REPORT OF THE 2008 SHARK STOCK ASSESSMENTS MEETING

(Madrid, Spain, 1-5 September, 2008)

1. Opening, adoption of Agenda and meeting arrangements

Mr. Driss Meski, ICCAT Executive Secretary, opened the meeting and welcomed participants.

The meeting was chaired by Dr. Gerald Scott, SCRS Chairman, during the two first sessions and by Dr. Andrés Domingo, the Shark Species Group Rapporteur, for the rest of the meeting. Dr. Scott welcomed Working Group participants, addressed the terms of reference for the meeting and presented a background of the process for which pelagic sharks had been incorporated into the ICCAT framework. Dr. Scott also highlighted the surprisingly and appreciated large number of participants at the meeting.

After opening the meeting, the Agenda was reviewed, modified and adopted (**Appendix 1**). The List of Participants is included as **Appendix 2**. The List of Documents presented at the meeting is attached as **Appendix 3.**

The following participants served as Rapporteurs for various sections of the report:

Section	*Rapporteurs*
1, 10, 11	P. Pallarés
2	C. Simpfendorfer and E. Cortés
3	J. Ellis and J. Mejuto
4	S. Clarke
5	V. Restrepo, F. Arocha and F. Hazin
6, 7, 8	B. Babcock, P. Apostolaki and K. Andrews
9	A. Domingo and E. Cortés

2. Review of biological information and ecological risk assessment

2.1 New biological information

2.1.1 Blue shark

Document SCRS/2008/144 presented information on reproductive aspects of female blue sharks. Data from Uruguay's tuna fleet observer program on mating areas and seasons were presented as well as embryo sizes. The size structure of males and females was analyzed and spatial distributions displayed.

2.1.2 Oceanic whitetip shark

New information on the reproductive biology of the oceanic whitetip shark (*Carcharhinus longimanus*) was presented based on research in the equatorial southwestern Atlantic Ocean (SCRS/2008/155). This region appears to be an important area for juveniles of this species; with 80.7% and 89.4% of males and females, respectively, being juvenile. Size at first maturity was estimated at 160-196 cm TL, and 181-203 cm TL for males and females, respectively. Litter sizes from three individuals ranged from 1 to 14. Mating was hypothesized to occur around March (austral autumn) and parturition approximately 10 months later in January. Ongoing sampling is aiming to confirm the hypothesis about the timing of the reproductive cycle.

2.2 Population organization of blue sharks in the South Atlantic

Information on the organization of the blue shark population in the South Atlantic based on observer data from the Uruguayan fleet was presented (SCRS/2008/144). The data indicated a relatively high level of spatial organization within the population, often based on sex and reproductive stage. Discussion following the presentation of the document confirmed the complex organization within the population that results from differences in movement patterns between sexes and reproductive stages. It was suggested that there may be a latitudinal structure within the population. Further research, the compilation of data from all available observer programs in the South Atlantic and any available tagging data, will be required to provide a clear understanding of the complex geographic organization and the movement patterns that drive it.

2.3 Ecological risk assessments

Ecological risk assessment (ERA), also known as productivity and susceptibility analysis (PSA), has become a common tool to provide information for data-limited shark populations. This approach is not a substitute for stock assessment, but can be used to help determine appropriate management actions and research recommendations. This type of analysis typically assesses the risk based on two factors: biological productivity and susceptibility to a particular type of fishery. ERA results for shark and ray species typically taken in Atlantic pelagic longline fisheries were presented in two documents. One document contained a level-3 quantitative ERA, with susceptibility to pelagic longline fishing data from a range of different fleets (SCRS/2008/138); the other (SCRS/2008/140) used a multidimensional measure of risk that added the estimated position of the inflection point of the population growth curve (a proxy for the level of depletion at which MSY occurs) and IUCN Red List status to productivity and susceptibility (mostly from US observer data). The two assessments utilized the same biological productivity data, which were based on the biological parameters listed in **Table 1**. Neither document presented results for the crocodile shark as there were insufficient life history data to determine biological productivity. The multidimensional assessment also did not include the smooth hammerhead. Life history data for longfin mako were not available, but parameters from the shortfin mako were used as a proxy. Although ERA does not provide a measure of the status of a species, inclusion in the ERA of species for which stock assessments are available (e.g. blue shark and shortfin mako in this case), allows one to potentially determine the level of risk of over-exploitation for other species by comparing their relative positions on the risk plots.

The two ERAs provide similar overall estimates of risk of over-exploitation for the species considered (**Figure 1**). Blue sharks or pelagic stingrays were consistently the species with the lowest level of risk. Scalloped hammerhead sharks also had lower levels of risk. Species with higher levels of risk from both ERAs were considered the bigeye thresher, shortfin mako, longfin mako, oceanic whitetip and silky sharks. Two species, common thresher and porbeagle, had somewhat contradictory levels of risk between the two assessments; the multidimensional ERA indicated higher levels of risk **(Figure 1a**), while the two-dimensional ERA indicated lower levels of risk (**Figure 1b**). Since the same biological productivity values were used in the two ERAs, differences in risk levels for these two species were the result of differences in susceptibility values. These values are strongly dependent on the fleet (or fleets) from which observer data were used. Analysis of observer data from six different fleets, and a combined fleet, showed relatively large differences in risk rankings (**Table 2**). The differences between fleets reflect different fishing practices, gear types, available markets and or geographic extent of fisheries.

Data on the distribution of some species of pelagic elasmobranch species within the Atlantic based on observer surveys on Uruguayan vessels (SCRS/2008/143) showed significant differences with respect to those in the literature that were used in the current ERA assessments. These differences were especially large for species such as the scalloped and smooth hammerhead sharks, which have traditionally been best known from continental shelf waters. Similarly, common thresher and porbeagle are more abundant in shelf seas, and are hence less vulnerable to pelagic longline fisheries. These new data, and others like them, should be used to improve susceptibility estimates in ERAs so that they better reflect the true distribution of species and areas or sites of high relative abundance.

Discussion following the presentation of the ERA results identified the need to have representative information on susceptibility from all fleets, the need for accurate biological information to enable the estimation of productivity, and that the inclusion of a range of taxa that interact with pelagic longline fisheries would be useful for comparative purposes. It was also pointed out that species that also occur in continental shelf waters, and hence interact with a range of other fisheries, may be difficult to fully represent in ERAs. Given the variability in susceptibility values, and their potential variation depending on fleets considered (both ICCAT and non-ICCAT), the group concluded that the use of biological productivity alone may be more informative with respect to relative risks imposed by all fishing. To this end, rankings of species by biological productivity values (intrinsic rate of increase) are given in **Table 3**. For species with the most conservative biological characteristics and for which sufficient data to undertake a stock assessment are not available, fishing mortality values would need to be below the intrinsic rate of increase, which in these cases is close to zero, if a precautionary approach to management is taken. In the precautionary management context an increase in data could result in more liberal management approaches to achieve the same conservation objective. Thus, the group considered that there was a critical need for both more biological and fisheries data to provide improved understanding of the status of most pelagic species.

In developing management recommendations based on productivity, ERAs do not provide information about precise stock targets as do stock assessments. Thus, management measures would need to focus on the reduction of fishing mortality (F), which can be achieved by a variety of methods, which may depend on the fleet, species or area. Types of approaches to achieve lowering F include (but are not limited to): live release, size limits, time or area closures, prohibition and [others]. Given the difficulties in implementing reductions in F (and that the Commission has already recommended reductions in F by encouraging live release and research to make gear more selective [Resolution 04.10 paragraphs 6 & 8]), and the variety of approaches possible, if the Commission implements such a policy but does not specify the exact measure, then it should require contracting parties to report back on the measure(s) taken and their effectiveness so that assessments can be made of the overall benefits to stocks. This may include (but is not limited to) providing data from observer programs and results from research projects.

Given the limitations of the data available for shark species for which ERA represents the best available assessment, the Working Group was not able to evaluate the potential benefits of all of the methods available to reduce F. However, data presented to the meeting from observer programs of two Contracting Parties (USA and Venezuela) (**Table 4**) indicates the level of reduction in F (by species) that could be achieved if individuals that were alive when the gear is retrieved were released alive (**Table 5**). The data from the two countries probably represent the extremes of a continuum of outcomes, with the USA (which currently releases many sharks alive) being able to decrease F by relatively small amounts, while Venezuela (which currently retains all sharks) would be able to achieve large reductions in F.

3. Review of Tagging data and conversion factors (fin to body weight)

Blue shark are the best-studied shark species in terms of tagging studies, and comparable data are more limited for other species. **Well-designed tagging studies can be very useful and such programs should be encouraged for other priority species.** Conventional tagging may be particularly useful in terms of stock assessment, giving cost-effective information in the short term.

The Working Group was updated on the status of blue shark tagging data from the various tag-and-release programs being undertaken by various ICCAT members.

Data from the Irish recreational fishery for blue shark (SCRS/2008/130) were presented. These data have now been submitted to ICCAT. The dataset consists of fish tagged and/or recaptured from 1970 to 2006. Since 1970, 16,804 sharks were tagged and there have been 789 recaptures (4.7%). Sharks were tagged by recreational fishermen fishing in coastal waters, usually during the summer when the waters are >14ºC. As previously noted in scientific studies, females predominate in this part of the Atlantic at this time of the year. Tag recaptures have been reported from various fisheries, including offshore longline fisheries and drift net fisheries in the Bay of Biscay. There have been no reported recaptures from the South Atlantic and only one from the Mediterranean Sea, support the view that there is a single North Atlantic stock separate from that in the Mediterranean. The lack of recaptures in the central North Atlantic was noted, and it is unclear as to whether there is a biological explanation for this, and/or there are major differences in reporting rates by the various fleets operating in the North Atlantic. Further examination of combined Irish and U.S. recaptures and effort in tuna fisheries was performed during the meeting. Further work on reporting rates could usefully be undertaken, as should combined analyses of ICCAT/US/Irish tagging studies, with the results viewed in relation to the spatial distribution of the main fleets. The Working Group recommends that future tag seeding experiments be conducted to allow estimations of tag reporting rates.

Irish data (SCRS/2008/130) reported only one recapture from the Mediterranean Sea, and none from south of the equator. This agrees with Kohler *et al.* (1998), who found few captures from outside the North Atlantic. However, both datasets are based on tagging of sharks from well north of the equator and it is not possible to know if sharks tagged nearer the equator would move across it.

