as well as satellite tagging. Distribution in the South Atlantic was still described from the IUCN data. It was not possible to consider the relative density of porbeagle in different regions of the North or South Atlantic, so the spatial extent of their distribution encompassed all areas with at least one occurrence of porbeagle (presence/absence data). To characterize the spatial distribution of fishing effort, the sum of the number of hooks at a 5-degree spatial resolution was transformed into a raster grid. Effort was summed from the specific fleets that had contributed data to other components of the ERA, giving an aggregate effort distribution in the North and South Atlantic. Availability was calculated as the area of the effort distribution that overlaps with porbeagle distribution divided by the total area of porbeagle distribution in the North and South Atlantic, respectively (called Type 1 in the manuscript). Biologically, this calculation represents the proportion of the porbeagle population that is accessible to fishing activity. Three other metrics of overlap were calculated as well, representing the amount of fishing activity that overlapped with porbeagle divided by the total amount of effort (called Type 2 in the manuscript). This represents the proportion of fishing activity that has the potential to catch porbeagle. Estimates markedly changed when effort was characterized as presence/absence, or as a relative magnitude from Task 2 reporting (T2CE), or EFFDIS estimates of total effort.

There was ensuing discussion about how the new species distribution data obtained from electronic tagging was added to the IUCN species distribution shape file. In the case of the data presented by Spain in SCRS/2020/073 that show the occurrence of porbeagle in tropical regions (between south of 20° North and north of 20° South), while it is desirable to include the new available data since they substantially expand the prevailing species distribution range from IUCN, the Group concluded that they should be thoroughly investigated before being used.

There was also discussion about how to best consolidate the IUCN smooth species distribution shape file with the 5° x 5° degree square effort file and 5° x 5° spatial raster grids. The IUCN smooth species distribution shape file does not include land and therefore some grids along the coast would not be 5° x 5°, whereas the 5° x 5° square effort file and spatial raster grids include land (i.e. the entire area within the grid square). A question was then asked about the best way to treat these coastal grids when calculating the area overlap ratio of effort and species distribution for the SAFE availability component. It was noted that the effort data represented centroids and needed to be shifted by adding a 2.5° offset to the centroid of the 5° x 5° square in the North and shifting down 2.5° in the South. In response to these comments, this modification was introduced, and effort data are now represented by centroids where every point has its own 5° x 5° square. These shifts moderately increased the previous SAFE availability estimates.

It was also noted that, while availability for the South Atlantic was calculated with respect to the distribution of the species in the entire Southern hemisphere, it would be desirable to calculate availability in relation to the species distribution in the South Atlantic only. Thus, the southern distribution was restricted to the ICCAT Convention area, encompassing -70° to 20° degrees longitude.

All effort data was shifted to represent centroids and POR distribution for the southern stock was restricted to the South Atlantic in an updated analysis. For consistency with the effort centroids, the species distribution in the South was also put on a 5° spatial scale. As a result, availability in the North Atlantic increased marginally from 0.53 to 0.59, but increased markedly in the South Atlantic from 0.11 to 0.49.

It was also noted that using presence/absence data is a rough representation of the species distribution because it assumes uniform occurrence of the species throughout its range. However, this is a data-poor assessment and there were not sufficient data to calculate relative species density as could be the case for a data-rich assessment.

It was also noted that, as was done for the 2012 ERA, it would be desirable to calculate availability separately for fleets that include both a shallow and deep-water component. It was also mentioned that it would be desirable to increase the current 5° x 5° spatial resolution when these data become available in the future.

SCRS/2020/099 presented a preliminary SAFE (Sustainability Assessment for Fishing Effects) of pelagic longlines in the North and South Atlantic. The approach calculates a proxy for fishing mortality as the product of four components: availability of the stock to the fleet(s), encounterability of the gear given the species vertical distribution, gear selectivity, and post-capture mortality. F values were compared to an F-based reference point (F_{MSY}) calculated based on the productivity (expressed as the maximum lifetime reproductive rate, $\hat{\alpha}$) estimated in SCRS/2020/090 (Cortés and Semba 2020) and F_{MSY}/M ratios from Cortés and Brooks (2018) to evaluate the overfishing status. Preliminary results suggested that porbeagle in the North and South Atlantic are not undergoing overfishing.

Description of the SAFE method

Susceptibility was computed quantitatively based on the SAFE approach as the product of four conditional probabilities (availability, encounterability, selectivity and post-capture mortality). Availability is the probability that the fleet will interact with the stock on the horizontal plane; encounterability is the probability that one unit of fishing effort will encounter the available stock; selectivity is the probability that the encountered population will actually be captured by the fishing gear; and post-capture mortality is the probability that the captured population will die.

The analysis included the fleets for which information from observer programs was made available. For the North Atlantic we used data from Canada, Japan, Portugal, and USA; and for the South Atlantic, information from Japan, Namibia, South Africa, and Uruguay. We limited the analysis to 2010-2018 because of the likely influence of management changes on catch rates, size compositions, and treatment and disposition of the catch.

Availability was calculated as the proportion of the spatial distribution of the pelagic longline fleet that overlaps that of the stock as has traditionally been done in previous ERAs. Spatial effort distribution was aggregated for all years to calculate a single availability metric at a 5° x 5° resolution (see Bowlby *et al.,* 2020; SCRS/2020/100 for more details on computation of availability IUCN (Global Marine Species Assessment) distribution maps were used to describe species distribution, with information from observer records, catch records, and archival (satellite) tagging augmenting the IUCN data in the northwest Atlantic. Distribution data were also aggregated at a 5° x 5° resolution to allow comparison with the effort distribution (Bowlby *et al.* 2020; SCRS/2020/100).

Encounterability was estimated as the degree of overlap between the depth distribution of the stock and that of the longline gear. To that end, we described the approximate depth distribution of the gear from each of the fleets included in the analysis. We then collated information on depth preference of porbeagle sharks tagged with archival satellite tags from several sources, including activities from the Shark Research and Data Collection Program (SRDCP), summarized as histograms of time at depth in 5 m bins during the day and night. Information was available from four sharks tagged in the northeast Atlantic (latitude ~ 47° N, longitude ~ 7° W; two females: 195 cm FL each; two males: 181-203 cm FL), from 18 sharks tagged in the northwest Atlantic (latitude ~ 42 to 44° N, longitude ~ -48 to -70° W; 13 females: 88-209 cm FL; three males: 95-127 cm FL; 2 sex unknown: 110-152 cm FL), and 1 animal tagged in the southwest Atlantic (latitude: -36.191, longitude:-52.850, tagged 7/3/2016, 181 cm FL mature male, 28 days with complete depth information at a sampling rate of 10 minutes). We combined the satellite tagging data from the northwest and northeast Atlantic to construct the porbeagle depth distribution histograms for the North Atlantic and data from the single, but detailed, southwest Atlantic shark for the South Atlantic. The final step was to calculate the overlap between the species distribution and that of the gear at night and during the day (day and night were defined with an algorithm that takes into account time, data, latitude, longitude, and nautical dusk and dawn in the specific region) and average them to obtain the daily probability of being encountered. For the Uruguayan fleet, encounterability was calculated as the mean of the values for the shallow and deep-water components. Overall encounterability was calculated as the mean of values for each individual fleet weighted by the proportional effort exerted by each fleet to the total effort by all fleets (from EFFDIS for 2010-2018).

Selectivity is size dependent by definition, and thus any attempt to produce a single value for a stock should be regarded as a crude approximation. Here, we estimated a "contact selectivity" (proportion of fish encountering the gear that are caught; Griffiths *et al*., 2018) by 1) obtaining a stable age distribution from a life table/Leslie matrix approach (Cortés and Semba 2020; SCRS/2020/090) and transforming it into a "stable length" distribution through the von Bertalanffy growth function separately for females and males (because the stable age/length distribution from the life table/Leslie matrix is only available for females, the female stable age distribution was assumed for males); 2) computing length-frequency distributions for females and males from 2010-2018 observer program data; 3) using these observed length-frequency distributions to estimate selectivity by eye, assuming a dome-shaped selectivity function; 4) computing a value of selectivity for each fleet as the sum of the products of the stable length distribution and the proportion selected at each length bin (doing this separately for females and males); 5) computing the overall selectivity for each fleet as the mean of the selectivity values for females and males (assuming females and males are equally abundant); and 6) computing a single value of selectivity for all fleets combined as the mean of selectivities for the individual fleets weighted by the proportional total catch of each fleet to the total catch of all fleets during 2010-2018 obtained from Task 1 (**Table 2**). In equation form, selectivity for each fleet f for females is:

$$Sel_{f,females} = \sum_{l=min}^{l=max} p_l \times s_{l=females}$$

and for males:

$$Sel_{f,males} = \sum_{l=min}^{l=max} p_l \times s_{l=males}$$

where p_l is the proportion of the population in each length interval from minimum to maximum length (equal for females and males), and $s_{l=females}$ and $s_{l=males}$ are the proportions in each length interval selected according to the fit of the selectivity curve to the observed data for females and males, respectively. The selectivity for each fleet is then computed as the average of $Sel_{f,females}$ and $Sel_{f,males}$.

For all fleets combined, selectivity was expressed as:

$$Sel_{all\ fleets} = \frac{\sum_{f=1}^{f=n} Sel_f \times C_f}{\sum_{f=1}^{f=n} C_f}$$

where C_f is the total catch of fleet f during 2010-2018.

Post-capture mortality was estimated based on information on status (at-vessel, prior to boarding) and fate (action taken) of animals collected in scientific observer programs. Total post-capture mortality (PCM) was calculated as the sum of animals kept (K) and discarded dead (DD) relative to the total number of animals observed. We also accounted for cryptic mortality by applying post-release mortality (p_D) to the sum of animals lost (L) and whose fate was unknown (U). Mortality of animals released alive (RA) was also estimated by applying the same post-release mortality estimate. The equation was thus:

$$PCM = \frac{K + DD + (L + U)p_D + RAp_D}{K + DD + L + U + RA}$$

Post-capture mortality for all fleets combined was calculated as the mean of PCM values for the individual fleets weighted by the proportional total catch of each fleet to the total catch by all fleets during 2010-2018 from Task 1 (**Table 2**).

The fraction of the populations lost to fishing (Zhou and Griffiths 2008), which is the exploitation rate (U) was approximated as the product of the four components: availability, encounterability, selectivity, and post-capture mortality, such that:

$$U \approx \frac{\sum a_f}{A} \times \frac{D_f}{D} \times Sel \times P\ CM$$

where a_f is the spatial distribution of the fleet, A is the spatial distribution of the stock, D_f is the depth distribution of the gear, D is the depth distribution of the stock, Sel is selectivity, and PCM is post-capture mortality.

The value of U is the fraction of the population lost due to fishing and the corresponding instantaneous fishing mortality rate (F) is:

$$F = -\ln(1 - U)$$

This *F* can then be compared to an *F*-based reference point such as F_{MSY} derived based on life history (Cortés and Brooks 2018).

Status determination

We used values of $\hat{\alpha}$, the maximum number of female spawners that can be produced by a female spawner throughout her life, from Cortés and Semba (2020; SCRS/2020/090) to determine the productivity level (low, medium, high) reported in Cortés and Brooks (2018). The derived productivity levels can then be linked to a specific F_{MSY}/M ratio that takes into account when animals are selected (i.e., immature, mature) and the type of fishery selectivity. Using the average values of *M* used in Cortés and Semba (2020;

SCRS/2020/090), the resulting value of F_{MSY} can then be compared to the F value obtained in the SAFE analysis to determine whether overfishing is occurring.