Summary results were also presented for Japanese tagging studies (SCRS/2008/151). In the Atlantic observer program of Japan, 499 sharks of six species were released with tags by the scientific observers from 2000 until now. Blue shark was dominant, accounting for more than 93% (n = 462), with porbeagle (3%) the second most tagged species. Twenty-seven tags attached to blue sharks were returned, with a recapture rate of 5.4%. The longest time at liberty is 610 days and the longest migration is about 3,200 km, which suggest the large-scale migration of blue shark. A partial submission of these data (only the recoveries) has recently been received by ICCAT. Given its importance for longline fishing mortality studies, the Secretariat should request to Japan the complete tagging dataset (499 sharks tagged).

Revised analyses of tagging data from the ICCAT database were also presented. These data have previously been used to show the movements of the North Atlantic stock. The presentation focused on modelling of tagging data to examine fishing mortality, using a population dynamics model modified from Hilborn (1990). Tagging data were allocated to four regions, broadly equating with the NW, NE, SW and SE sectors of the North Atlantic; three tag shedding scenarios were considered (0, 10 and 20%), and various scenarios of tag reporting rate were also examined for four of the main fishing nations in the area (USA, Spain, Japan and Venezuela). Preliminary results indicated that F was heterogeneous (<0.1 in the western areas, and approaching 0.2 in the eastern Atlantic).

The Working Group viewed the work very favorably and further development of this model is encouraged, including sensitivity analyses of reporting rates. The addition of Irish tagging data, increased complexity (e.g. size and sex-specific components), more modelling of effort time series and further studies on the reporting rates by the different fleets could also be usefully undertaken, and such work could be best done by correspondence.

It is recommended that the USA, European and other tagging data be combined for an integrated stock assessment model for the wider North Atlantic. Any new or unsubmitted data should be provided to ICCAT prior to its use in the next assessment.

There was also a brief overview of the tagging information held at ICCAT, with recent data from Spanish and Uruguayan studies, and revised information from the USA recently supplied (3000 extra releases) (**Table 6** and **Figures 2** and **3**). The combined data sets should be examined, and contrasted to maps of effort distribution by the main fleets in order to better gauge the apparent lack of recaptures from the central North Atlantic, as described above.

3.1 Stock identity

There were also discussions regarding the southern limits of North Atlantic shark stocks, with rationales suggested for using either the equator or 5ºN. Data from Irish tagging studies have had recaptures between the equator and 5ºN, but not south of the equator, and the equator has been used as the southern boundary in some previous assessments. However, other large pelagic species have a southern boundary of 5ºN for assessment purposes, including swordfish (e.g. Chow *et al.* 2007; ICCAT, 2007), and such data have been used in the estimation of shark landings. The oceanography of the region would also suggest a boundary at 5ºN. The revision of around 2,000 records of blue shark recaptured by the Spanish longline fleet in the North and South Atlantic (see SCRS/2004/103) from different tagging programs carried out by different countries indicated that around 99% of blue sharks tagged in the North Atlantic were recaptured north of 5ºN and only around 1% of recaptured individuals were reported from areas located between 5ºN-5ºS. It was not possible to define the extent of South-North movements because of the more restricted amount of tagging data available in the South Atlantic regions.

Taking into consideration this information and other factors, such as the estimation of shark catches was based on tuna catches using the 5ºN as boundary, the **Working Group recommended to separate North and South Atlantic stocks of blue and shortfin mako at 5ºN latitude, and also into eastern and western stocks for porbeagle, due to their greater abundance in shelf seas**. The Working Group also recommended studying the implication of this assumption on the shark CPUE standardization of those fleets that are not using the same boundary criterion in the future.

In terms of FAO areas, the southern borders of FAO areas run along 5ºN (from South America to 40ºW), 0º (between 20-40ºW) and along 6ºS from 20ºW to the coast of Africa.

4. Review of fishery statistics: Effort and Catch data, including size frequencies and fisheries trends

4.1 Presentation and Discussion of Documents concerning Catch

The issue of catch statistics was addressed in the following presented papers: SCRS/2008/045, SCRS/2008/134, SCRS/2008/139, SCRS/2008/145, SCRS/2008/146, SCRS/2008/147, SCRS/2008/148, SCRS/2008/150,

SCRS/2008/152, SCRS/2008/153, SCRS/2008/156, and SCRS/2008/158. Some of these papers also presented catch rate or biological information and are described in these respects in subsequent sections of this report.

SCRS/2008/134 described catch statistics for pelagic sharks caught by French fisheries in the Atlantic and Mediterranean. A time series of national commercial landings statistics, logbook data and biological information from sampling commercial and research catches have been collated to assess the status of five pelagic shark species caught by French domestic fisheries. According to official statistics, average catch levels, for the last five years for porbeagle (*Lamna nasus*), blue (*Prionace glauca*), thresher (*Alopias vulpinus* and *A. superciliosus*) and basking (*Cetorhinus maximus*) sharks are approximately 270 t, 96 t, 7.5 t and less than 1 t, respectively. Nevertheless, it is likely that large numbers of discarded sharks have gone unrecorded. Generally speaking, there is a paucity of biological data available for pelagic shark species caught by domestic fleets.

In the discussion it was noted that some of the data presented differ from data submitted by France to ICCAT. Delegates from France were requested to provide any updated French catch data in digital form to ICCAT as soon as possible. The reported catch ratio by species showing that porbeagle are caught in greater numbers than blue shark was queried. The discussion clarified that high reported porbeagle catches reflect the fact that this species is a target species, and reported catches of blue shark were suspected to be lower due either to discarding at sea or because fishermen targeting porbeagle will attempt to avoid fishing grounds with high blue shark catch rates. In response to a question regarding why there appear to be more females than males caught, the author cautioned that due to the low number of samples available thus far, the results should be considered preliminary. Clarification was also requested regarding whether the data represented catches (including discards) or landings. The issue of ICCAT data reporting requirements was subsequently discussed in detail as recorded in Section 4.2.

SCRS/2008/139 described a methodology to estimate shark catches in the Atlantic by all fleets based on a characterization of the global fin trade as of 2000, including number and biomass by shark species. Hong Kong trade-based estimates for 2000 were scaled to annual global values for 1980-2006 using the observed quantity of imports to Hong Kong and an approximation of Hong Kong's share of the global trade in each year. The resulting global fin trade figures for each year were then scaled to Atlantic-specific values using three different factors: (1) area of the Atlantic range relative to the global range of pelagic sharks; (2) Atlantic catches of tunas and billfishes relative to global catches of tunas and billfishes; and (3) Atlantic longline effort relative to global longline effort. It was noted that mortality that does not produce fins for international trade (e.g. dead whole discards, post-release mortality, or fins which are taken but not traded internationally) is not accounted for. Therefore, while total removals are likely to be higher than the fin trade-based estimates, total removals are very unlikely to be lower than fin trade-based estimates.

Clarification was requested regarding the unit of effort used in the effort-scaled estimates and which fin to carcass ratios were applied. The author explained that the unit of effort was longline hooks and that fin length to body length, and body length to body weight ratios had been used rather than fin to carcass ratios. It was agreed that the trend of increase over time shown in the results is likely to reflect the increasing utilization of shark fins which occurred during the 1990s. For this reason the estimates were considered to be most useful as a minimum estimate of mortality such that any catch estimates below these levels would be questioned. The ICCAT Secretariat indicated that effort figures for the Atlantic had been revised since the paper was prepared. The author agreed to re-calculate the estimates using the new Atlantic effort data.

SCRS/2008/145 provided data on the catches of blue and shortfin mako shark from 1994-2007 by Mexican pelagic longliners targeting yellowfin tuna (*Thunnus albacares*) in the Gulf of Mexico. Compared to other longline fleets the bycatch of sharks in this fleet is very low, representing only 5% of the catch. These catches are distributed throughout the Gulf of Mexico reflecting the wide distribution of the yellowfin tuna fleet.

Information on species identification methods was requested given that the paper uses the name "tintorera" to refer to both *Galeocerdo cuvier* and *Prionace glauca*. It was explained that observers are able to distinguish between the two species and record them separately. It was also clarified that while some length observations have been estimated, the proportion of length estimates which are estimated versus measured is decreasing with time as observer training improves. In response to a question regarding the very low reported catches of blue sharks, it was explained that since the fishery is not using steel leaders, 4-5% of the hooks are lost before haulback, probably due to sharks biting through the leaders. It was noted that this fishery has 100% observer coverage and observers make note of the bite-offs. Since some of the data in the paper differed from the data previously submitted by Mexico to ICCAT, the authors were requested to provide any data updates in digital format as soon as possible.

SCRS/2008/146 reported catch figures and species composition for a coastal artisanal shark fishery in the coastal waters of the Gulf of Mexico with particular reference to catches of blue and shortfin mako sharks. The species composition data for the area of the Gulf of Mexico around Veracruz was shown because that is the Mexican state that usually shows the highest catches of shortfin mako shark. However, the percentage of the catch that was shortfin mako was only around 0.15%. It was noted that the blue shark is not caught by this artisanal fishery.

SCRS/2008/147 and SCRS/2008/14*8*, containing catch data for Canadian fisheries, were presented on behalf of the authors. SCRS/2008/147 presents data on blue shark catches by the bluefin tuna rod and reel fishery and the pelagic longline fishery for swordfish and tunas. Neither fishery targets sharks and finning has been prohibited in the area since 1994. Substantial blue shark catches in Canadian waters are only reported by Canadian, Faroese, and Japanese vessels, the latter two operating under 100% observer coverage. Total blue shark by-catch has averaged over 2,000 t annually in recent years; landings and dead discards have averaged about 1,000 t annually since 2002. When accounting for discards of blue shark the paper states that 60% are alive upon release in the longline fishery and survival is believed to be about 80% for the rod and reel fishery since the sharks are not on the line as long in this fishery. SCRS/2008/148 presents similar data for shortfin mako. There is no directed fishery for mako, and most catches are bycatch from pelagic longline fisheries targeting swordfish. Observer data confirms that most of the mako caught by both foreign and domestic vessels is retained. Observed catch between 1990 and 1999 averaged about 20 t annually, with most of that attributed to Japanese vessels. Since 1999, virtually all observed catch has been by Canadian vessels and in recent years these catches have averaged 60-80 t per year.

It was noted that the catch data for shortfin mako presented in the latter paper generally match the catch data submitted by Canada to ICCAT but this is the not the case for the blue shark catch data presented in the former paper. The difference may be due to the inclusion of mortality due to dead discards in the catch data presented in the former paper. Canadian scientists were asked to confirm the Canadian catch data in the ICCAT database as soon as possible.

SCRS/2008/150 reported on catch data for the Japanese longline fleet in the Atlantic. Catches for blue shark and shortfin mako caught by the Japanese tuna longline fishery in the north and South Atlantic Ocean were estimated using species-specific logbook data from 1994 to 2006 filtered with a 80% reporting rate. Catch estimates were obtained by calculating CPUE for seven strata, multiplying CPUE by effort and then converting product weight to live weight. Yearly catches of blue shark in the entire region were estimated to be 112,000-359,000 (mean 230,000) in number and 2,900-9,700 t (mean 5,900 t) in weight. Catches of shortfin mako were estimated to be 3,400-13,900 (mean 6,700) in number and 120-640 t (mean 270 t) in weight. Though decreasing trends were observed in both catch number and weight of the two species until 2002, subsequent recoveries were recognized. As estimated catches were considerably higher than reported landings, the difference was assumed to reflect discards at sea. Since most pelagic sharks are alive when hauled, most discards are expected to be live releases. However, it is believed that landings are under-reported and therefore discard/release figures are likely to be over-estimated.

The assumption that sharks which are alive when brought to the vessel are also alive when released was queried given that Japanese fishermen often cut the hook from the shark in order to salvage the gear. It was agreed that more study of this issue would be necessary. In the interim, it was suggested that an assumption of 100% mortality for all sharks which are reported caught could be applied as a sensitivity analysis.

SCRS/2008/152 provided preliminary results from a research program aimed at porbeagles caught by a French fishery in the northeast Atlantic which has targeted this species since the 1960s. The fishery is a seasonal and traditional one which uses drift longlines. Landings have shown a decreasing trend for the past 15 years and the proportion of porbeagle weighing less than 50 kg has increased. In December 2007, a Total Allowable Catch limit was introduced based on international scientific advice which raised concerns regarding the life history of porbeagle shark and the lack of reliable information available. In 2008, a cooperative research program (EPPARTIY) was initiated by the French National Fishery Committee (CNPMEM), the Association pour l'Etude et la Conservation des Sélaciens (APECS), and the commercial sector. This research program will compile catch and biological data from observer and landings data sources. Preliminary management proposals for the fishery, including minimum lengths and area closures, are presented in the paper.

In response to a question regarding the location of the catches of smaller porbeagles, it was clarified that these are occurring in ICES Divisions 7G and 7H. The author explained that due to the limited data available under the research program thus far it is not possible to tell whether there has been any recent change in targeting strategies. It was also clarified that curved fork length measurements are being collected. Attention was drawn to the differences in catch statistics presented in this paper and the ICCAT database and the author was asked to provide any updated data to ICCAT in digital form as soon as possible.

SCRS/2008/153 provided data on the ratios of shark by-catch to target species recorded by observers from 2002 to 2006. These data were used to estimate historical catches of blue and shortfin mako sharks by the Chinese Taipei longline fishery in the Atlantic Ocean. These species are the dominant bycatch species in both the North and South Atlantic. It was explained that the shark bycatch in tropical areas is higher than that in temperate areas. Shark bycatch in weight ranged from 1,601 t in 1984 to 12,872 t in 1996 in the South Atlantic and from 196 t in 1989 to 3,066 t in 1994 in the North Atlantic. Since these results are based on a limited number of observer records, they are considered preliminary and further investigation is needed.

During the discussion, the methodology used to calculate shark catches was further explained. Observer data for 107 trips during 2002-2006 were used to develop a ratio of shark catch to tuna catch and to estimate the proportion of shark catch which was blue shark and shortfin mako shark for each of five areas. These ratios and proportions were then applied to tuna catches recorded in logbooks for 1981-2006 to provide estimated catch figures for sharks. Although unadjusted logbooks are believed to under-report sharks, if no tuna catch was recorded ratios and proportions were not applied and the logbook data for sharks was used without adjustment. The Working Group noted that while the approach was innovative it requires the major assumption that species composition has not changed over time.

SCRS/2008/156, concerning preliminary observer data from China, was presented on behalf of the authors. This paper provides observer data on sharks from two Chinese longliners fishing in the area of 5-12^{o}N between northeastern South America and West Africa. The observer records cover the period December 2007 through April 2008. Eight species of sharks were recorded including blue shark, which accounted for 76.2% of the observed sharks by weight. The paper also includes information on monthly shark CPUE, and sex ratios and size frequencies for blue and shortfin mako sharks.

Participants acknowledged the contribution of these data to the workshop. Receipt of these data from China in the ICCAT format for incorporation into the ICCAT database is anticipated.

SCRS/2008/45 provided an overview of all bycatch levels by species landed by the Spanish surface longline fleet targeting swordfish (*Xiphias gladius*) in the Atlantic Ocean and Mediterranean Sea from 1997 to 2006. It was originally presented to the billfish working group earlier this year. Most of the information provided is related to shark by-catch since sharks are the most prevalent bycatch species. Previous estimates were updated based on data for 2005 and 2006 resulting in by-catch estimates for 21 taxa of sharks. In the 2005-2006, the three most prevalent species in the catch, *Xiphias gladius*, *Prionace glauca* and *Isurus oxyrinchus* represented, on average 94.2% and 96.1% of the total Atlantic and Mediterranean landings in weight, respectively. In 2005-2006 the species assumed to be by-catch accounted for a large amount of the total landings in weight from the Atlantic areas –large pelagic sharks, 67.4%; tunas, 2.2%; billfish 1.2% and other species 0.9%. In contrast, in the Mediterranean Sea, the reported by-catch amounted to only around 7.0% of the total landings in weight –large pelagic sharks, 4.6%; tunas, 1.6%; other species, 1.3% and billfish close to 0%. *Prionace glauca* and *Isurus oxyrinchus* were the most important species within the group of large pelagic sharks, representing 88.2% and 9.5% of catch, respectively in the Atlantic –very similar to levels observed in other oceans. These species comprise 77.3% and 6.0%, respectively, of the group of large pelagic sharks in the Mediterranean.

In the discussion the author clarified that data shaded in Table 2 of the paper represents data which have been revised. Similar to other papers, it was noted that the data in the paper do not match exactly with official data previously submitted by Spain to the ICCAT database and therefore the author was asked to work with the Secretariat to provide any available updated data as soon as possible. In response to a question regarding whether discards of blue shark are included in the catch figures, the author explained that since 1997 the level of discarding of blue shark has reduced to almost nil and discard rates for shortfin mako have always been near zero. In response to a question regarding whether there may be additional shark bycatch from other Spanish fisheries, the author stated that while there may be minor catches for large pelagic sharks by other gear types not related with tuna fisheries, such as trawls in the ICES area, the figures presented should represent nearly all of the sharks taken in oceanic areas related with tuna and tuna-like fisheries. Addressing the issue of whether sharks are a target species, the author pointed out the difficulties associated with determining targeting criteria from the types of information generally available in logbooks of most fleets. Additional information on this issue is provided in SCRS/2008/129.

SCRS/2008/158 described the European Union (EU) surface longline fleet operating in the Atlantic Ocean and a compilation of detailed Eurostat data on shark catches by EU fleets in the Atlantic. A fleet of 158 longliners greater than 24 meters are registered with ICCAT for fishing tuna, tuna-like species and billfishes by Spain, Portugal, Cyprus, Malta and the UK. Combined catches of blue and shortfin mako sharks by the Spanish and Portuguese surface longline fleets, respectively, comprise 69% and 72% of the total catch. There are 47 EU surface longliners between 20 and 24 meters which are active this year but not included in the ICCAT list of authorized vessels. These vessels are unlikely to report their catches to ICCAT and therefore this may be a source of unreported catches. Comparisons of ICCAT and Eurostat data indicate an under-reporting of Atlantic shark catches in some cases. For example, in 2006 19 EU Member States report Atlantic shark catch data by species to EUROSTAT whereas only six Member States reported data, sometimes not by species, to ICCAT in 2006. Total Atlantic shark catches in 2006 as reported to EUROSTAT were 52,019 t, compared to a total catch reported to ICCAT of 42,361 t in the same year.

In discussion of the last document, the Group expressed concerns about the calculation of average total catch per vessel for Spain, Portugal and the United Kingdom by means of dividing total catch by the number of vessels authorized to fish by ICCAT. Since the number of vessels authorized to fish may not be an accurate reflection of the number of vessels actually actively fishing in the Atlantic, this factor alone could account for the wide range in the calculated average catches. It was suggested that using effort data to the extent to which it is available at the time of analysis, rather than number of vessels, would be a better basis for comparison. Several concerns were also expressed regarding use of the Eurostat data due to differences in the way it is compiled as compared to the ICCAT data. Some of the potential differences identified included different species identification standards, inclusion of non-pelagic sharks in EUROSTAT, varying conversion factors, and differences in the degree of scientific review of the data prior to submission. It was nevertheless agreed that the Eurostat data would be examined in detail against the ICCAT database with a view to appropriate filling of any data gaps identified in the ICCAT database (see Section 4.2).

4.2 Presentation of catch data from the ICCAT database and other databases

4.2.1 Requirements for reporting shark catches to ICCAT

As a preface to presentation of data in the ICCAT Task I and Task II databases, the data reporting requirements for sharks to ICCAT were discussed. Some participants stated that although ICCAT requires submission of data on total removals of sharks, some data submissions appear to reflect only those sharks which are landed and/or only those sharks caught by fisheries targeting tuna and tuna-like species. Other participants stated that such reporting requirements had not been made clear by the Commission. These differences in understanding of the reporting requirements can contribute to under-reporting of shark catches to the ICCAT database and to discrepancies between the ICCAT shark catch data and other fisheries databases.

The Secretariat explained that from 1995 to 2004, three resolutions pertaining to sharks, [Res. 95-02], Res. 01-11], and [Res. 03-10], were adopted by ICCAT. While the latter two included references to submission of statistics, reporting procedures were not specified. The first recommendation [Rec. 04-19], *Recommendation by ICCAT Concerning the Conservation of Sharks Caught in Association with Fisheries Managed by ICCAT*, states: "*Contracting Parties, Cooperating non-Contracting Parties, Entities or Fishing Entities (CPCs) shall annually report Task I and Task II data for catches of sharks, in accordance with ICCAT data reporting procedures, including available historical data."* The last paragraph limits the application of the recommendation to "*only to sharks caught in association with fisheries managed by ICCAT*". Although supplemental recommendations such as Rec. 07-06 also pertain to the submission of statistics, there is not a common understanding regarding whether these requirements would also apply to non-ICCAT fisheries.

In conformance with Rule 13 of the ICCAT Rules of Procedure, it was noted that the Shark Working Group and SCRS have recommended and the Commission has endorsed that for the purposes of stock assessments, it is necessary to account for the total fishing mortality for shark stocks of concern to ICCAT, which includes, but is not limited to blue, shortfin mako, and porbeagle. For this reason, it is necessary that CPCs provide data on the total level of catch, size characteristics, and catch-effort statistics for these species from the full range of gears that impact on these species in the Convention area. It was also noted that such reporting might require a combination of logbook, market and observer data sources.