SAFE method results

After the presentation of SCRS/2020/099, there was a question about why a dome-shaped selectivity was assumed in the computation of the selectivity component. The rationale was that there are likely to be more bite-offs of larger animals. In the case of Canada, selectivity was previously estimated from an integrated statistical catch-at-age model (Campana *et al.,* 2010) and was dome-shaped. It was also mentioned that large sharks tend to be found at higher latitudes than where most of the fleets operate, leading to the capture of smaller animals, and that circle hooks could lead to the retention of smaller animals.

There was also a question about the effect of assuming that post-release mortality is equal to the mean of the Campana *et al.,* (2016) study (27.2%) and the Anderson *et al.,* (2019) study (0%). It was clarified that sensitivity runs assuming the values from each of these two studies could easily be undertaken to evaluate whether the value used affects conclusions.

There was also a question as to why the average (vs. the sum) of the day and night values was used in the computation of encounterability. In response to this inquiry, it was explained that if the species were to occupy the full range of the gear depth distribution both during the day and at night, the sum of the two would equal 200%, hence the use of the mean.

In response to these comments and the new values of availability generated following the presentation of SCRS/2020/100, the SAFE analysis was updated to incorporate the following changes: 1) using the new availability values for the North and South Atlantic, 2) adjusting the computation of encounterability to reflect the fact that it should be the average, not the sum, of the day and night overlap between the gear and the species vertical distribution, and 3) using updated values for post-release mortality (PRM). Use of the new availability values increased estimated F, but this was offset by the reduction in encounterability. For post-release mortality (3), it was clarified that most of the porbeagles included in the Campana *et al.,* (2016) study had been brought onboard, whereas, of 15 sharks caught by longline that transmitted data in the Anderson *et al.,* (2019) study, 7 were in "good" or "healthy" condition and 8 in "poor" or "injured" condition, and that there was only one mortality of a shark that was "injured", which would result in a post-release mortality rate of 6.7%. Based on these findings, the new average PRM rate would be 16.95% (mean of 27.2 and 6.7) and two sensitivity scenarios were explored: high PRM (27.2%) and low PRM (6.7%). Incorporation of all these changes did not affect conclusions on status, with the prediction remaining that neither the North Atlantic nor the South Atlantic stocks are undergoing overfishing (**Tables 3 and 4**). It was also noted that results for the South Atlantic are in line with those found in the Southern Hemisphere assessment, which reported an average value of F/F_{MSY} = 0.063 (range: 0.046 to 0.083 for 2006-2014), whereas those found here ranged from F/F_{MSY} = 0.107-0.119 for 2010-2018.

3.2. Incidental Catch Model

SCRS/2020/096 proposed a new life history-based simulation approach for data-poor assessment and status evaluation (an Incidental Catch Model; ICM), using the northwest Atlantic porbeagle stock as an example. The approach was designed for assessments where length-frequency data and CPUE series may not be available to index changes in abundance. The model was based on the same general premise as other data-poor assessment approaches, in that it used life-history information and equilibrium assumptions to derive a theoretical age-structured population in the absence of fishing. Preliminary results demonstrated how status of the northwest Atlantic stock changed depending on productive capacity, where the stock was predicted to be above the Overfished threshold if reproduction was annual but had a substantial probability (72%) of being overfished in 2018 if reproduction was a mix of annual and biennial or exclusively biennial. In all reproductive scenarios, future removals needed to remain low to permit population recovery.

Description of the ICM method

The ICM is a simulation model with two main parts: (1) a backward-projecting component, used to predict the historical abundance trajectory given the actual time series of removals and assess status relative to reference points, and (2) a forward-projecting component that can be used to assess the probability of population increase given different levels of fishery removals. The ICM accounts for uncertainty in our understanding of porbeagle life history by simulating over a distribution of values for population

productivity. This distribution comes from the Leslie matrix approach described in Cortés and Semba (2020; SCRS/2020/090) to get the theoretical maximum capacity for population growth in the absence of fishing (r_{max}). Similar modeling approaches have been previously applied to assess the capacity of bycatch species to withstand removals. There are examples for cetaceans (Caswell *et al.,* 1998; Dans *et al.,* 2003), basking sharks (Campana *et al.,* 2008) and white sharks (Bowlby and Gibson 2020). This is the first time that this type of simulation model has been applied for stock assessment at ICCAT, which is being applied to a species that was historically targeted, but is now almost exclusively non-retained bycatch.

The backwards projections use a simple exponential model to predict changes in population size (N) from the current year (y) to the previous year (y-1), accounting for removals (R):

$$(1)\quad N_y = e^r N_{y-1} - R_{y-1}$$

which can be rearranged as:

$$(2)\quad N_{y-1} = \frac{(N_y + R_{y-1})}{e^r}$$

The time series of removals from Task 1 data informs R and needs to be calculated in numbers rather than biomass. The backwards projections occur on an annual time step where population increase happens first and removals take place afterwards. This makes the analysis more precautionary as it slightly exaggerates the effects of removals by modeling them as a discrete rather than a continuous process. Note that the population's capacity for growth in the absence of fishing (r_{max}) was used in the backwards projections, based on Cortés and Semba 2020 (SCRS/2020/090). This means that the effect of removals in each year was calculated relative to the population's theoretical capacity for growth at equilibrium, which is the same premise that underlies length-based assessment approaches (Hordyk *et al.,* 2015a; Hordyk *et al.,* 2015b).

The forwards projections used a simple logistic growth model, assuming a high carrying capacity (K) (i.e. very weak density dependence).

$$(3)\quad N_{t+1} = e^r N_t \left(1 - \frac{N_t}{K}\right)$$

A logistic model ensured that the future projections could not grow without bound and thus substantially overestimate the potential for population recovery. The population was projected forwards for 50 years (2.5 generations) under multiple different removals scenarios, to assess how future fishing mortality could influence the probability of being overfished. In an age-structured population, fishing mortality (F) reduces the population growth rate (r) by changing survival at age (l_x). Natural mortality rates (M) were determined from the life history analysis of Cortés and Semba 2020 (SCRS/2020/090) and survival at age becomes:

$$(4)\quad l_x = \prod_{i=0}^{x-1} e\left(-(M_i + F_i)\right)$$

The value for F is found through minimization of the sum of squared residuals between observed removals (R_y) and predicted removals, accounting for the selectivity of the fishery. From the basic relationship between an annual exploitation rate (u) and instantaneous fishing mortality (F):

$$(5)\quad u = 1 - e^{-F}$$

The number of animals in the population in a given year (N_y) that are vulnerable to the fishery becomes:

$$(6)\quad vulnerable = N_y \frac{\sum_{x=sel}^{A} lx}{\sum_{x=0}^{A} lx}$$

Predicted removals are simply *vulnerable*u.*

The ICM approximated a dome-shaped selectivity function by assuming constant fishing mortality rates on juveniles and no fishing mortality on adults. This reflects the length composition data from various fleets, where the vast majority of fisheries captures are immature.

Recent research has suggested a possible biennial reproductive cycle for porbeagle (Natanson *et al.,* 2019). Thus, three different scenarios for productivity were considered in the ICM: a reproductive periodicity of one year (annual; high productivity), a reproductive periodicity of two years (biennial; low productivity), and an intermediate scenario that assumes a 50:50 mix of annually-reproducing and biennially-reproducing females (annual + biennial; medium productivity).

Status evaluation

Overfished status in 2018 or in each year of the future projections can be evaluated using the SPR_{MER} reference point proposed by Brooks *et al.,* (2010): the Spawning Potential Ratio at Maximum Excess Recruitment. This biological reference point is derived entirely from life history data and has been found to accurately predict overfished status relative to Maximum Sustainable Yield (MSY) reference points from traditional stock assessments (Cortés and Brooks 2018). It is calculated as:

(7) $SPR_{MER} = \frac{1}{\sqrt{\hat{\alpha}}}$

where $\hat{\boldsymbol{\alpha}}$ represents the maximum lifetime reproductive rate (Myers *et al.,* 1997, 1999), which is the maximum number of female spawners that can be produced by a female spawner throughout her life (Bowlby and Gibson 2020). It is calculated from the net reproductive rate or spawners per recruit (SPR) multiplied by maximum age-0 survival (Brooks *et al.,* 2010). Overfished status is determined by comparing current abundance with a threshold value. This value typically represents a given proportion (p) of the stock size which is expected to produce MSY. Previous assessments have used p = (1-M) for sharks (Brooks *et al.,* 2010).

The threshold value representing the depletion of spawners and recruits at Maximum Excess Recruitment, assuming a Beverton-Holt stock-recruit relationship, is:

(8) $\frac{\boldsymbol{S_{MER}}}{\boldsymbol{S_0}} = \frac{\sqrt{\hat{\boldsymbol{\alpha}}}-\mathbf{1}}{\hat{\boldsymbol{\alpha}}-\mathbf{1}}$

The population is considered overfished if the level of depletion in an abundance index (I) divided by the threshold value in Equation (8) is smaller than the proportion p:

(9) $\frac{\frac{\boldsymbol{I_{current}}}{\boldsymbol{I_{unfished}}}}{\frac{\boldsymbol{S_{MER}}}{\boldsymbol{S_0}}} < \boldsymbol{p}$

Predicted abundance at the start of the removals time series was taken to represent unfished population size and abundance in 2018 represents current abundance. Each iteration of the simulation yields a different value for $\hat{\boldsymbol{\alpha}}$, as well as for current and unfished population size due to the manner in which variability is incorporated into the model (MC sampling from distributions; Cortés and Semba 2020; SCRS/2020/090). Therefore, solving Equation 9 gives a distribution of values that can be compared to p.

Similarly, the proportion of simulations that are overfished at a given time step in the forward projections can be found by using predicted future abundance as $\boldsymbol{I_{current}}$. The forward predictions were evaluated at 5-year intervals relative to removal scenarios ranging from 0 to 24,000 animals. In each future year, the proportion of trajectories that are overfished becomes the number of simulations < p divided by the total number of simulations.

Validation

The ICM model is a simulation approach that is conditional on the input values used where different inputs give different results. Unlike traditional fisheries models, it does not compare predicted and observed data using a statistical fitting procedure. In order to qualitatively validate the ICM as a reasonable approach, inputs (time period, productivity assumptions, NAFO removals series) were standardized as close as possible with a historical Canadian Statistical Catch-at-Age (SCA) model (Campana *et al.,* 2010b) and the 1961-2009 abundance trajectory predicted by the ICM was compared with that from the SCA. The ICM and SCA gave extremely similar results, predicting nearly identical initial abundance and decline rates over the time series. The ability of the ICM to re-create the SCA output when inputs were standardized between the two approaches suggested it was a reasonable assessment method.

ICM discussion and additional work

Following the presentation, there was a question of why a knife-edged selectivity was chosen, where F on adults drops to zero. The authors clarified that F is estimated from a female-only life history model (life-table analysis and Euler-Lotka equation), so the selectivity reflects the assumption that adult females are encountered very rarely in the catches. It is a simplification of previous selectivity estimates from the 2009 assessment (dome-shaped with low selectivity on adults).

A follow-up question asked for clarification if the entire ICM model was female only, and if the removals series had been partitioned to be only females. The authors clarified that the life-history method to estimate population productivity was female only, but that the abundance predictions from the ICM are for the whole population and use the whole removals series.

There was a question on whether the declines in the historical trajectory match the peaks in the removal series. The authors clarified that they do. They also noted that the only way to get population decline when projecting backwards ($N_{t-1} > N_t$) using an exponential model is if removals are higher than the annual productive capacity of the stock.

There was a question on the sensitivity of the predicted historical abundance trajectory to assumed abundance in 2018, as this would affect the probability of being overfished. It was noted that the Canadian SCA model was being used to approximate 2018 abundance even though the SCA only considered years up to 2009. A request was made to better match the prediction of 200,000 animals in 2009 in the historic abundance trajectory of the ICM. The authors noted that matching the 2009 value was possible and that it would give different results for the three productivity scenarios used in the ICM. They also commented that this match had not been done originally because productivity based on the most recent life history data (SCRS/2020/090) was lower than that used in the SCA model, which would affect absolute abundance predictions.

The authors presented updated ICM model output for all three productivity scenarios in which 2009 abundance had to be ~200,000 animals. This caused two main changes: (1) initial abundance in 2018 increased considerably because recent removals are very low, and the trajectory is predicted to be increasing from 2009 to 2018; and (2) the extent of historical population decline was reduced, dropping to ~56% over the time series if reproduction was annual vs. ~76% in the original model formulation.

This sparked a discussion on the removal series in recent years and whether a consistent method had been used to derive the Task 1 data from 2009-2018. The Secretariat confirmed that no estimations had been performed in the 2009 to 2018 time period, and the Group remarked that such estimations would typically be carried out at a Data Preparatory meeting, which was not conducted in advance of this assessment. Following substantial work to use a consistent methodology to estimate removals throughout the time series (see section 2.2), the Group decided to use the updated removals in the ICM. This change increased removals in 2009 to 2018 and reduced the level of predicted population increase from 2009 in the ICM.

There was substantial discussion on whether it was useful to use the 2009 abundance prediction from the Canadian SCA model to scale the ICM, given that status in 2018 is sensitive to the value used to initialize abundance in 2018. It was noted that abundance predictions in the terminal year of an SCA tend to be the most uncertain, while the relative changes in the trajectory are less uncertain. Updated fits to the ICM where 2009 abundance had to be ~200,000 animals substantially reduced the extent of predicted historical population decline, and increased 2018 abundance by > 100,000 animals. The original ICM model predicted a more similar total decline as the SCA, while ICM predictions from a higher abundance in 2018 reduced the historical decline rate substantially. The Group decided to use the original formulation of the model, but to show the output from a run assuming higher abundance in 2018 as a sensitivity.

The authors requested clarification on which productivity scenario would be considered the most plausible in the assessment. The Group decided to use the medium productivity scenario (annual + biennial) as the base case and to show the results from the high productivity scenario (annual) as a sensitivity run. Annual reproduction was assumed in the previous assessment and so some consideration of an annual reproductive life history is required for continuity.

There was a question of how the ICM could be applied to other populations, specifically in the South Atlantic where there is no abundance prediction from the historical assessment that could be used to scale abundance in 2018. The authors noted that it would be necessary to have the ICM match an index of relative decline (i.e. changes in a CPUE index). Using information on the extent of population decline over a specific number of years, given the observed time series of removals, would give an estimate of 2018 abundance, current status relative to the overfished reference point, and enable evaluation of future fisheries removals.

The authors presented preliminary fits of the ICM to trends in the CPUE index of Uruguay, using the life-history parameters given for the South in Cortés and Semba 2020 (SCRS/2020/090). This CPUE series was quite variable and suggested a decline of ~85% from 1993 to 2012. Matching this trend over the same time period using the ICM predicted that the population in the South Atlantic was extremely small in 2018 (~30,000 animals), and that there was a very high probability of being overfished. An alternate CPUE index from the Japanese fleet (Semba and Yokawa 2011) was considered, and the Group noted that the CPUE series from Japan showed no evidence of decline over a similar range of years. The Group decided not to move forward with the ICM model for the South Atlantic, given the conflicting information in the CPUE indices.

There were three comments related to standardizing this assessment with others conducted at ICCAT. Firstly, the threshold value (p) for the SPR_{MER} reference point should be calculated relative to MSY. This means that $p = 1$ should be the critical value rather than $p = 1\text{-}M$. Secondly, future projections should show abundance relative to abundance at MSY, in order to help understand where the population is relative to the overfished reference point. Thirdly, the projections needed to be redone to assume average catches from 2016-2018 in 2019 and 2020, in order to account for the lag in implementing management regulations following an assessment. The constant removal scenarios should start in 2021.

ICM Results

In response to these comments, the ICM model was applied to the northwest Atlantic stock only and was updated to incorporate the following changes: (1) biomass was transformed into numbers using stock-specific length-frequency information from Santos *et al.,* 2020 (SCRS/2020/097) and the growth parameters from Cortés and Semba 2020 (SCRS/2020/090), (2) the critical value of $p = 1$ was used to assess overfished status, (3) the removals series was updated to incorporate estimation of recent catches (2009-2018; section 2.2), (4) the annual + biennial (medium productivity) life-history scenario was considered to be the most representative, (5) a sensitivity analysis for the medium productivity scenario was run, which scaled 2009 abundance at 200,000 animals in the backwards projections, (6) a second sensitivity analysis was run to consider the annual reproduction (high productivity) scenario, (7) the original plot showing future median abundance in each removal scenario was replaced with a Figure showing relative abundance and the threshold value for assessing overfished status, and (8) the projections were redone to start in 2021, assuming average catches from 2016-2018 for 2019 and 2020.

The backwards projections of the ICM indicated that maximum abundance for the northwest Atlantic stock occurred in the 1960s, with a median predicted population size just under 1 million animals (**Figure 4** top panel). The two distinct periods of decline in the 1960s and the 1990s correspond to years with comparatively high removals, based on reconstructed Task 1 catches (**Figure 4** bottom panel). Minimum abundance is predicted to have occurred in 2001, and the population is likely to have been increasing since that time. If removals in 2019 and 2020 remain at the average level during 2016-2018, population increase is sustained. This increasing trajectory is consistent with trends in the Japanese CPUE index for the northwest Atlantic from 2014 to 2018 (Semba and Kai 2020; SCRS/2020/084) but is much smaller in magnitude. The trajectory from the ICM represents the maximum potential for population growth based on life history, given observed removals.

The stock is currently overfished with a high probability, with 98% of simulations falling below the MSY threshold value for biomass in 2018. If removals were to be reduced to zero, the future projections suggest that it would still take over 10 years or more than half a generation for the population to rebuild to abundance at MSY with a 60% probability (**Figure 5; Table 5**). If removals are higher, the time period required for rebuilding becomes greater (**Figure 5**). The future projections suggest that removals must remain below 7,000 animals (214 mt) to rebuild to MSY in 50 years, or 2.5 generations, with a 60% probability (**Table 5**).

From the reconstructed catch series, removals averaged 47 mt from 2014-2018, 143 mt from 2009-2013 and 305 mt from 2000-2009. The results of this assessment suggest that the porbeagle stock in the northwest Atlantic cannot sustain the level of fishing pressure seen in the 10-year period preceding the 2009 assessment. However, management changes following the 2009 assessment (including international trade restrictions related to listing on Appendix II of CITES and the closure of the Canadian porbeagle-directed fishery in 2013) have reduced removals to a level that allows for a population increase. The Group also noted that there have been substantial changes in discarding practices since 2014, yet dead discards and post-release mortality from live discards could not be incorporated into the removal series used for this assessment. If removals were underestimated in recent years, status in 2018 would not change, but the time necessary to reach biomass at MSY would increase in the future projections.

Relative to the sensitivity analyses, assuming a reproductive periodicity of one year (annual reproduction) reduces the probability that the population is currently overfished from 98% to 83%. Although current status is the same, higher productivity allows the population to increase more quickly in the future projections. Under a high productivity scenario, removals could be as high as 13,000 animals (398 mt) to have a > 60% probability of reaching abundance at MSY in 50 years, or 2.5 generations. Similarly, scaling the historical abundance predictions of the ICM relative to an abundance of 200,000 animals in 2009 reduces the extent of historical population decline predicted by the ICM. Abundance in 2019 becomes much greater, at ~310,000 animals, yet the historical maximum in 1961 remains very similar to the base case (just under 1 million animals). This scenario suggests that the population in 2018 is much closer to biomass at MSY, even though it still has a 70% probability of being overfished. In this scenario, future removals should be kept below 14,000 animals (428 mt) to have a > 60% probability of reaching abundance at MSY in 50 years, or 2.5 generations.

The sensitivity analyses do not markedly affect the perception of status in 2018 for porbeagle in the northwest Atlantic. All scenarios evaluated suggest that the population is currently overfished with a high probability and that the stock has declined by > 56% from maximum abundance in the 1960s.

3.3 Length-based Spawning Potential Ratio

SCRS/2020/P/040 presented a study on the possibility of applying length-based models to estimate the reproductive potential of porbeagle. This was defined at the Reproductive Workshop that was held in Faro, February 2020, after a testing application of a framework called FishPath (FP). This framework was used to contribute to the discussions about what kind of method could be used to assess the species considering the lack of data necessary to apply traditional stock assessment methods. Before the first model runs, an exploration of the available size data for female porbeagle was performed splitting the data by stock, fleet, and year, using only years with more than 70 measured individuals. However, this exploration revealed that the catches were composed mainly of immature individuals, as can be seen in the figures of SCRS/P/2020/040. The lack of representativeness of mature females prevents the use of the LBSPR to assess the stock status since this model requires a representative size composition of the mature portion of the stock.

3.4 Other Methods

SCRS/P/2020/036 showed some results of a set of closed-loop simulations under development to potentially apply a Management Strategy Evaluation approach for porbeagle shark stocks. The approach built operating models using Stochastic Stock Reduction Analysis (Walters *et al.,* 2006) that were conditioned on EffDis effort reconstruction information (Taylor *et al., in press*) and Task 1 time series for the NW porbeagle stock. Each operating model was fitted to CPUE time series extracted from the 2009 porbeagle stock assessment (Anon., 2010) and to length composition information extracted from the Task 2 catch at size data prepared at the meeting. The closed-loop simulations explored the performance of a series of predominantly input control including a variety of length-based management procedures. Even given the preliminary state of development of the simulations, the presentation illustrated the possibility of employing the approach to evaluate the performance of alternative Management Procedures for the stock assessment and management of porbeagle sharks.

There were many comments on the presentation. First, the Group noted that some examples of input controls having been applied at ICCAT, including time-area closures in tropical fisheries, rolling periods of closures, effort capacity limitation, and others, suggesting that these might be practical management measures to consider in Management Procedures. The issue of unreported discards as a potential problem was brought up as one that needed to be addressed for the performance of any harvest control rule and, for that matter, parameterizing operating and assessment models. The reliability of effort and its linear proportionality to catch was discussed: the Group noted that while incidental catch may be proportional, effort targeting porbeagle in the historical effort series should be considered differently for fleets where Porbeagle is predominantly bycatch. In addition, some refinement of data and assumptions would be beneficial. The key issue was that there were (and are) many regulations about catch: these will affect the conditioning of operating models as well as the efficacy of any input and output control management procedure explored. The Group suggested cross-checking the fit of the CPUE series in the operating models with SC-ECO indicators, and that other CPUE series possibly be developed. However, it was noted that the provision of indicators (i.e. stock status in B base and F base) for the SC-ECO Report Card being developed should be prioritized over MSE work that has not yet been identified by the Group.