Given this situation and the apparent confusion, it was agreed that the shark reporting requirements need further clarification. **It was recommended that data reporting procedures for the priority species identified by the**

SCRS be further specified and advertised to CPCs in order to reinforce the requirement for providing data on total shark removals. Data should be submitted for catches of the priority shark species, whether or not they are targets or by-catch, whether or not they are discarded, and regardless of whether the fleet is targeting tuna or tuna-like species. This issue should be referred to the ICCAT Statistics Committee for further action including liaison with other ICCAT working groups grappling with the same problem. In order to avoid unnecessary duplication of effort, consideration should be given to improving coordination on data submission issues between ICCAT and other organizations collecting fishery data.

It was also agreed that given the importance of targeting issues to both catch and catch rate data, that the advice of other species working groups to prioritize investigation of data analysis techniques to account for targeting strategies should also be reiterated.

4.2.2 Summary of data in the ICCAT Task I and Task II database

The ICCAT Secretariat presented a summary of the status of the data in the ICCAT Task I database with regard to the nominal catch series (Task I) of blue shark (*Prionace glauca*, BSH) and shortfin mako (*Isurus oxyrinchus*, SMA). Since the 2007 ICCAT Shark Data Preparatory meeting in Uruguay, only the Japanese longline time series for the period 1994-2006 has been made available for both species. Revisions to the preliminary Task I catches for the most recent time period (2005-2007) have been made by the majority of countries that reported Task I data. Those revisions were accepted by the Working Group.

It was then decided to update the Task I catch data with new information contributed by attending scientists and available from various scientific documents presented during the meeting and to use these as preliminary data pending the official data submission:

- SCRS/2008/147: overall BSH Canadian catch data (all gears combined) from 1986 to 2006 have replaced the entire Canadian Task I catch series;
- SCRS/2008/045: revised Spanish surface longline Task I catch data (BSH, SMA and other sharks) were used (changes only in years 2003, 2005 and 2006) to replace the unclassified sharks figures in 2005 and 2006;
- *SCRS/2008/134:* overall French catch data (BSH and POR) were used to complete the French time series (1999, 2003, 2006);
- Uruguay longline Task I revised catches (BSH for 1981 to 2006; SMA for 1992 to 2006) replaced current Task I series.

Despite these recent updates, the overall figures are not substantially different.

Additionally, the Working Group agreed to reclassify the entire historical Task I catches of unclassified mako sharks (MAK) into shortfin mako (SMA). This aspect mainly affects the historical USA catches (1982 to 2000); for which no SMA series existed; and small amounts of catches in the recent years for Belize, Brazil, Canada, Panama, Philippines, Russian Federation, Trinidad and Tobago. Some of the other shark catches in the ICCAT database are recorded as unclassified sharks and methods for disaggregating these data may need to be developed. Care should be taken to avoid double counting if unidentified sharks reported in past years are converted to species-specific catches.

Although there is not currently an ongoing and active comparison between the ICCAT database and other databases, **it was agreed that continued comparisons with the ICES, Eurostat, and potentially FAO, databases could be useful for identifying gaps in the ICCAT database**. If data from other sources are added to the ICCAT database to fill gaps, a data provenance system in place since 2000 is capable of documenting the source of these data.

A presentation on the ICCAT Task II database and shark catalogue was given by the ICCAT Secretariat. Particular issues raised included the need to link effort information to the Task II catch data, and the desirability of cross-checking between the Task I and Task II data. It was also noted that some “mako, unidentified” catches from countries other the US are still contained in the Task II database. Data pertaining to size composition and size at effort are sparse, for example porbeagle sizes are only reported by the US, but in the future efforts will be made toward rescue of historical data available for years prior to 2000. **It was agreed that further work to improve the content of the Task II database, particularly with regard to catch and catch rate information, should be prioritized for future action.**

4.3 Comparison between ICCAT Task I and other relevant databases

Further discussion of differences between the ICCAT and EUROSTAT databases, and also data from AZTI, was facilitated by presentation of a spreadsheet showing a side-by-side comparison by species and country, and plots of these data. These comparisons indicated that for blue and shortfin mako sharks there do not appear to be a large number of instances in which the ICCAT database has missing or potentially under-reported catch values. In fact, in many cases the ICCAT database values are higher than the EUROSTAT values. With regard to points made during the presentations, while there are some differences in the catches reported by France and Ireland for blue shark (no shortfin mako reported by either) to ICCAT and EUROSTAT, most reported catches are consistent. Discrepancies in the two databases for these countries in 2006 may be partially, or even wholly, due to lags in reporting of recent catches to ICCAT.

Most of the major discrepancies observed between the ICCAT and EUROSTAT database were associated with porbeagles. It was suggested that catches of porbeagles reported by Denmark to EUROSTAT prior to the early 1970s may represent catches of porbeagle off Iceland. With specific reference to the reason for discrepancies between Ireland's reporting of porbeagle to EUROSTAT and to ICCAT, it was noted that porbeagle caught in demersal trawl fisheries would be reported by Ireland to ICES rather than to ICCAT. It was again noted that all shark removals should be reported to ICCAT.

It was acknowledged that because ICCAT only began calling for shark data as of the mid-1990s, ICCAT data on shark catches prior to that time would be expected to be less reliable than more recent data and thus historical data rescue may be necessary. These efforts are expected to be a dynamic process that will continue for some time, but more immediate steps can be taken to ensure the best data available are used in ICCAT stock assessments. Recent efforts by members to update their national data were acknowledged as a very important part of this process. It can then be considered whether any remaining, identified gaps in the ICCAT database can be filled through use of other datasets such as EUROSTAT.

Despite that fact that differences between the ICCAT Task I database and the EUROSTAT database appeared to be minimal for the blue and shortfin mako assessments planned for this meeting, it was agreed to take a further step of examining how the catch data that could be used in this meeting's assessment would change if EUROSTAT data were incorporated under various scenarios. It was noted that there is no information on the gear type responsible for the shark catches in the EUROSTAT database and this may have implications for defining gear-specific selectivities for stock assessment modelling.

This was undertaken and reported upon by the ICCAT Secretariat as shown in **Table 7a**. A total of 385 t of blue shark and 2 t of shortfin mako shark were added to the Task I database as a result (**Table 7b**).

It was concluded that an examination of the ICCAT shark catch data against the EUROSTAT shark catch data undertaken in response to a recommendation arising from the 2007 Shark Data Preparatory meeting resulted in only minimal changes to the catch series for blue and shortfin mako sharks. Larger differences in the catch series may occur for other species, such as porbeagle, which are not being quantitatively assessed at this time. It was agreed that while cross-checking between ICCAT Task I and Task II databases would be valuable in identifying other potentially missing catch values, that this work could not be accomplished during this meeting and thus should be carried out in the future.

4.4 Catch data to be used in the assessment of blue and shortfin mako shark

In order to permit the separation of the overall Atlantic catches into two different management units (north of 5°N and south of 5°N) an adjustment was made to the Task I areas (i.e. ATL, ATMED, EAST, WEST) that did not automatically allow this separation. The relevant U.S catches, as well as the eastern catches of EC.Portugual and EC.Netherlands were allocated to the North management unit. For China PR and Chinese Taipei catches, the Chinese Taipei catch and effort statistics (stratified in 5 by 5 degree squares and month, with positive BSH and SMA catches) were used to disaggregate the overall Atlantic catches into the North and South management units.

Because the catches reported to ICCAT over time are known to represent only a portion of total removals of the species of concern to ICCAT, previous Working Groups have resorted to various methods to estimate a time-series of catch based on the ratio of tunas to shark catch from fisheries where reliable information was available. These estimates using the 2004 Shark Species Group method based on ratios of shark catch to tuna catch from fleets where that information was available and updated through 2006 are shown in **Table 8a** and are considered conservative because they do not represent catches made by all gear types impacting these species.

Alternative or minimum shark catch estimates derived from shark fin trade data were re-presented to the group for consideration after revising the effort-scaled estimates to reflect the latest available ICCAT effort data. The effect of the re-calculation was to make the effort-scaled estimates more similar to the area-scaled estimates. In particular, estimates in the most recent years (2004-2006) no longer show a strongly declining trend. The tuna catch-scaled fin trade estimate was discounted on the basis that it is unwise to assume a constant relationship between tuna and shark catches throughout the series. The effort-scaled series was selected as the preferred of the remaining two series as partitioning the estimates into North and South Atlantic components could be easily accomplished using the ratio of longline effort in each area as available in the ICCAT databases (**Table 8b**). It was noted, however, that using the longline effort ratio for the North versus South Atlantic to partition the shark fin trade estimates assumes that these estimates are mainly reflecting longline catches but actually they may include other gear types. Since the fin trade estimates can be considered a minimum estimate, it was agreed that an additional catch series would be prepared for both blue and shortfin mako shark by using the higher of the shark fin trade-based estimate and the ICCAT alternative catch estimate. These alternative catch estimate series, i.e. based on selecting the higher of the shark fin trade-based estimates and the ICCAT alternative catch estimate based on tuna catch ratios, are shown in **Figure 4**.

Reported blue shark catch mortality per hook fished varies considerably across the fleets from which we have information on catch and effort. The Spanish longline fishery shows the highest per hook production, on average, with relatively similar levels in the north and south Atlantic **(Figure 5**). In general, the Spanish rates are 10 or more times those of other fleets for which information exists, although in the south Atlantic, Namibia and Belize longliners show levels similar to or higher than the Spanish per hook blue shark production. There are many possible reasons for these differences, including location and method of fishing, but there also exists the possibility of inaccurate reporting as a partial explanation.

The Working Group hypothesized that some of the difference could be explained by the geographical distribution of fishing effort, mainly as a function of latitude of fishing, with higher catch rates expected at higher latitudes. The cumulative distribution of estimated nominal hooks fished by the major longline fleets operating in the north and south Atlantic from 1997-2007 was examined to test this hypothesis. While there are different distributions of hook densities by fleet (**Figure 6**), these differences alone were not sufficient to explain different blue shark per hook production figures noted above. For example, in the south Atlantic, the cumulative distribution of hooks by latitude was similar between the Spanish, Japanese, and Chinese Taipei fleets (**Figure 6**), while the per-hook blue shark production values were about 10 times higher for the Spanish fleet.

The effect of targeting was also investigated to address the question "Can a 10 fold difference in blue shark catch rates be explained by style of fishing?" Brazilian set-specific catch rate information by targeting cluster and by fleet type was compared (**Figure 7**). It is evident that more than a 10 -fold difference in blue shark catch rates are observed in fleets 'targeting' different species, with the highest rates observed in vessels targeting swordfish. In addition, when these same data are stratified by fleet, it is apparent that the Brazilian and Spanish leased fleets, which primarily targeted swordfish, had much higher catch rates for blue sharks than leased fleets primarily targeting yellowfin tuna or albacore (e.g. TAI, SVT, **Figure 7**).