The Group noted that North Atlantic porbeagle may not be targeted now because of stock depletion and/or EU prohibition, but the species remains potentially quite valuable for meat and fins. CITES Appendix II mandates trade measures aimed at ensuring sustainability, not necessarily catch limits or prohibitions (or any other specific fishery management measures). Despite CITES listing, neither porbeagles nor makos are subject to across-the-board ICCAT output controls at present. The ability to impose input controls or output controls depends on fishing nations' capacity, enforcement, and the consistency between them. Among these potential difficulties, a "live release" rule is very different from a prohibition on retention. Live release may be an incentive to ensure the shark is dead upon haulback if a legal market exists, whereas a retention prohibition is likely to switch the incentive to avoid catching the shark in the first place.

SCRS/2020/105 also evaluated a method to estimate fishing mortality rates from the average length of sharks that are in the fully selected age range, along with information on growth and natural mortality, using a method derived by Beverton and Holt. The method was applied to the northwest, southwest and southeast stocks. The Beverton and Holt estimator assumes that growth, mortality, and selectivity are consistent over time so that the length-frequency distribution reaches equilibrium. If this assumption is not met, then the estimated fishing mortality rates may reflect fishing mortality rates from the recent past rather than the current rate. Thus, the values should be treated as an index of whether F is increasing or decreasing, and not necessarily as an estimate of current F. For the southwest stock, the length-frequency distribution was bimodal so that only a small fraction of the catch could be assumed to be fully recruited. The estimates of F were well above the natural mortality rate M in the northwest and northeast population, but not in the south west. In the northwest, F appeared to be decreasing over time. Confidence intervals developed by bootstrapping the length data and drawing values of the life history parameters from a multivariate normal distribution showed a large uncertainty in the F/M values, implying uncertainty regarding recent trends.

In response to a request from the Group, the author re-did the analysis by fleet and found that the trends remained the same, including the decrease in F/M in the northwest. However, this analysis does not account for possible changes in selectivity in fleets over time, which could bias the results. The Group discussed why the results from this analysis estimated higher values of F than the SAFE analysis. The two methods have very different assumptions. In particular, because this analysis is based on only length-frequency data, high estimates of F should be interpreted as meaning that the length frequencies have not yet balanced to what would be seen in a population with no recent history of overfishing. The decrease in F in the northwest Atlantic may indicate that recent reductions in catch are allowing some rebuilding.

4. Synthesis of assessment results

Two modeling approaches were used to assess the status of porbeagle shark in the Atlantic and two additional modeling approaches were also explored. The SAFE approach (section 3.1) was used to evaluate whether the North and South Atlantic stocks were experiencing overfishing. The ICM model was used to evaluate whether the northwest Atlantic stock was currently overfished and to determine the stock's capacity for future removals (section 3.2). Exploratory analyses that were not used to derive advice for the current assessment included the ICM fit to the South Atlantic stock (Section 3.2); the fit of length-based approaches to the northwest, southwest, and southeast stocks (sections 3.3 and 3.4); and input control management options explored in a preliminary MSE approach for the northwest stock (section 3.4). All of the exploratory approaches show promise and could be further explored in future assessments.

Results of the SAFE approach indicated that neither the North Atlantic nor the South Atlantic stocks are undergoing overfishing (**Table 4,** section 3.1). The Group noted that while this is a data-poor approach, the overfishing status results were robust to the selectivity curve assumed and the post-release mortality value used in the computation of post-capture mortality. The Group noted that for the South Atlantic results are in line with those found in the Southern Hemisphere (SH) assessment, with F/F_{MSY} values from both studies being of relatively similar magnitude (0.063, range: 0.046 to 0.083 for 2006-2014 in the SH assessment vs. 0.107-0.119 for 2010-2018 in the SAFE analysis).

Annual plus biennial reproduction was considered the most likely for the porbeagle population in the northwest Atlantic (see section 2.4, Life history) so these productivity assumptions were used for the base case formulation of the ICM model. The removals series that was used in the model was updated to the augmented catch series (Section 2.2; **Table 2**) and the threshold value used to assess status was based directly on an MSY proxy (i.e. p = 1 rather than p = (1-M)) to be consistent with other ICCAT assessments. Two alternate parameterizations of the ICM were evaluated to determine the model's sensitivity to life history assumptions, as well as to the assumed population size in 2018. The first sensitivity analysis assumed a reproductive periodicity of one year (annual reproduction), consistent with productivity assumptions in the 2009 assessment (Anon., 2010). The second assumed larger population size in 2018, so that predicted abundance in 2009 matched the value of 200,000 animals from the Canadian Statistical-Catch-at-Age model presented at the 2009 assessment (Campana *et al.,* 2010b). In all formulations, the stock was predicted to be overfished in 2018 with > 70% probability, even though abundance has been increasing since 2001. The scenarios differed in how far 2018 abundance was below the MSY proxy for biomass, with both sensitivity analyses suggesting that the population was closer to the threshold value.

The base case formulation of the ICM estimated biomass in 2018 to be 57% of the MSY proxy reference point (353,000 animals), giving a 98% probability of the stock being overfished. Projections indicated that removals of less than 7,000 sharks (214 mt) would allow rebuilding with a 60% probability by 2070 (a projection interval of 2.5 generations) and removals of less than 8,000 sharks (245 mt) would allow rebuilding with a 50% probability by 2060 (**Table 5**). If removals remained similar to 2014-2018 (mean = 47 mt), the stock was predicted to rebuild with at least a 50% probability between 2030 and 2035 (**Table 5**). However, the Group emphasized that recent removals are very likely underestimated because few CPCs report dead discards, and post-release mortality of live discards was not taken into account.

The LB-SPR model (section 3.3) initially attempted to estimate the reproductive potential for the species was not further considered due to a lack of representation of mature individuals in the available size-distribution data from all stocks and fleets. However, the Group also evaluated an alternative length-based method derived from the original Beverton-Holt formulation (section 3.4). As a result of the assumptions implicit in this method, the values obtained should be treated as an index of whether *F* is increasing or decreasing, and not necessarily as an estimate of current *F*. The estimates of *F* were well above the natural mortality rate, *M*, in the northwest and northeast populations, but not in the southwest stock. In the northwest, *F* appeared to be decreasing over time, but there was large uncertainty about recent trends. These results held when the analysis was disaggregated into fleets but may be biased because potential changes in selectivity are not considered. Also, because the analysis is based only on length-frequency data, high estimates of *F* should be interpreted as meaning that the length frequencies have not yet reached the distribution that would be expected in a population with no recent history of overfishing. The decrease in *F* in the northwest stock may indicate that recent reductions in catch are allowing some rebuilding. The Group also noted that the reason for the difference in the overfishing prediction between this method and the SAFE method is that the two methods have very different assumptions and the computation of *F* relies on widely different data inputs.

While some preliminary simulation results for a porbeagle MSE were presented, the main intent of the MSE (section 3.4) was not to draw any specific conclusions, but rather to demonstrate that analyzing the performance of management procedures may be feasible for porbeagle and explore the effectiveness of some input control options for management of the NW porbeagle stock.

5. Recommendations

5.1 Research and Statistics

1. Given that the stock identity for South Atlantic stocks is unclear, further studies (including genetic studies as well as life-history and tagging studies) are required to better inform on stock units in the Southern Hemisphere.
2. Although stock structure in the North Atlantic is better understood, there is a need for more targeted research, for example, the potential mixing between NW Atlantic, NE Atlantic and Mediterranean porbeagle.
3. According to the new information presented during the meeting, more data are required from the fisheries in the equatorial zone (between 20° south latitude and 20° north latitude) in order to corroborate the presence of the species in this area.
4. Improve understanding of Southern Hemisphere porbeagle dynamics in conjunction with other RFMOs, including IOTC, CCSBT, and IATTC, so as to collate better data on catch, distribution, commercial CPUE and stock structure.
5. Given that porbeagle in the North Atlantic represent a key pelagic stock in continental shelf ecosystems, as well as in the high seas, ICCAT and RFMOs (e.g. NAFO, ICES) should continue to cooperate on the development of assessments and management actions for this species.
6. Porbeagle may associate with hydrographic features (or as an indirect effect by associating with their main prey). A better understanding of the temporal and spatial distribution of porbeagle in relation to such environmental/ecosystem features (including population structure) may enhance our understanding of catch and CPUE trends.
7. More historical information on catch and effort data may be available and should be investigated. In the absence of historical effort data, estimates of fleet size could provide a useful surrogate.
8. Get better estimates of discards in shelf and high-seas fisheries and continue studies to measure post-release survival.
9. Conduct research to improve knowledge of life history in different areas and for different stocks.
10. Improve the estimation methods for non-reported landings and dead discards developed at the meeting and used in the assessment (which will appear in the ICCAT database as being estimated by the SCRS) by considering the spatiotemporal pattern of operation and discarding practices of each fleet. It is preferable that scientists from each CPC be involved in this process.
11. Need to allocate sharks reported as unclassified to species where possible.

5.2 Management Recommendations

1. SCRS needs the cooperation of all CPCs to improve catch statistics, which is critical to advancing the assessments of all porbeagle stocks.
    a) Only 1 CPC has reported live discards of porbeagle. The Group underlines that the reporting and quantification of live discards is critical, especially for a stock where all live animals must be released (Rec. 15-06); the Commission should find ways to encourage improved reporting of live discards.
    b) There is a need for CPCs to strengthen their monitoring and data collection efforts, including but not limited to improved estimates of dead discards and the estimation of CPUEs using observer data.
    c) The Group requests that CPCs revise their porbeagle catch series (landings, live discards, and dead discards), including incidental captures from their other non-ICCAT fisheries (gillnet, trawling, purse seiner, etc.) to allow the SCRS to incorporate all mortality sources into future assessments and reduce the uncertainty in stock status and projections.
    d) In addition, the Group recommends that ICCAT liaise with parties (e.g. other RFMOs) and engage in data mining to determine the total capture from non-ICCAT parties.

2. The Group notes that management recommendations for porbeagle stocks under the responsibility of ICCAT are drafted for ICCAT fisheries. However, porbeagle stocks are subject to mortality from CPCs' coastal fisheries and countries that are not ICCAT Parties, therefore the Group recommends developing integrated management approaches (with other countries, other Regional Fisheries Bodies, FAO) to assure the sustainability of Atlantic porbeagle stocks.

3. The Group notes that some landings and the majority of discards go unreported, meaning that total mortality of porbeagle from all sources (i.e. landings, dead discards and live releases that subsequently die as a result of gear interactions) is underestimated. For the purposes of this assessment, the Group estimated unreported landings and dead discards that were 89% higher than reported, but did not estimate mortality following live release. Commissioners should be aware that actual removals are higher than what is being reported and Kobe matrices will be overly optimistic to the extent that removals are underreported.

4. For the northwest stock, all formulations of the ICM model indicate a rebuilding trend since 2001, yet biomass in 2018 was still only 57% of biomass at the SPRmer reference point and the stock is predicted to be overfished with a 98% probability. There are contradictory signals with respect to the overfishing status (with the SAFE approach indicating no overfishing and the exploratory length-based method suggesting overfishing), but with the large reduction in recent removals, the Group does not consider it likely that the stock is undergoing overfishing if total removals (unreported landings, dead discards, and post-release mortalities) do not largely exceed what the Group has estimated for removals. However, as the magnitude of dead discards remains uncertain and post-release mortalities are not incorporated in this assessment, there remains considerable uncertainty in the overfishing status.

5. Considering the underreporting of removals, and the current low stock status of the northwest Atlantic stock, the Group recommends that catches do not exceed current levels to allow for stock recovery. Although the Kobe matrix might suggest that some increases in catches could allow for potential recovery in the long term, the assessment suggests that the stock is productive enough to recover in a much shorter time frame if catches are maintained at a lower level. This is consistent with [Res. 11-13] that overfished stocks be recovered in as short a period as possible. However, commissioners should be aware that actual removals (particularly dead discards and live post-release mortalities) are higher than what is being reported and the Kobe matrix is overly optimistic to the extent that removals are underreported.

6. While there is large uncertainty in southern stock structure (se section 2.1), new information (see Section 2.1) suggests a single stock of porbeagle in the South Atlantic; until now, the Group had considered two stock units: southwest and southeast. Indeed, there may be a southern stock that extends across the Indian and Pacific Ocean basins. More research on stock structure needs to be undertaken to determine an appropriate unit stock. Until this research is done, the Group recommends leaving the management units as currently defined.

7. The Group was not able to draw any conclusions on the overfished status of the southern stock(s) (see data improvement recommendation above). It noted that, indeed, conventional data (e.g. landings, representative length compositions) cannot be collected for porbeagle stocks, so the Group concluded that alternative (e.g., fishery independent) data collection methods that allow CPUE or length-frequency data (or other altogether different forms of data) to be collected are required to provide more reliable estimates of stock status in the north and in the South Atlantic.

6. Executive Summary

The Executive Summary will be provided after this report is approved.

7. Other matters

No other matters were raised.

8. Adoption of the report and closure

The report was adopted by correspondence.

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Table 1. New preliminary series of L (landings) and DD (dead discards) estimated by the Group.

Stock	Catch type	Flag	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
POR-NW	L	Barbados	0.4	0.5	0.5	2.0	3.1	13.1	0.8	1.6	1.0	1.0	1.0
		Chinese Taipei	2.3	1.9	3.0	7.4	14.7	49.6	0.9	4.5	3.7	5.8	4.5
		Korea Rep.	0.9	1.1	0.6	12.8	20.0	2.5	0.1	0.0	0.0	0.0	0.0
		Venezuela	1.1	3.1	2.7	9.2	18.8	69.1	4.0	5.9	4.0	8.1	4.3
	DD	Barbados	0.0	0.1	0.3	0.1	0.1	0.3	0.7	3.7	1.1	0.9	1.0
		Chinese Taipei	0.2	0.5	1.9	0.2	0.6	1.0	0.7	10.7	4.1	5.2	4.5
		Japan	0.4	1.3	3.8	0.3	1.0	1.1	1.4	4.8	1.0	1.3	0.5
		Korea Rep.	0.1	0.3	0.4	0.0	0.8	0.1	0.1	0.0	0.0	0.0	0.0
		Venezuela	0.1	0.8	1.7	0.3	0.7	1.4	3.3	14.0	4.3	7.2	4.4
Task 1 reports			136	73	98	54	86	146	23	48	11	21	8
Task 1 (new)			141	84	113	87	147	284	35	93	30	50	28
% increase			4%	15%	15%	60%	71%	95%	53%	95%	181%	143%	248%

Table 2. Porbeagle total Task 1 catches by stock (NW, NE, SW, SE), major gear (longline, others), catch type (landings [L], dead discards [DD]), and year (1950-2018).

	POR-NE					POR-NW					POR-SE					POR-SW					POR(MED)				
	Longline		Others		Total	Longline		Others		Total	Longline		Others		Total	Longline		Others		Total	Longline		Others		Total
Year	L	DD	L	DD		L	DD	L	DD		L	DD	L	DD		L	DD	L	DD		L	DD	L	DD	
1950	1362		1900		3262																				
1951	781		1600		2381																				
1952	609		1600		2209																				
1953	816		1100		1916																				
1954	895		700		1595																		6		6
1955	999		600		1599																		7		7
1956	872		400		1272											1				1			6		6
1957	1200		600		1800											1				1			6		6
1958	1383		907		2290											8				8			3		3
1959	1786		609		2395											42				42			3		3
1960	2431		410		2841											52				52			1		1
1961	1058		609		1667	1924				1924						53				53			2		2
1962	451		420		871	3017				3017						82				82			2		2
1963	124		217		341	6593				6593						154				154			1		1
1964	95		305		400	9302				9302						162				162			5		5
1965	208		208		416	5208				5208						146				146			8		8
1966	227		206		433	2150				2150						37				37			3		3
1967	313		207		520	646				646						28				28			2		2
1968	623		107		730	1084				1084						64				64			2		2
1969	920		103		1023	1097				1097						392				392			2		2
1970	279		205		484	926				926						463				463			0		0
1971	222		953		1175	563				563						104				104			0		0
1972	222		1430		1652	393				393						171				171			2		2
1973	12		953		965	361				361						107				107			4		4
1974	9		726		735	88				88						116				116			2		2
1975	12		1104		1116	143				143						82				82			3		3
1976	9		1179		1188	473				473						91				91			2		2
1977	10		823		833	475				475						129				129			3		3
1978	11		1022		1033	250				250						146				146			3		3
1979	8		1272		1280	469				469						163				163			2		2
1980	12		1168		1180	579				579						153				153			1		1
1981	12		1027		1039	514				514						247				247			1		1
1982	14		324		338	339				339						266		0		267			1		1
1983	28		877		905	366				366						288		1		289			1		1
1984	100		464		564	281				281						303		1		304			1		1
1985	23		429		452	355				355						319		1		320			1		1
1986	26		413		439	462				462						420		1		420			0		0
1987	33		370		403	580				580						348		0		348			1		1
1988	72		497		569	554				554						381		2		383			0		0
1989	43		418		461	626		1		627						341		0		341			1		1
1990	28		650		679	695		1		696						328				328			0		0
1991	48		419		467	1585		1		1586						256		0		256			1		1
1992	15		622		637	2019	2			2021						384		0		385			0		0
1993	23		754		777	1475				1475						213		1		213			0		0
1994	101		943		1045	1724	1			1726						282		1		284			0		0
1995	64		685		749	1422		2		1424						170		0		170	0				0
1996	55		373		428	1206		6		1212	3				3	326		0		327	1				1
1997	39		405		444	1420		12		1432	15		4		19	159		1		159	0				0
1998	33		338		371	1126		19		1144	1		0		1	259	1	1		261	1				1
1999	28		396		424	1034		12		1047	2		4		6	170	1	1		172	0				0
2000	33		533		567	985		3		988						213		0		214	1				1
2001	41		465		506	566		8		574	1				1	141		0		141	1				1
2002	83		527		610	269		13		282	1				1	181		0		181	0				0
2003	142		385		527	151		13		164	9				9	187				187	0				0
2004	275		303		578	253		12		264	3				3	105				105	2		1		3
2005	63		305		367	226		12		237	1				1	133				133	2		0		2
2006	62		240		302	209		8		217						122				122	0		1		1
2007	301		120		421	91		11		101	5				5	143		0		143	0				0
2008	229		162		391	131	1	9		141	30				30	55				55	2				2
2009	143		206		349	67	4	13		84	36		0		37	26				26	1		0		1
2010	9		13		21	83	11	18		113	6				6	10				10	0		0		1
2011	2	0	12		14	68	2	17		87	7	0	0		7	14	0			14	0	0	0		0
2012	1	0	24		25	134	5	8		147	25	0	0	0	26	12	0			12	1	0	0		1
2013	1	0	9		10	248	6	30	0	284	29	0	0	0	29	0	0			0	0	0	0	0	0
2014	0	0	5	0	5	14	14	7		35	13	0	25		38	0	0			0	0	0	0	0	0
2015	5	0	3		8	15	67	9	2	93	3	0			3	0	0			0	0				0
2016	3	0	6		9	10	13	5	2	30	1	0			1	0	0			0	0	0	1		1
2017	1	0	7	0	8	16	24	8	2	50	0	0	0	0	0	0	0	0	0	0	0	0	1		1
2018	0	0	4		4	11	12	3	2	28	4	0			4	0	0			0	0	0	0		0

Table 3. Updated values of the four components of susceptibility (availability, encounterability, selectivity, and post-capture mortality) used to calculate the harvested proportion of the population (U) and the corresponding *F* proxy by fleet and for the North and South Atlantic areas combined.

Fleet	Availability	Encounterability	Selectivity	Post-capture mortality	U	F
Canada	0.10	0.31	0.66	0.42	0.0089	0.0089
Portugal	0.15	0.20	0.46	0.51	0.0073	0.0074
Japan North	0.32	0.09	0.20	0.58	0.0033	0.0033
USA	0.33	0.46	0.19	0.53	0.0154	0.0155
Japan South	0.44	0.07	0.20	0.67	0.0043	0.0043
Namibia	0.11	0.16	0.47	0.71	0.0060	0.0060
South Africa	0.11	0.04	0.29	0.71	0.0009	0.0009
Uruguay	0.12	0.13	0.40	0.75	0.0047	0.0048
North Atlantic	0.60	0.18	0.38	0.50	0.0200	0.0202
South Atlantic	0.49	0.08	0.26	0.69	0.0070	0.0070

Table 4. Updated values of instantaneous fishing mortality rate (*F*) and F_{MSY} values for the North and South Atlantic obtained with different assumptions about selectivity. "Original" refers to the preliminary values in SCRS/2020/099; "New mean PRM" is the updated scenario assuming a PRM equal to the mean of the two available values (now 16.95%); "New high PRM" is the updated scenario assuming the high PRM value (27.2%); and "New low PRM" is the updated scenario assuming the low PRM value (6.7%).

	F				F_{MSY}		
Area	Original	New_mean PRM	New_high PRM	New_low PRM	Dome-shaped	Logistic	Both
North	0.031	0.020	0.023	0.018	0.049	0.036	0.042
South	0.005	0.0070	0.0074	0.0066	0.062	0.045	0.053

Table 5. Probability of being above the overfished reference point by 5-year time period for removal scenarios ranging from 0 to 24,000 individuals (0-734 mt) for porbeagle in the northwest Atlantic. The highest removals scenario that enables the stock to rebuild with a 60% probability within 2.5 generations (50 years) is shown in bold.