Questions were raised regarding the strong similarities in CPUEs obtained by dividing the estimated catches using the tuna catch ratio for the North and South Atlantic by the respective effort in each area between 1997-2006. It was explained that this result is somewhat expected because both the shark catch (derived from tuna catch) and effort data series derive from the same major fleets' catch reports of major tuna species. The point regarding the unreliability of the trend shown in the shark fin trade-based series due to under-estimation in the early part of the series was reiterated, but it was noted that this series on its own is not being used in the stock assessment modelling. **It was concluded that it is not possible at this time to fully understand the reasons for differences in catches and catch rates in the North and South Atlantic and that this will necessarily be a source of uncertainty in the assessment.**

5. Relative abundance indices and other fishery indicators

5.1 Information presented in SCRS documents

Document SCRS/2008/095 presents indices of abundance developed for blue shark (from the Venezuelan Pelagic Longline Observer Program (VPLOP) for the period 1994-2007, which covers on average 12.7% of the fleet trips. Indices were calculated using a Generalized Linear Mixed Model under a delta lognormal model approach. In the analysis, vessel category and individual vessels were used. Individual vessels were analyzed with repeated measures GLM models (used only in positive sets), assuming an autoregressive variance-covariance matrix (AR1) and Compound symmetry (CS) variance-covariance. The main objective was to evaluate if variance within vessels was consistent; results suggested that within vessels, the variability of catch rates was smaller compared to the size class grouping, and that smaller/medium size vessels showed the higher catch rates of blue shark in the Venezuelan pelagic longline fishery. However, the vessel size category model achieved better fit than the repeated measures models CS or AR1. The standardized CPUE series showed that the relative abundance of blue shark increased in the early part of the series (1994-98) followed by a decline from 1998 until 2006 with the lowest value in 2005, with a small recovery in the last year of the series.

Document SCRS/2008/129 provides Spanish longline standardized catch per unit of effort data obtained for the shortfin mako and blue shark using General Linear Modeling (GLM) procedures from 7,511 and 11,244 trip records for the blue shark and shortfin mako during the periods 1997-2007 and 1990-2007, respectively. The main factors used for modeling were year, area, quarter, gear and ratio between swordfish and blue shark catches. The significant models explained around 80% and 40% of the CPUE variability for both species, respectively. As in the case of the Atlantic swordfish, an important fraction of the variability in the blue shark CPUE was attributed to the ratio between the two most prevalent species in the catch. Other less important factors were also identified as significant for this species. The area was identified as the most relevant factor to explain the CPUE variability in the shortfin mako. The results obtained show CPUE trends that are quite stable for both species during the respective periods considered. A moderate decrease in the CPUE for the North Atlantic shortfin mako was observed during the initial period 1990-1995 −when the highest longline activity on the North Atlantic swordfish fishery was achieved− and stability afterwards.

Document SCRS/2008/130 presents two series of nominal CPUE from the Irish recreational fishery for blue shark. The first was based on a survey of recreational catches (numbers of sharks) and represents an average of the number of anglers per day in a given year. This dataset included both targeted shark fishing and general fishing. In order to obtain a more adequate representation of the fishery, a subset of 10 vessels was chosen that had the same skippers, technical specifications and fishing patterns. The skippers of these vessels had been fishing continuously for the period 1989-2005. CPUE was expressed as numbers of blue shark per day of shark fishing for 10 fishing stations, on the Irish south, west and north coasts. These correspond to a spatial extent of two 5 degree ICCAT squares. Both Irish series showed the same peaks in 1990, 1993, 1996 and 1997 with a decline since 1997 to levels much lower than the earlier period. A slight upturn in 2005-2007 was observed, but overall CPUE is much lower in the recent period. Similar downward trends since the mid 1990s were also reported from Venezuelan fisheries (SCRS/2008/095), US mid-east coast (SCRS/2008/136) and the US observer program data (SCRS/2008/137), though not from Canadian bluefin tuna and bigeye/swordfish fisheries (SCRS/2008/147). Data from the Japanese tuna longline fishery showed a similar peak to the Irish data from the mid 1990s (SCRS/2008/149), though a slight increase occurred earlier than in the Irish data. A standardization of these data was made during the meeting and is presented in **Appendix 4**.

Document SCRS/2008/132 provides standardized catch rates from the national Brazilian longline fleet and leased vessels. Although these fleets fish over the same areas, they probably do not target the same species. Hence catch rates of a given species may show a different time trend according to the fleet (national or leased). Standardized catch rates of blue shark caught from 2000 to 2006 by national and leased boats from Spain were compared. In order to calculate standardized indices, the document analyzed Task II catch/effort data using gamma and binomial distributions to model positive catch rates and proportion of positive catches, respectively. Factors included in the models were year, quarter and area. Catch rates of national and leased boats showed contradictory time trends probably due to different fishing strategies adopted by those two fleets. The document concluded that standardized catch rates from these Task II data are not useful as relative abundance indices, and that this problem is exacerbated because fishing strategies cannot be inferred from these data to be included in the standardization process.

Document SCRS/2008/136 represents an update to prior analyses (SCRS/2007/071), in which abundance indices for unclassified mako (*Isurus* spp.) and blue sharks off the coast of the United States from Virginia through Massachusetts were developed using data obtained during interviews of rod and reel anglers in 1986-2007. Subsets of the data were analyzed to assess effects of factors such as month, area fished, boat type (private or charter), interview type (dockside or phone) and fishing method on catch per unit effort. Standardized catch rates were estimated through generalized linear models by applying delta-Poisson error distribution assumptions. A stepwise approach was used to quantify the relative importance of the main factors explaining the variance in catch rates in previous calculations for the indices from these data (2005 and 2006). The standardized CPUE series for blue shark showed an increasing trend from the beginning of the time series and peaked in 1996 and a general decreasing trend until 2006, which was reversed in 2007. For mako shark the estimated standardized

CPUE series followed the same pattern with a maximum value observed in 1998.

Document SCRS/2008/137 updated indices of abundance developed for blue shark and mako sharks (*Isurus* spp.) from two commercial sources, the US pelagic longline logbook program (1986-2007) and the US pelagic longline observer program (1992-2007). Indices were calculated using a two-step delta-lognormal approach that treats the proportion of positive sets and the CPUE of positive catches separately. Standardized indices with 95% confidence intervals are reported. For blue sharks, the logbook time series showed a marked decreasing trend with signs of a potential recent recovery, but the observer time series showed no clear trend. For makos, both the logbook and observer time series showed a concave shape, with essentially no decline since 1992 and an upward trend since the late 1990s.

Document SCRS/2008/141 presents updated standardized indices of the catch-per-unit-of-effort (CPUE) of blue shark caught by the Uruguayan longline fleet. The indices were obtained by Generalized Linear Models (GLM) with a delta lognormal approach. The data in number and weight of the fish caught are from the fishing logbooks of the Uruguayan longline fleet that operated in the South Atlantic Ocean between 1992 and 2007. The standardized CPUE shows similar trends in both cases (for the CPUE calculated in number and in weight) with a relatively stable trend in the last eight years, and an observed recovery in the catch rates in the last year of the series.

Document SCRS/2008/142 provides updated standardized indices of catch-per-unit-of-effort (CPUE) of shortfin mako caught by the Uruguayan longline fleet. The indices were obtained by Generalized Linear Models (GLM) with a delta lognormal approacj. The data in number and weight of the fish caught are from the fishing logbooks of the Uruguayan longline fleet that operated in the South Atlantic Ocean between 1982 and 2007. The standardized CPUE shows similar trends in both cases (for the CPUE calculated in number and in weight) with a stable trend in the recent years, and a minor recovery in the last year of the series studied.

Document SCRS/2008/147 indicates that there is no directed fishery for blue sharks in Canadian waters, and virtually all blue sharks caught as by-catch in pelagic longline fisheries are discarded dead or alive at sea. Based on an extensive series of observer measurements, total by-catch by both observed and unobserved vessels was estimated since 1986. Two indices of abundance were developed from standardized blue shark catch rates in tuna and swordfish longline fisheries. Although the two abundance indices were not completely consistent with each other, neither one showed a decline in net abundance since 1996. The document indicated that the models demonstrated both strong interaction and aliasing between the factors year and vessel, a combination that has the potential to confound a catch rate series. Nevertheless, there was no evidence that blue shark abundance has declined in Atlantic Canadian waters in recent years. The Working Group noted that the document lacked details about model fits that would allow for a thorough discussion on the usefulness of these indices for stock assessment.

Document SCRS/2008/148 provides catch rate information on shortfin makos. Annual catches in Canadian waters average 60-80 t per year. Therefore, Canadian catches represent a small part of the North Atlantic population as a whole. The standardized catch rate series was developed based on observed foreign tuna fleets fishing within Canadian waters and the Canadian swordfish fleet. There was no consistent trend in abundance since 1996 based on the standardized catch rate analysis. The Working Group also noted that the document lacked details about model fits that would allow for a thorough discussion on the usefulness of these indices for stock assessment.

Document SCRS/2008/149 provides updated standardized CPUEs for blue shark and shortfin mako caught by the Japanese tuna longline fishery in the Atlantic Ocean. Indices were estimated using filtered logbook data during 1971-2006 for blue shark, and 1994-2006 for shortfin mako, whose reporting rates were more than 80%. Blue shark CPUE shows some fluctuations and relatively stable trends during the past three decades for North, South and whole Atlantic stock hypotheses. Shortfin mako CPUE indicates a decreasing trend until 2001, but after that time recovery to the level at the beginning is observed.

Document SCRS/2008/153 presents the historical shark by-catch (1981-2006) of Chinese Taipei's longline fishery in the Atlantic Ocean. Historical shark by-catch was estimated based on the ratios of shark by-catch to target species recorded by observers from 2002 to 2006. The GLM including main effects of year, quarter, area and interactions under the assumption of lognormal error structure was used for standardization of nominal CPUE for 1981-1994, and the model including an additional factor, gear configuration (deep longline vs regular longline), was applied for 1995-2006. Nominal CPUEs of blue shark in both South and North Atlantic Ocean fluctuated, and were greatly reduced in the CPUE standardization. However, the stable CPUE trends were found for mako shark in both South and North Atlantic Ocean. The results in this study, based on short-term observer records, are preliminary and further investigation is needed.