Removals (#)	Removals (mt)	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
0	0	2%	21%	47%	68%	83%	92%	96%	98%	99%	99%	100%
1000	31	3%	21%	44%	63%	77%	87%	92%	95%	97%	98%	99%
2000	61	2%	19%	40%	57%	71%	81%	87%	91%	94%	95%	96%
3000	92	1%	16%	35%	50%	62%	72%	79%	85%	88%	90%	92%
4000	122	2%	15%	32%	47%	58%	66%	73%	78%	82%	84%	87%
5000	153	2%	13%	27%	41%	50%	58%	64%	68%	72%	76%	78%
6000	183	1%	12%	25%	37%	45%	52%	57%	62%	65%	67%	70%
7000	**214**	**2%**	**10%**	**22%**	**32%**	**39%**	**46%**	**50%**	**54%**	**57%**	**60%**	**62%**
8000	245	2%	10%	19%	27%	34%	39%	44%	47%	50%	53%	55%
9000	275	2%	8%	17%	23%	30%	34%	38%	41%	43%	45%	47%
10000	306	2%	8%	14%	20%	25%	29%	31%	34%	36%	38%	39%
11000	336	1%	6%	13%	17%	21%	25%	27%	29%	31%	32%	33%
12000	367	2%	7%	11%	15%	18%	21%	23%	24%	26%	27%	28%
13000	398	2%	5%	9%	12%	14%	16%	18%	19%	20%	21%	22%
14000	428	2%	5%	7%	9%	12%	13%	14%	15%	16%	17%	18%
15000	459	1%	3%	5%	6%	8%	9%	10%	11%	11%	12%	12%
16000	489	2%	3%	4%	5%	6%	7%	8%	9%	9%	10%	10%
17000	520	2%	2%	3%	4%	5%	5%	6%	6%	6%	7%	7%
18000	550	2%	2%	2%	3%	3%	4%	4%	4%	5%	5%	5%
19000	581	2%	1%	2%	2%	3%	3%	3%	3%	3%	3%	4%
20000	612	2%	1%	1%	2%	2%	2%	2%	2%	2%	3%	3%
21000	642	2%	1%	1%	1%	1%	1%	2%	2%	2%	2%	2%
22000	673	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
23000	703	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
24000	734	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%

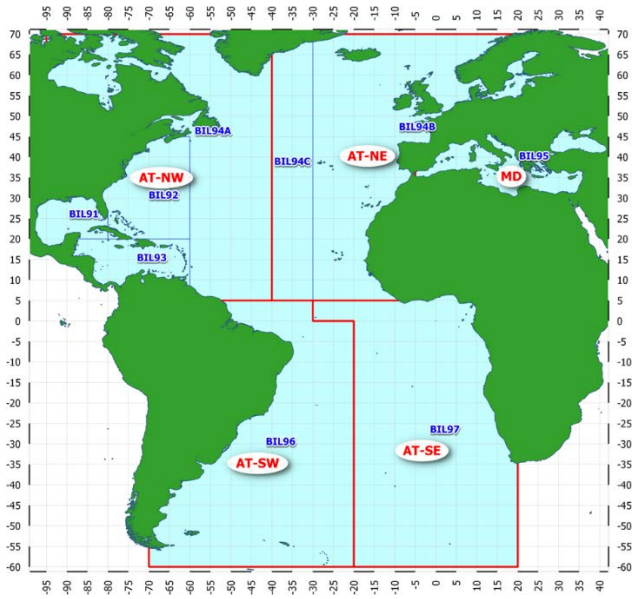


Figure 1. Billfish (BIL) sampling areas used to allocate the Task 1 nominal catches of POR into the four stocks. The Mediterranean area (BIL95) was left apart for future consideration.

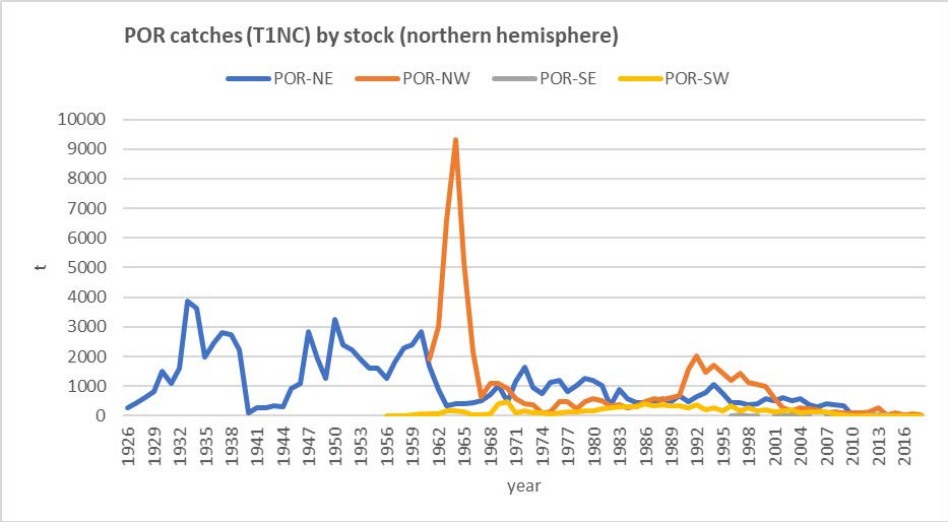
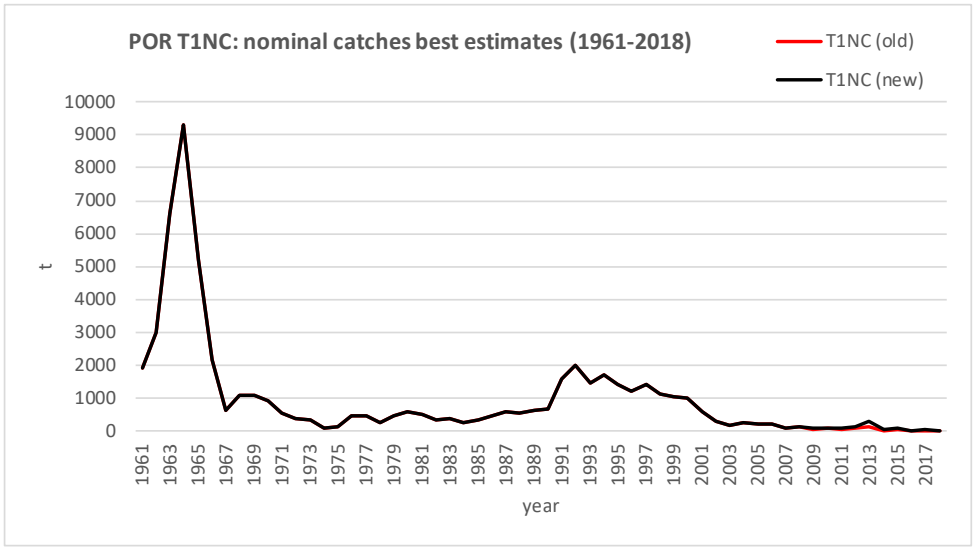


Figure 2. POR Task 1 nominal catches (t) by major stock between 1926 and 2018.



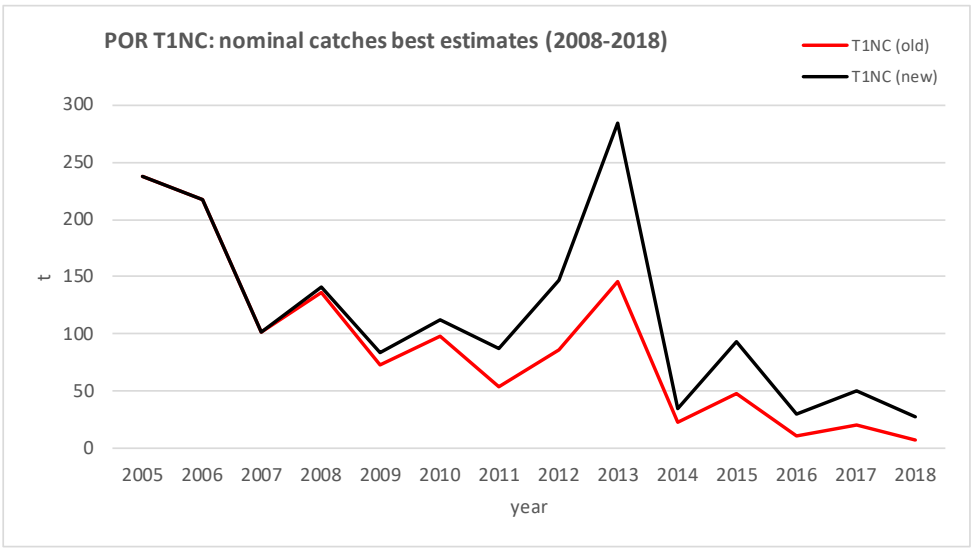


Figure 3. Old and new estimated T1NC catch series for Porbeagle shark, 2005-2018.

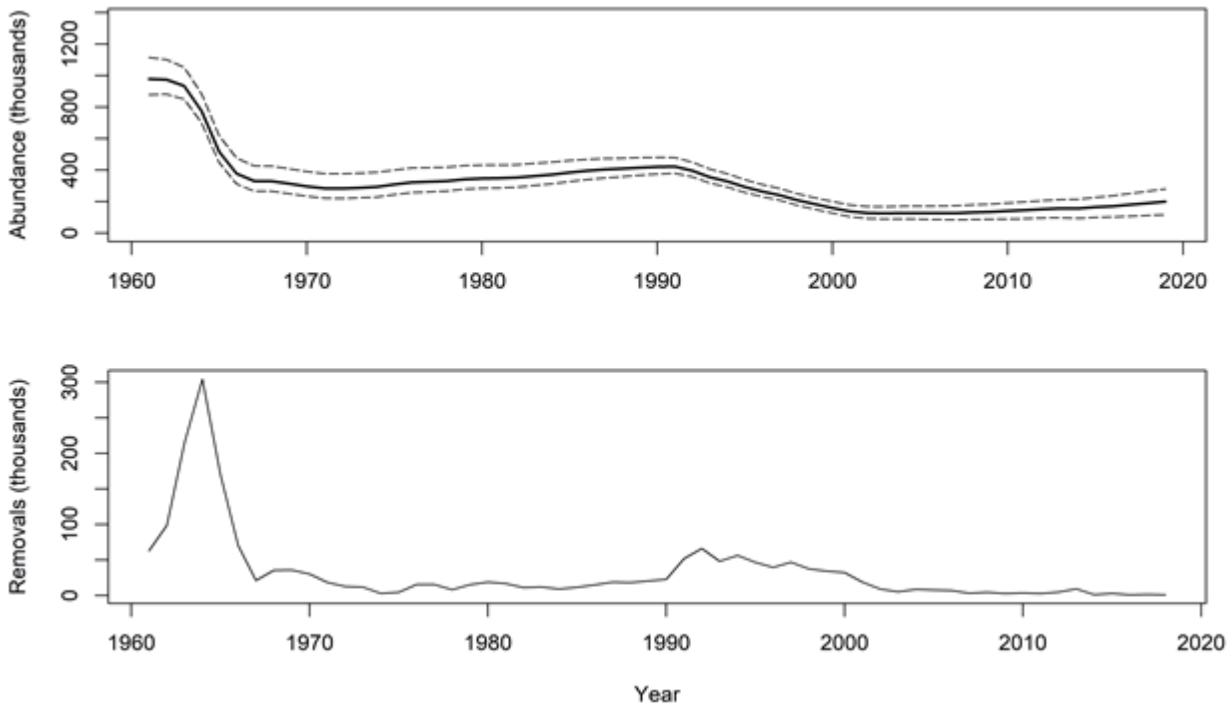


Figure 4. Median predicted abundance (solid line) plus 80th percentiles (dashed lines) from the ICM during 1961 to 2019 for the northwest Atlantic stock of porbeagle (top panel) compared to the re-constructed time series of removals from Task 1 (lower panel). Both are shown as a number of animals rather than biomass.