Document SCRS/2008/154 provided blue and mako shark catch and effort data from Brazilian tuna longline fleet (national and chartered; 60.645 sets), which operated in the southwestern Atlantic Ocean, from 1978 to 2007 (30 years). The CPUE of both species was standardized by a GLM, by three different approaches: i) a negative binomial error structure (log link); ii) the traditional delta-lognormal model, assuming a binomial error distribution for the proportion of positive sets, and a Gaussian error distribution for the positive blue and mako sharks catches; and iii) the Tweedie distribution, recently proposed to adjust models with high proportion of zeros (Shono, 2008). Blue shark standardized indices showed a relatively stable trend from 1978 to 1995. From 1995 on, however, there was an increasing trend, with a sharp rise between 2000 and 2002, up to a maximum value in 2007. Like for the blue shark, the mako shark standardized CPUE was relatively stable up to the mid-1990s, increasing in more recent years. The use of a cluster analysis to identify the target species, incorporating it as a factor in the GLM models, was discussed. A multivariate analysis was proposed as an alternative method to deal with the apparent high correlation between the blue shark and the swordfish catches. The great influence of the targeting strategy on CPUE variability was acknowledged, as well as the consequent and urgent need to further studies on more precise ways to incorporate such influence in the CPUE standardization process. In this context, it was recognized that, given the increasingly frequent changes of species target/ gear configuration during a same fishing trip, there is growing difficulty to define the target species of a particular longline fishing set. It was highlighted, therefore, that, to the extent possible, set-by-set data should be used in order to generate standardized CPUE series, instead of aggregated data.

5.2 Information from other publications

The Group discussed the index of relative abundance for blue shark in the northwestern Atlantic Ocean estimated by Aires-da-Silva *et al.* (2008). The group noted that the index, which begins in 1957, could be useful to track population size from the beginning of the Atlantic longline fisheries. However, some concern was expressed that much of the earlier data were from research cruises that were not necessarily designed to monitor shark abundance. It was also noted that for the latter part of the series the index contained some of the same data used in SCRS/2008/137 and that the latter index would be preferable for that time period because it had a broader spatial coverage.

The Group also discussed the paper by Ferretti *et al.* (2008) which examined a suite of datasets in the Mediterranean. The Group believed that the paper's analyses of disparate datasets was subject to the same criticisms expressed by Polacheck (2006) in relation to Myer and Worm's (2003) paper on world-wide declines in tuna populations from fitting exponential decline models to CPUE data. The Group also noted that the original data used by Ferretti *et al.* (2008) were not available from the paper to allow for the application of proper standardization methods during the meeting. The revision of some data sets used in the analyses indicates an inappropriate interpretation of the original information.

5.3 Indices to be used in the assessment

Tables 9-12 show the various indices available to the Working Group.

In discussing which indices to use for the blue and shortfin mako assessments, participants generally agreed that it would be better to use indices from fisheries with oceanic distributions that matched the distribution of the species. On the other hand, it was also noted that some coastal indices from the fringe of a species' distribution could also be informative. The Working Group agreed to weight the various indices by relative catch proportions as was done in the 2004 assessment, as well as by the area covered by each fishery.

The following series were used for the 4 base case assessments: (1) North Atlantic BSH: US Logbook (USLL-log), Japan Longline (JLL-N), Ireland recreational (Ire), US early time period (values for 1957-1985 from Aires da Silva, 2008; Usold), Venezuela Longline (VenLL), Spain Longline (SpLL-N); (2) South Atlantic BSH: Japan longline (JLL-S), Spain Longline (SpLL-S), Uruguay Longline (UrLL), Brazil Longline (BrLL); (3) North Atlantic SMA: US Logbook (USLL-log), Japan Longline (JLL-N), Spain Longline (SpLL-N). (4) South Atlantic SMA: Uruguay Longline (UrLL), Japan Longline (JLL-S), Brazil Longline (BrLL), Spain Longline (SpLL-S).

There are major changes to the choice and availability of indices for this assessment compared to the 2004 assessment, including:

- A Spanish longline index became available for the 4 stocks assessed

- A historical (since 1957) index for blue shark in the North Atlantic became available
- An index for blue shark in the North Atlantic from the Irish recreational fishery was now included
- The available Japanese longline index series became shorter
- The Chinese Taipei longline index was not used in this assessment because the group had concerns about the assumed historical species composition (see Section 4.1)
- Estimated trends in several of the series changed substantially, probably as a result of modeling targeting strategies

5.4 Combined indices

The Working Group decided to produce combined indices as overall indicators. The indices were combined though a GLM (normally-distributed) with two choices of weighting: by area fished, and by catch. The weights were scaled to add up to 1.0 in each year (**Table 13-14**). In order to calculate area, the 5x5 degree data on longline hooks prepared by the 2008 Sub-Committee on Ecosystems were used, with the following two exceptions: two rectangles were assumed for the Irish recreational fisheries, and Uruguayan longline fisheries were assumed to cover one-third of the area covered by Brazilian longline fisheries.

The combined indices are given in **Table 15** and shown in **Figure 8**. The choice of weighting had little impact on the estimated combined indices, except for shortfin mako in the South Atlantic.

6. Methods and other data relevant to the assessment

6.1 Bayesian surplus production (BSP) model

Document SCRS/2008/135 presented an updated Bayesian Surplus Production (BSP) model, similar to that used for the 2004 assessment. As requested by the Shark Working Group in 2007, the new version of the software can use effort to predict catches in the early years of the fishery before catches were reported by all fleets. Catch data are used for more recent years when they are thought to be reliable. This combination of fitting to catches and fitting to effort allows the model to be applied to the entire history of the fishery. With the data available before the meeting, the effort fitting model provided reasonable results and diagnostics. For blue sharks in the North Atlantic, it was necessary to increase the weighting of the catch data relative to the CPUE data to obtain a good fit between observed catches and catches predicted from efforts. The authors cautioned that predicting catches from effort would not be appropriate if catchability had changed over time, for example, if there was a shift in the relative catches of fleets with different catchabilities.

The BSP model was applied to the model runs described in **Table 16** for blue and shortfin mako sharks in both the North and South Atlantic. The base case for all four populations had a starting year equal to the first year in which either catch or CPUE data were available. The starting biomass ratio (Bo/K) was given an uninformative (uniform) prior between 0.2 and 1.1. The base case prior for K was uniform on log(K), with minimum and maximum values adjusted as needed so that the boundary conditions did not influence the posterior distribution. The prior for r was lognormal, with mean of 0.014 and log standard deviation of 0.28 for shortfin makos sharks, and mean 0.301 and log standard deviation of 0.099 for blue sharks (SCRS/2008/138). Bmsy/K was assumed to be 0.5 for all base case runs.

The indices used in the base case model runs are described in (**Tables 9-12**). The base cases weighted the indices in each year by the relative geographic area covered by the series in that year (**Table 13**). For blue shark in the North Atlantic, CPUE data were available from 1957, but catch data were not available until 1971, so we estimated catches from 1958 to 1970 from longline effort (**Table 17**), using the method described in SCRS/2008/135. The catchability (*catq*) relating observed catches to catches estimated from effort was estimated using catch and effort data from 1971 through 2007, and was given a prior that was uniform on log(*catq*).

The base case catch data series was the total catches estimated from the tuna ratio for shortfin mako in the North and South Atlantic (**Table 8a**). For blue shark, the base case catch in each year was equal to the maximum of the catch estimated from the tuna ratio and the catch estimated from the fin trade data (**Tables 8a, 8b**). From the mid- 1990s, catches were much higher in the fin ratio scenario than in the tuna ratio scenario (**Figure 4**)

A number of sensitivity analyses (**Table 16**) were conducted to evaluate the impact of all of these inputs on the model results. These included considering additional CPUE data series or subtracting one CPUE series at a time, equal weighting of the CPUE data points, weighting by relative catch in each series instead of by area covered (**Table 14**), considering a prior for K uniform on K, and doubling the log SD in the prior for r. For some runs we started the time series in 1950 instead of the first year of data and used effort to estimate catches until the catch data started, in either 1971 or 1997. For model runs beginning in 1950, we used an informative lognormal prior for the starting biomass ratio (B_{1950}/K) with mean 1.0 and log standard deviation 0.20. For blue sharks, we also did a catch sensitivity analysis using the tuna ratio catch series instead of the maximum of the tuna ratio and fin trade catch estimates. For shortfin mako sharks, we also considered a sensitivity analysis in which the position of the inflection point of the population growth curve was fixed at 0.84K (value found in demographic modeling described in SCRS/2008/140). For the model runs in which additional CPUE indices were used, the data points were weighted by the area covered by each series as in the base case, and the number of 5 x 5 degree squares assumed to be covered by each of the additional series was 5 for US-LPS and US-MRFSS, and 1 for US-tourn.

The Sampling Importance Resampling (SIR) algorithm was used to calculate the posterior distributions, using the priors as an importance function.

6.2 Age Structured Production Model (ASPM)

North Atlantic blue shark

The age-structured model presented in SCRS/2008/131 was applied to data for blue shark in the North Atlantic. The values of the input parameters of the model are shown in **Table 18**. The model requires information about the selectivity of each of the fisheries for which information on exploitation is available. The selectivities used for the fleets that take blue sharks in the North Atlantic are shown in **Table 19**. The catch data used were the maximum of the value estimated from the tuna ratio and that estimated from the fin trade (**Tables 8a and 8.b).** Six CPUE series were available for this stock (described in **Table 9**), plus one CPUE series that was the combination of the six CPUE series (**Table 15**). Each point of each CPUE series was characterized by a weight (**Table 13**), which was used to weight each point's contribution to the likelihood the model uses to find the most plausible combination of values for the estimated parameters.

A run was done using the six CPUE series with equal weighting (RUN A), one with inverse (area) weighting (RUN B) and one using the combined CPUE series (RUN C).

North Atlantic shortfin mako shark

The age-structured model was also applied to data for mako shark in the North Atlantic. The values of the input parameters of the model are shown in **Table 18**. The selectivities used for each of the fleets that take mako shark in the North Atlantic are shown in **Table 19**. The catch data used were the maximum of the value estimated from the tuna ratio and that estimated from the fin trade (**Tables 8a and 8.b)**. Three CPUE series were available for this stock (described in **Tables 11**) plus one CPUE series that was the combination of the three CPUE series (**Table 15**). As with the blue shark series, each point of each CPUE series was characterized by a weight. A run was done using the three CPUE series with inverse (area) weighting (RUN D) and one with equal weighting (RUN E). The model was not run for the combined CPUE series.

6.3 Catch-Free Age Structured Production Model

The catch-free model (SCRS/2004/110) was applied to North and South Atlantic stocks of blue shark, and the North Atlantic stock of shortfin mako shark. A number of scenarios were requested initially from the meeting participants and are listed in **Table 20**. The biological assumptions and selectivities are listed in **Table 21**.

The model is fully described in Porch *et al.* (SCRS/2004/110). In general, the catch-free model is an age-structured production model that derives all the fishery information from CPUEs rather than a combination of catches and CPUEs. The model outputs management benchmarks, but is unable to estimate catch scenarios or yield estimates.

7. Stock status results

7.1 Bayesian Surplus Production (BSP) Model

All but two of the model runs converged on the posterior distribution with good diagnostics of model convergence although the CPUE indices were not well fit by all models. (**Tables 22-25**). The North Atlantic blue shark sensitivity analysis with additional CPUE series (run blue north b), and the North Atlantic blue shark sensitivity analysis with a uniform prior for *K* (run blue north m) did not converge.

For the blue shark North Atlantic base case (Run blue north d, **Figure 9**, **Table 22**), the six CPUE series were quite variable and not consistent with each other. Thus, the data were not informative, and the posterior distributions were very similar to the priors. Despite the increasing catches over the history of the fishery, the estimated biomass trajectory was quite flat, with a current depletion of B_{2008}/B_{MSY} of 1.87 (CV=0.13), and current fishing mortality was low, with mean F_{2008}/F_{MSY}=0.17 (CV=2.57). The estimated carrying capacity (K) was high, so that F remained low even as catches increased from 25,000 to 62,000 mt over the time series. All of the sensitivity analyses (**Table 22**, **Figure 10**) were consistent in finding that the population abundance is probably above B_{MSY} and fishing mortality is probably below F_{MSY}. The only sensitivity analysis that showed depletion to around the B_{MSY} level was the series with equal weighting (run "o" in **Table 16**), and the Working Group considered that equal weighting was not appropriate given that one of the CPUE series came from a small, local fishery (Ireland recreational) at the fringe of the range of blue sharks, while the others are more widespread and more likely to track overall abundance. The sensitivity analysis with a higher variance in the prior distribution of *r* showed similar population status, although the posterior distribution of *r* was more variable (**Figure 11**).

For blue sharks in the South Atlantic, the abundance indices were also variable and inconsistent, so that the posterior distributions of *r* and *K* were very similar to the priors (**Figure 12**). The model estimated a very high *K*, and the group noted that there is no biological reason why the carrying capacity in the South Atlantic should be more than an order of magnitude higher than that in the North. Because K was high, F remained low even as catches increased from 5,000 to 57,000 mt since 1971. The base case model found a current depletion of B_{2008}/B_{MSY} of 1.95 (CV=0.06), and current fishing mortality was low, with mean F_{2008}/F_{MSY} =0.04 (CV=2.74). The results of all the sensitivity analyses were nearly identical (**Figure 10**).

For shortfin mako sharks in the North Atlantic, the data were more informative, so that the posterior distributions of *r* and *K* were noticeably different from the priors (**Figure 13**). The model estimated fishing mortalities above F_{MSY} for most of the time series, leading to a decline in biomass. The current depletion was estimated as B_{2008}/B_{MSY} of 0.95 (CV=0.45), and current fishing mortality was high, with mean F_{2008}/F_{MSY} =3.77 (CV=1.09). All but two of the sensitivity analyses were consistent in finding that current biomass is around 50% of K and fishing mortality is several times F_{MSY}. The case with catches estimated from effort until 1997 (run mako north j, **Table 24, Figure 14**), found a higher relative biomass, and the case with B_{MSY}/K set at 0.84 (run mako north k) found current biomass well below B_{MSY}.

For North Atlantic shortfin mako sharks, despite the different histories of the three fisheries, the three abundance indices were consistent, and all showed a decreasing trend in the 1980s and 1990s, followed by an increase in the current decade. To determine whether it was possible for mako sharks to increase so rapidly, we projected the population forward 30 years using the base case model (mako north d) with a fishing mortality equal to 0, F_{MSY} or the current fishing mortality rate (F=3.77 * F_{MSY}). The projections showed that, even in the absence of fishing, given the input value of r, the population was only capable of growing about 6 percent in each decade (**Table 26, Figure 15**). Thus, the increasing trend in the abundance indices cannot be explained by population productivity. The group considered that the biological information used to calculate the prior for r was well estimated, so that the estimate of r was more believable than the trends from the fisheries CPUE, which could be biased by changes in catchability over time. The group discussed, but did not reach consensus, on other possible explanations for this increase in the abundance trends. There could have been increased species-specific reporting of catches, particularly for longline series which are based on logbooks, not scientific observer data. There could be changes in catchability caused by a contraction in the range of the population, or changes in the spatial distribution, target species, fishing depths, or fishing gear used by the three fleets. The population could be open, with migration from other regions explaining the increase. Increasing regulations resulting in lower catches of tuna species could explain the increasing reported catch rates of shortfin mako sharks.

For shortfin mako in the South Atlantic, the posterior and prior distributions for *r* and *K* were similar but not identical to the priors (**Table 25, Figure 16**). The estimated *K* was 1,097,719,940 mt, more than 2000 times the value calculated in the North Atlantic, which does not seem plausible. Because of this very high estimated biomass, the fishing mortality is very low, even while the catches continue to increase. The current depletion was estimated as B_{2008}/B_{MSY} of 1.27 (CV=0.33), and current fishing mortality was low, with mean F_{2008}/F_{MSY} =0.21 (CV=3.19). The sensitivity analysis all found that current biomass was above B_{MSY} and F was well below F_{MSY}, except for the case where B_{MSY}/K was set equal to 0.84 (run mako south k), which found that B was less than B_{MSY}.

7.2 Age Structured Production Model (ASPM)

North Atlantic blue shark

The model did not converge under RUN B, thus results for this run are not presented. The predictions of the model for the stock size under Run A and C at the mode of the joint posterior pdf are shown in **Figures 17** and **18**. The fit of the model to the CPUE series for the modal values of the estimated parameters is shown in **Figure 19** for RUN A and **Figure 20** for RUN C. The model predictions for some of the key estimated parameters are shown in **Table 27**.

The posterior pdfs for pup survival and virgin biomass for RUN A are shown in **Figures 21** and **22**, respectively. The posterior for pup survival is very similar to the prior. The prior for the virgin biomass assigned high values to a very small number of biomass values but also indicated that the range of plausible values of this parameter is very wide (long tail). This is probably because there is not enough information in the data to allow the model to provide a more narrow range of plausible values than the one we started with and thus, provide a more precise estimate of the biomass of the stock. The posterior pdf for the relative current size of the stock favors two sets of values (**Figure 23**); one around 0.3 and one around 0.95 with the later set being assigned the highest probability.

North Atlantic shortfin mako shark

The model converged under both runs. The predictions of the model for the stock size at the mode of the joint posterior pdf are shown in **Figures 24** and **25**. The fit of the model to the CPUE series for the modal values of the estimated parameters is shown in **Figures 26** and **27**. The model predictions for some of the key estimated parameters are shown in **Table 28**.

The posterior pdfs for the virgin biomass and pup survival for RUN D are shown in **Figures 28** and **29**. The posterior for pup survival is slightly different from the prior. As in the case of blue shark, the prior for the virgin biomass assigned high probability to a small number of biomass values but continued to assign a small probability to a very wide range of values (long tail). As shown in **Table 28** the model predictions for the relative current status of the stock cover a wide range of values ranging from 0.45 (mode for RUN D) to 0.73 (mean value for RUN D).

7.3 Catch-Free Age Structured Production Model

North Atlantic blue shark

The model did not converge when all six base catch rate series were used. The model was then fit to one CPUE series at a time (USLL-log or JLL-N), and to the combined index. A combined selectivity was calculated to represent the combined selectivities of the fisheries represented in the combined index. Also, several levels of initial depletion were considered: 0%, 10% and 20% at the end of the historic period (1956-1970 unless noted otherwise). Model runs did not use effort data, rather a constant F was estimated for the historic period, and an average F with annual deviations was estimated for the modern period. The four models presented here were the only ones that converged in the limited time available during the meeting. For the model with an assumption of 20% depletion by 1971, the estimate of current spawning stock biomass (SSB) was 83.1% of virgin level, which is greater than the estimated SSB_{MSY} (**Table 29**). The current fishing mortality rate (F_{curr}) was estimated to be 0.0203, which is over F_{MSY} (**Table 29**). The estimates of alpha, the maximum lifetime reproductive rate, and natural mortality are very close to the mode of their priors, suggesting that there is very little information from which to estimate these parameters. The fits to the combined index for all three depletion scenarios are given in **Figure 30**. Both the diagnostics (AIC, AICc and objective function value) and the plots suggest that the model fits the 10% historic depletion and the virgin depletion equally well. The relative trend in SSB for all three scenarios is given in **Figure 31**. The model estimates of F_{curr}, F_{MSY}, and SSB_{curr}/SSB_{MSY} are fairly stable across models, and the assumption of historic depletion in 1971 primarily affects the model estimate of historic fishing mortality rate (F_{hist}).

South Atlantic blue shark

The model did not converge with all of the base indices. The combined index was used to run a single scenario, virgin conditions until 1971. An additional combined selectivity was calculated and input for the South Atlantic blue shark fisheries. The results are similar to the calculations for the North (fit to index is in **Figure 32**), in that there is no indication of an overfished stock or of any overfishing. The SSB is 86.1% of virgin levels (**Figure 33**), and the natural mortality parameter followed closely the prior specifications. There was enough information in the data for the alpha value to substantially deviate from the values specified in the prior.

North Atlantic mako shark

To be consistent, an initial run incorporating all of the base indices was attempted. The model did not converge, as there were not enough data to calculate parameter estimates. As a result, the combined index run for the North Atlantic was used as a base case **(Table 30**, **Figure 34a**). This run estimated a relative depletion to 72.8% of virgin conditions (**Figure 35a**). Also, there was sufficient information in the data to estimate M and alpha values different from the means of the specified priors. The current fishing mortality was estimated as 48.2% of what would be required to drive the stock to MSY. Given these results, this model does not estimate any overfishing of this stock or that its status is overfished. The second scenario was a slight modification of the base case scenario. Since there were too few data to estimate parameters when the model was started in 1956, the following scenario was constructed. All three suggested indices were included (ULL-log, JLL-N, and SpLL-N) using a combined selectivity calculated from the three catch rate series. The model was started in 1971, assuming virgin conditions with a gradual depletion until the first year of data, 1986. This model estimates a more pessimistic situation than the other run for North Atlantic mako shark. The relative depletion is 56.3% of virgin conditions (**Table 30**, **Figure 34b**, **Figure 35b**), and the current fishing mortality is 69.8% of what would be required to drive the stock to MSY. While the natural mortality estimate is similar to the mode of the prior, the alpha value diverges significantly (2.49 vs a prior mode of 1.49).