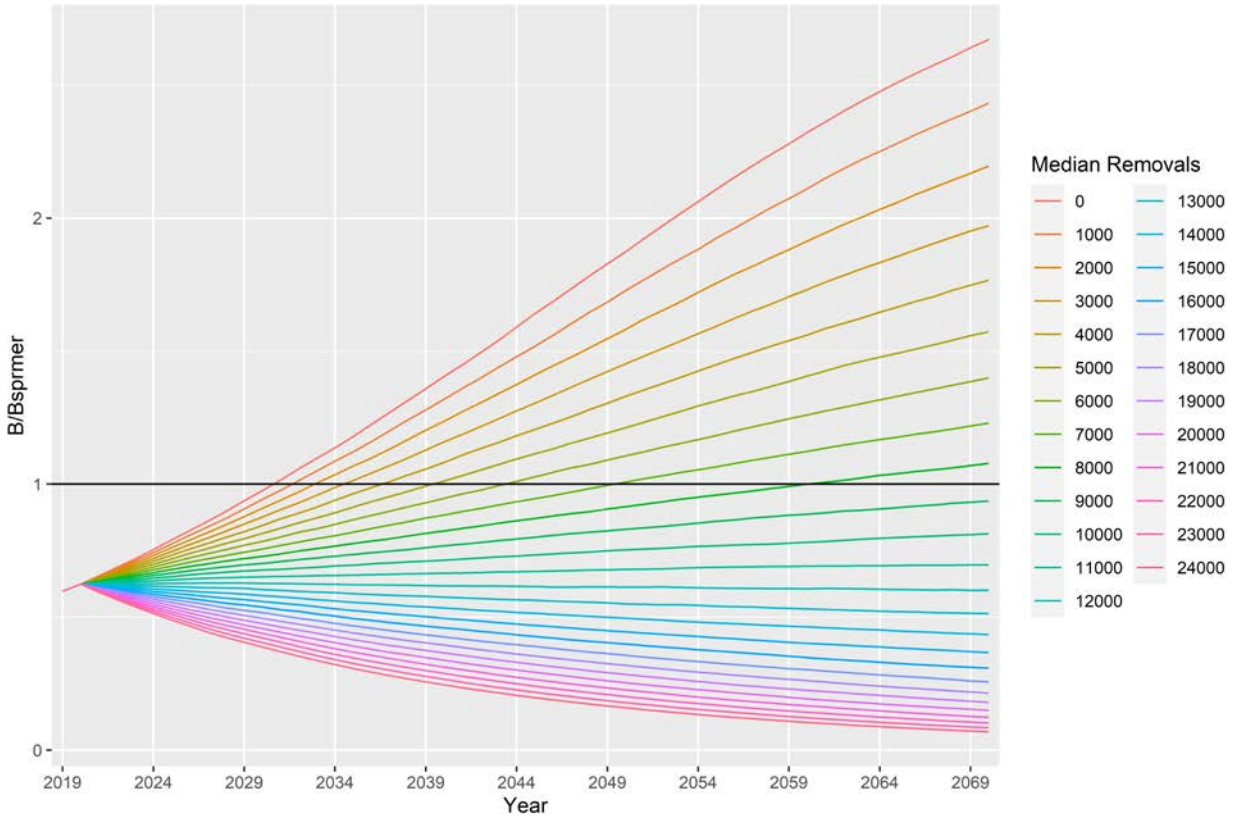


Figure 5. Predicted relative abundance for annual removals ranging from 0 to 24,000 animals, expressed as the biomass/biomass at SPR_{MER} ratio for the base case of the ICM. The horizontal line shows the reference point and the projections extend for 50 years. Average removals from 2016-2018 were assumed for 2019 and 2020 and the projection starts in 2021.

Appendix 1

Agenda

15-19 June 2020 (working hours 12:00 - 16:30 CET)

1. Opening, adoption of Agenda and meeting arrangements
2. Summary of available data submitted by the assessment data deadline (**15 May 2020**)
   2.1 Stock identity
   2.2 Catches
   2.3 Indices of abundance
   2.4 Life history
   2.5 Length compositions
   2.6 Other relevant data
3. Methods and other data relevant to the assessment
   3.1 Quantitative (SAFE) Ecological Risk Assessment
   3.2 An incidental catch model (ICM)
   3.3 Length-based Spawning Potential Ratio
   3.4 Other methods
4. Stock status results
   4.1 Quantitative (SAFE) Ecological Risk Assessment
   4.2 An incidental catch model (ICM)
   4.3 Length-based Spawning Potential Ratio
   4.4 Other methods
   4.5 Synthesis of assessment results
5. Recommendations
   5.1 Research and statistics
   5.2 Management

22 June 2020 (working hours 12:00 - 17:00 CET)

6. Executive Summary for Porbeagle
7. Other matters
8. Adoption of the report and closure

Appendix 2

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Kimoto, Ai
Taylor, Nathan G.

Appendix 3

List of Papers and Presentations

SCRS/2020/008	Report of the Porbeagle stock assessment meeting	Anonymous
SCRS/2020/073	Distribución de tallas de *Lamna nasus* en la pesquería española de palangre dirigida al pez espada	Mejuto J., Ramos-Cartelle A., García-Cortés B., and Fernández-Costa J.
SCRS/2020/084	Indicator analysis of porbeagle in the northwest Atlantic Ocean based on Japanese longline observer data	Semba Y., and Kai M.
SCRS/2020/090	Estimates of vital rates and population dynamics parameters of interest for porbeagle shark in the western North Atlantic and South Atlantic oceans	Cortés E., and Semba Y.
SCRS/2020/096	An incidental catch model for porbeagle assessment and status evaluation	Bowlby H.D., and Cortés E.
SCRS/2020/097	Size distribution of porbeagle shark in the North and South Atlantic using data from observer programs	Santos C.C., Forselledo R., Mas F., Cortés E., Carlson J., Bowlby H., Semba Y., Kerwath S., da Silva C., Parker D., Jagger C., Rosa D., Domingo A., and Coelho R.
SCRS/2020/099	Preliminary sustainability assessment for fishing effects (SAFE) of pelagic longline fisheries on porbeagle sharks and identification of f-based biological reference points	Cortés E., Bowlby H., Carlson J., Coelho R., Domingo A., Forselledo R., Jagger C., Mas F., Parker D., Santos C., Semba Y., Taylor N., and Zhang X.
SCRS/2020/100	Quantifying horizontal overlap between longline fleets and porbeagle distribution for ecological risk assessment	Bowlby H.D., Taylor N., and Carlson J.
SCRS/2020/105	Estimates of mortality rates from mean length in the fully selected size range for porbeagle	Babcock E.

SCRS/P/2020/034	Hooking mortality of porbeagle shark (*Lamna nasus*) in pelagic longline fisheries in the southwestern Atlantic Ocean	Federico Mas, Rodrigo Forselledo, Sebastián Jiménez & Andrés Domingo
SCRS/P/2020/035	Standardized CPUE of porbeagle shark (*Lamna nasus*) caught by the Uruguayan pelagic longline fleet in the southwestern Atlantic Ocean (1982-2012)	R. Forselledo, F. Mas, A. Domingo and S.D. Hoyle
SCRS/P/2020/036	The performance of input control options for the management of porbeagle shark - a management strategy evaluation approach.	Taylor N.G.
SCRS/P/2020/037	Fisheries independent abundance index for porbeagle	Bowlby H., Yin Y., Joyce W.
SCRS/P/2020/038	Estimates of vital rates, productivity, and other population dynamics parameters of interest for Porbeagle sharks	Cortes E. and Semba Y.

SCRS/P/2020/039	Preliminary Sustainability Assessment for Fishing Effects (SAFE) of pelagic longline fisheries on Porbeagle sharks and identification of F-based biological reference points	Cortés E, Bowlby H., Carlson J, Coelho R, Domingo A, Forselledo R, Jagger C, Mas F., Parker D, Santos C, Semba Y, Taylor N, and Zhang X
SCRS/P/2020/040	Study on the possibility of applying length-based models to estimate the reproductive potential of Porbeagle	Cardoso L.G.
SCRS/P/2020/041	An incidental catch model for porbeagle assessment and status evaluation	Bowlby H.D. and Cortés E.
SCRS/P/2020/042	Quantifying horizontal overlap between longline fleets and porbeagle distribution for ecological risk assessment.	Bowlby H.D., Taylor N., and Carlson J.

Appendix 4

SCRS Documents and Presentations abstracts as provided by the authors

SCRS/2020/073 A total of 5,136 size observations of porbeagle were recovered for the period 1987-2017. The GLM results explained very moderately the variability of the sizes considering three main factors, suggesting minor but significant differences in some cases especially for the year factor and non-significant differences in other factors depending on the analysis. The greatest differences in the standardized mean length between some zones were caused by some large fish of unidentified sex. The standardized mean length data for the northern zones showed stability throughout the time series, a very stable range of mean values and very few differences between sexes. The size distribution for northern areas indicated an FL-overall mean of 158 cm. The size showed a normal distribution confirming that a small fraction of individuals of this stock/s is available in the oceanic areas where the North Atlantic fleet is regularly fishing and the fishes are not fully recruited to those areas and /or this fishing gear up to 160 cm. The data suggests that some individuals could sporadically reach some intertropical areas of the Atlantic.

SCRS/2020/084 This document presents indicator analysis, a review of the results for the annual change of abundance index and body size of porbeagle (*Lamna nasus*) caught in the northwest Atlantic Ocean based on Japanese longline observer data between 2000 and 2018, to examine the trends of abundance after implementing the management measure. Due to the low spatiotemporal coverage of the catch data, the modeling approach for the standardization of CPUE (catch number per 1,000 hooks) was limited in terms of the explanatory variables used. The estimated annual trend of abundance was close to that of nominal CPUE and stable between 2000 and 2014 at a low level of < 1.0 catch number per 1,000 hooks, but it showed an increasing trend from 2014 to 2018. Body size in the dataset used for the standardization showed that juvenile dominated in both sexes, but annual trend was observed during the period. In relation to the trend of the abundance index, median and mean body length became smaller (<1m PCL) in recent years with increasing CPUE, compared to those in the preceding years. The sex ratio was generally even and the adult ratio was lower than 5% in most years, except for few years in both sexes. Although these trends were obtained based on limited area and thus careful consideration is necessary, a series of results may suggest the possibility of an increasing trend of abundance and young individuals since the mid-2010s.

SCRS/2020/090 Vital rates and population dynamics parameters for potential use as inputs in stock assessment models were updated for the western North Atlantic Ocean population of porbeagle shark and computed for the South Atlantic Ocean based on published biological information. Population dynamics parameters included maximum population growth rate (rmax), generation time (A), steepness of the Beverton-Holt stock-recruitment relationship (h), position of the inflection point of population growth curves (R), and spawning potential ratio at maximum excess recruitment (SPRMER). We used multiple methods to compute rmax: four age-aggregated methods and two age-structured methods. Additionally, we used a Leslie matrix approach to incorporate uncertainty in growth parameters, maturity ogive, natural mortality, and lifespan. Productivity (rmax) for the western North Atlantic assuming an equally probable 1- or 2-year breeding frequency was 0.045-0.068 yr-1for the six deterministic methods. For the stochastic Leslie matrix, mean values were: rmax = 0.059 yr-1(approximate 95% CIs=0.037 – 0.081), h = 0.45 (0.31 – 0.59), R = 0.60 (0.54 – 0.70), A = 20.1 years (17.3 – 21.3), and SPRMER = 0.56 (0.41– 0.74). The South Atlantic was more data deficient and we had to use life history data from the South Pacific. The stochastic Leslie matrix resulted in very low or implausible values of productivity and other population parameters for all breeding frequency scenarios, especially for the assumption of long breeding frequency and even for the annual reproductive cycle some estimated parameters were out of bounds. Based on this we recommend using results of the deterministic scenario with an annual reproductive cycle and longevity obtained through bomb radiocarbon (65 years), which yields rmax = 0.059 yr-1, h = 0.45, and SPRMER = 0.55.

SCRS/2020/096 Fisheries landings and associated biological data collection for porbeagle shark (Lamna nasus) declined substantially following CITES Appendix II trade restrictions in 2013. This document describes a new stock assessment method that can be used when length-frequency data and CPUE series are not available or reliable to index changes in abundance. The Incidental Catch Model (ICM) is based on the same general premise as data-poor, length-based assessments, in that it uses life history information and equilibrium assumptions to

derive a theoretical age-structured population in the absence of fishing. In the ICM, the effect of historical fishing pressure on productivity is taken into account prior to evaluating fishery removals and abundance relative to reference points. The northwest Atlantic stock was used to demonstrate the method, which can be easily adapted to assess stocks in the northeast and South Atlantic by changing life history inputs.

SCRS/2020/097 Information on size and sex distribution of porbeagle sharks collected by fishery observers from several longline fleets in the Atlantic (EU-Portugal, Canada, Japan, Namibia, South Africa, Uruguay and the USA) were analyzed. Datasets included information on the geographic location, size and sex of the specimens. A total of 26,404 porbeagle shark records collected between 1992 and 2019 were compiled, with the sizes ranging from 45 to 285 cm FL (fork length). The distributional patterns presented in this study provide a better understanding of different aspects of the porbeagle shark distribution in the Atlantic and can be used in the 2020 ICCAT POR stock assessment.

SCRS/2020/099 A Sustainability Assessment for Fishing Effects (SAFE) was conducted for the porbeagle shark in the North and South Atlantic oceans. The SAFE approach is a quantitative assessment that computes a proxy for fishing mortality rate as the product of four susceptibility components: availability of the species to the fleets, encounterability of the gear given the species vertical distribution, gear selectivity, and post-capture mortality. The information used to compute the four components came from several sources: observer programs from several ICCAT fleets (capture location, size, status, and disposition of observed animals, vertical distribution of the gear), archival tags from various ongoing projects (distribution, vertical habitat use, and post-release mortality), and ICCAT catch and effort data. The product of these four components was used to compute a harvest rate that can be expressed as F (instantaneous fishing mortality rate) and compared to a value of FMSY obtained based on productivity values derived exclusively from life history data. Results suggest that the porbeagle in the North and South Atlantic are not undergoing overfishing.

SCRS/2020/100 The Sustainability Assessment for Fishing Effects (SAFE) ecological risk assessment was updated by the Sharks Species Group for the 2020 assessment of porbeagle shark (*Lamna nasus*). This paper describes how distribution information for the northern and southern stocks was evaluated relative to fishing effort to determine the extent of geographical overlap (i.e. availability) of porbeagle to commercial fishing activity. Availability was calculated as the amount of the porbeagle distribution (5x5 degree resolution) used by the fishery divided by the total area of the porbeagle distribution in the North or South Atlantic. For comparison, the proportion of fishing effort that overlaps with porbeagle relative to the total amount of fishing effort was also calculated in the North and South Atlantic

SCRS/2020/105 The method of Beverton and Holt was used to estimate fishing mortality rates from mean lengths of fully selected porbeagle sharks in each year for the northwest, southwest, and southeast stocks. Confidence intervals were calculated by bootstrapping the length data and drawing values of the parameters from a multivariate normal distribution. The analysis was conducted first with all the length data combined for each stock and then by fleet within each stock. Fishing mortality rates were estimated to be higher than M and declining in the northwest Atlantic, high and variable in the southeast Atlantic, and low in the northeast Atlantic. These results imply that the length distributions in the northwest and southeast are consistent with a population experiencing overfishing, while the southwest is not experiencing overfishing. However, since this method makes an equilibrium assumption, the results reflect historical overfishing more than current fishing mortality rates.

SCRS/P/2020/034. In the frame of the Shark Research and Data Collection Program (SRDCP), and the upcoming Porbeagle shark (*Lamna nasus*) stock assessment, this document has the main objective of presenting new information related to hooking mortality of the species in the southwest Atlantic Ocean. To this end, data gathered by the Uruguayan National Observer Program onboard longline fishing vessels as well as data from Uruguay's research vessel were used. Data from fishing vessels came from two fleets, namely the Uruguayan longline fleet (2003-2012) and the Japanese longline fleet which operated within the Uruguayan EZZ in 2009-2011 and during 2013. A General Additive Mixed Model (GAMM) with a binomial distribution was adjusted considering biological, environmental, and operational covariates. The final model also included the Vessel ID as random factor. Covariates considered included size (fork length), sex, mean sea surface temperature, gear type (deep: Japanese vessels; shallow: Uruguayan vessels including the research vessel) and soak time. Results

showed a significant effect of size and sex, albeit the interaction between these terms was not significant. Porbeagle hooking mortality was higher in males but also in larger individuals compared to smaller ones. Mean sea surface temperature had a positive effect on hooking mortality. Gear type was also found to have a significant effect with higher mortality rates in shallow longline sets compared to deep ones. It is suggested that the longer branch-lines used by the Japanese fleet (40-45 m) may allow the specimens to swim more freely, whereas the Uruguayan shorter branch-lines (10-16 m) might restrict their movement and therefore their ventilation capacity. Given that the porbeagle is a highly active and metabolically demanding species, this restriction in movement might result in higher rates of mortality. Soke time was also considered as a covariate in the model but it rendered inconsistent results, probably because it does not fully reflect the time elapsed between hooking and gear retrieval. In addition, sharks caught in the same fishing set would have the same soak time which may confound the real effect of the variable. Possible solutions for this issue in future works are discussed, including the use of hook timers or temperature depth recorders attached to the branch-lines.

SCRS/P/2020/035 corresponds to a paper presented to the WCPFC (Forselledo *et al* 2017) as part of the 2017 Southern Hemisphere Porbeagle Shark Stock Status Assessment. The document presents a standardized CPUE of porbeagle shark caught by Uruguayan longliners in the southwest Atlantic Ocean between 1982 and 2012 based on data from logbooks. The Uruguayan tuna fleet started its activities in 1981 and can be divided into two well-defined periods regarding vessels, type of gear and target species characteristics. In the first period (1982-1992), the fleet was comprised mainly of large freezer vessels with Japanese-style longlines. During the second period (1993-2012) most of the fleet was replaced by smaller size fresh fishing vessels operating mainly with American-style longlines and a few operating with Spanish-style longlines. Vessels in the later period set their fishing gears at shallower depths. Given the change in the fleet, standardization analyses were performed using Generalized Additive Mixed Models as a whole (1982-2012) and as two periods: 1982-1992 and 1993-2012. Finally, the split two-period standardization was selected and presented. Results of the GAMM models show the important effect of *Sea Surface Temperature* (SST), as well as *Latitude,* on porbeagle catches. Standardized CPUE values increase over most of the first part of the time series, when catch rates are higher. In the second part of the time series, after the fleet changed its fishing gear from a Japanese-style to an American-style longline, catch rates are in general much lower. The substantial changes in catch rate after the transformation of the fleet from Japanese style to American-style longlines are independent of *SST* and *Latitude*, suggesting that fishing method factors such as set depth or bait type may affect porbeagle catch rates.

SCRS/P/2020/036 showed the result of a set of MSE simulations on the performance of a series of alternative management procedures that could be used for the assessment and management of porbeagle shark. The approach was to develop operating models based on CPUE series from the 2008 porbeagle assessment, updated task I catch data, and Task 2 size composition information. Model conditioning and closed-loop simulation were developed using the R package MSEtool. The simulations illustrate the performance of a variety of input and output controls for porbeagle shark. Additional development will involve adding fleet structure, updated catch series, and adding implementation error. While some preliminary simulation results for a Porbeagle MSE were presented, the main intent of the MSE (section 3.4) was not to draw any specific conclusions and management procedure performance at this point, but rather to demonstrate that analyzing the performance of management procedures was feasible for porbeagle and that there may be some effective input/out control options for management of porbeagle.

SCRS/P/2020/037 A summary of the preliminary results and analyses of the Canadian fishery-independent longline survey (2007, 2009, 2017) was presented. Although this fixed-station survey was standardized to the extent possible, environmental changes at individual stations likely influenced catch rates of porbeagle. A spatially-implicit hurdle model that incorporated environmental effects suggested that porbeagle distribution has become more diffuse (less concentrated along the shelf edge) and that abundance has declined from 2007 to 2017. The strong abundance decline is counter to predictions from fishery assessment models and CPUE indices from catch data. Variability in catch rates was unacceptably high from this fixed-station design and catches may have been related to a predictor variable that was not considered. These results were not intended to inform the abundance trajectory in the northwest Atlantic for the current assessment. They were provided as an example of why a survey may not index abundance for a pelagic shark like porbeagle.

SCRS/P/2020/038 corresponds to document SCRS/2020/090.

SCRS/P/2020/039 corresponds to document SCRS/2020/099.

SCRS/P/2020/040 The study on the possibility of applying length-based models to estimate the reproductive potential of porbeagle was defined at the Reproductive workshop that was held in Faro, February 2020, after a testing application of a framework, called FishPath (FP). This framework was used in order to contribute to the discussions about what kind of method could be used to assess the species taking into account the lack of data necessary to apply traditional stock assessment methods. FP is a decision support system that, in addition to other possibilities, allows users to characterize a fishery with respect to data and biological/life-history attributes available to identify the most appropriate assessment models. After this application, the group realized that most of the methods suggested by FP were already been considered. But, the Length Based Spawning Potential Ratio (LB_SPR) became another option. This model compares a modeled virginal length composition, and the length composition observed from the catches and, by difference, estimates the available SPR in the stock. It allows for the setting of the reproductive output of mature individuals as constant and independent of size, making it possible to be applied for sharks. At that time, the main challenge was to include dome-shape selectivity to the existing Length Based Spawning Potential Ratio (LBSPR) model, which assumes logistic selectivity. This issue was resolved by a tool launched in May 2020 by Jason Cope (NWSFC – NOAA, USA) which made it possible to include dome-shape selectivity into length based SPR assessment (Stock Synthesis data-limited tool). Before the first model runs, an exploration of the available size data for female porbeagle was performed, splitting the data by stock, fleet, and year, using only years with more than 70 measured individuals. However, this exploration revealed that the catches were composed mainly by immature individuals as can be seen in the figures of document SCRS/P/2020/040. The lack of representativeness of mature females prevents the use of the LBSPR to assess the stock status since this model requires a representative size composition from the mature portion of the stock.

SCRS/P/2020/041 corresponds to document SCRS/2020/096.

SCRS/P/2020/042 corresponds to document SCRS/2020/100.