7.4 Stock status summary

Although both the quantity and quality of the data available to conduct stock assessments has increased with respect to those available in 2004, they are still quite uninformative and do not provide a consistent signal to inform the models. Unless these and other issues can be resolved, the assessments of stock status for these and other species will continue to be very uncertain.

Blue shark

For both North and South Atlantic blue shark, the biomass is estimated to be above the biomass that would support MSY. As was the case in the 2004 stock assessment, in many model runs (using surplus production models, age-structured models and catch-free models), stock status appeared to be close to unfished biomass levels and fishing mortality rates well below those corresponding to the level at which MSY is reached. While results from all models used were conditional on the assumptions made (e.g., estimates of historical catches and effort, the relationship between catch rates and abundance, the initial state of the stock in the 1950s, and various life-history parameters), most models consistently predicted that blue shark stocks in the Atlantic are not overfished and that overfishing is not occurring. A full evaluation of the sensitivity of results to these assumptions was not possible at the meeting using all the modeling approaches.

Shortfin mako shark

Estimates of stock status for the North Atlantic shortfin mako shark obtained with the different modeling approaches were much more variable than for Atlantic blue sharks. For the North Atlantic, multiple model outcomes indicated stock depletion to about 50% of virgin biomass (1950s levels) and levels of F above those resulting in MSY, whereas others estimated considerably lower levels of depletion and no overfishing. In light of biological information that places the point at which B_{MSY} is reached with respect to the carrying capacity at levels higher than for blue sharks and many teleost stocks, there is some non-negligible probability that the stock could be below the biomass that supports MSY and above the fishing mortality rate associated with MSY. A similar conclusion was reached by the Committee in 2004, and recent biological data show that the productivity for this species is lower than previously believed. Only one modeling approach could be applied to the South

Atlantic shortfin mako stock. The estimated unfished biomass was biologically implausible, and we have no conclusions about the status of this stock at present.

Figure 36 shows stock status results (depletions with respect to virgin biomass and F/F_{MSY}) of the baseline scenarios from the surplus production and catch-free, age-structured production models. A band denoting a range of biomass levels at which MSY is predicted to be reached based on biological considerations (SCRS/2008/140) is depicted. Any points to the left or within that band indicate a potentially overfished stock; any points above the horizontal line are indicative of overfishing.

Porbeagle shark

SCRS has not yet conducted an assessment of porbeagle.

Porbeagle in the Atlantic are mainly taken in fisheries which are not directed at tuna and tuna-like species and have been the target of several Atlantic fisheries in both the north and south. For the purposes of analysis, in the Atlantic, porbeagle are considered to be comprised of four stocks: NW, NE, SW, and SW. Available catch information is in **Table 31**.

Canadian scientists conducted a recent assessment of porbeagle stock status in the northwestern Atlantic (Gibson and Campana 2005), which indicated the stock had been depleted to levels well below B_{MSY} by 2004 and that rebuilding to MSY levels could require more than 30 years if fishing mortality were completely eliminated and on the order of 100 years if annual catch was limited to 2% of the fishable biomass per year, due to the level of depletion and the low intrinsic rate of increase for the stock. Recent fishery monitoring information suggests that harvest rates may have exceeded this level, which may have resulted in further decline in the stock (NAFO 2008).

Similar assessments have not yet been conducted for the other stocks, due to data limitations. ICES has undertaken data compilations and provided advice to the EC for northeast Atlantic porbeagle where there are historically target fisheries. Similar data compilations need to be undertaken for southern hemisphere porbeagle stocks. A joint ICCAT-ICES intersessional is proposed in 2009 to undertake further assessments in conformity with [Rec. 07-06]. As porbeagle in the North Atlantic are mainly taken in fisheries not directed at tuna, participation in the proposed assessment by additional RFMO scientific experts would be most beneficial.

Ongoing studies and data compilation for NE Atlantic porbeagle were undertaken by the ICES Working Group on Elasmobranch Fishes (WGEF) during the meeting. Catches for 1973-2007 were updated, although these data are considered under-estimates. Potential data gaps should be addressed prior to the next assessment meeting. Data from the French targeted porbeagle fishery were presented (SCRS/2008/152) and were updated. These data will be presented in the 2008 report of WGEF.

Given that the NE Atlantic porbeagle stock is concentrated in the boreal and temperate waters on and along the continental shelf, catches of this stock are taken mostly in those fisheries in the ICES area. Given the decline in landings of porbeagle, especially in the northern parts of the ICES area, and due to the biological characteristics of porbeagle, ICES (2006) advised that "*No targeted fishing for porbeagle should be permitted on the basis of their life history and vulnerability to fishing. In addition, measures should be taken to prevent bycatch of porbeagle in fisheries targeting other species, particularly in the depleted northern areas*". **Figure 37** shows the degree of overlap between the geographical distribution of porbeagle and that of the fishing effort exerted by the major pelagic longline fleets operating in the Atlantic Ocean.

8. Recommendations

8.1 Research and statistics

The Group recommends separating the stocks of blue shark and porbeagle into North and South, from a latitude of 5ºN, and also separating porbeagle into East and West.

The Group considers it essential to interact with other SCRS groups to compare assessment methods (ERA), and to discuss how deficiencies in the data and similar problems are handled, as a means to make good use of the efforts made by other groups.

The Group considered the imporance of developing research projects at the regional level which result in rapidly increasing knowledge available on pelagic sharks as well as the importance of specific funds for research on this group of species.

The Group recommends that the Commission request Contracting Parties to undertake research on all sharks caught on pelagic longlines, giving priority to those species with known biological vulnerability (bigeye thresher, longfin mako), known population decline (porbeagle) and for which biological data are limited for Atlantic populations (i.e. crocodile shark, smooth hammerhead, pelagic stingray). This should include observer programs to document the frequency of capture, fate, collect biological data and other relevant information.

Scientists were urged to study the technical and operative aspects of the fleets that result in reducing the incidental catch of sharks.

The Group considers it necessary that the target species be taken into account in the CPUE standardization process.

It was also recommended that the ICCAT Working Group on Tagging carry out work on generating a worldwide network in order to centralize all tagginig information.

8.2 Management

Precautionary management measures should be considered for stocks where there is the greatest biological vulnerability and conservation concern, and for which there are very little data. Management measures should ideally be species-specific and in most cases only generic information is given here. **Table 3** provides a ranking, based on species productivity for priority species. Fleet-specific measures may also be necessary. Additionally, some species are also taken in non-ICCAT fisheries and management measures also need to be taken through a species' range. Furthermore, the efficacy of the potential management measures discussed below is heavily dependent on discard survivorship. Implementing no management measures is likely to be ineffective for preventing overfishing.

Measures that prohibit the take of certain species of concern have been used in a range of fisheries. Such measures could benefit those species that are only encountered very rarely throughout the region, and for which there are no known sites of high abundance. Mandatory release of certain species would prevent targeted fisheries developing and help protect the species in question. However, for those species that are more difficult to identify, there could be problems of misidentification and/or misreporting. For species such as the bigeye thresher, which probably has one of the lowest productivities among all shark species, is poorly known, has almost no catch and effort data reported, is easily recognised, typically caught in low quantities and is likely to have a high discard survival, such precautionary measures could be effective for conservation. In contrast, some members of the genus *Carcharhinus* can be difficult to identify at the species level, and enforcing mandatory release of such species could be more problematic. The effectiveness of the mandatory release of 'prohibited species' or only mandatory release of live individuals may depend on the degree of compliance.

For some pelagic sharks, reducing fishing mortality on the juvenile and/or the mature female component of the stock will benefit the population, and could be considered as precautionary measures. If the locations of nursery and/or pupping grounds are well known, and they are in discrete areas, then space-time technical measures could be considered. For stocks for which these stages are more dispersed or the locations of important areas are unknown, then size restrictions might deter fisheries exploiting such life-history stages. Minimum landings sizes (MLS) would afford protection to juveniles, although other technical measures may be an alternative to protecting juveniles. These should be investigated for effectiveness and implemented. If exploitation rates on the mature female part of the stock is of concern, and they are known to aggregate, then a maximum landing length (MLL) could be considered to decrease fishing mortality on the breeding part of the population. Once again, if there are data on the temporal-spatial distribution of such parts of the stock, then other technical measures may be more appropriate.

9. Other matters

No other matters were addressed by the Working Group.

10. Adoption of the report and closure

The report was adopted by correspondence.

The Chairman thanked the participants and the Secretariat for their hard work.

The meeting was adjourned.

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Table 1. Life history variables and population parameters used in the ecological risk assessment. Three letter codes following species names are ICCAT codes. S_0, survival of 0+ age class; S_{1+}, survival range of all subsequent age classes; T, generation time, R_0, net reproductive rate; r, intrinsic rate of population increase. From SCRS/2008/140 and SCRS/2008/138.

Species	Litter Size	Repro. period (yr)	Female K (yr^{-1})	Female maturity(yr)	Female longevity(yr)	S_0	S_{1+}	T	R_0	r
Alopias superciliosus (BTH)	2	1	0.092	12-13	20	0.75	0.79-0.91	17	0.93	0.010
Alopias vulpinus (ALV)	4	1	0.160	5.8	24	0.77	0.80-0.93	12	5.56	0.141
Carcharhinus falciformis (FAL)	2-15	2	0.098	7-12	22	0.70	0.75-0.91	14	2.91	0.076
Carcharhinus longimanus (OCS)	4-14	2	0.099	4-7	17	0.66	0.72-0.93	10	2.46	0.087
Isurus oxyrinchus (SMA)	12.5	3	0.125	18.5	32	0.75	0.79-0.94	24	19.18	0.014
Isurus oxyrinchus (old) (SMA*)	12.75	3	0.084	7	16	0.69	0.75-0.93	11	2.28	0.073
Isurus paucus (LMA)	2-4	2?	?	14	?	?	?	25	?	0.014
Lamna nasus (POR)	4	1	0.061	13	24	0.81	0.82-0.93	20	2.83	0.053
Prionace glauca (BSH)	4-75	1	0.130	5.5	15	0.70	0.78-0.86	11	18.2	0.301
Pteroplatytrygon violacea (PST)	6	0.5	0.200	3	12	0.47	0.68-0.88	7	3.02	0.169
Sphyrna lewini (SPL)	35	1	0.130	15	31	0.61	0.70-0.91	20	6.20	0.090
Sphyrna zygaena (SPZ)	20-49	1	0.139	?	18	0.62	0.69-0.90	16	7.30	0.124

Table 2. Susceptibility (A) and vulnerability rank (B; smaller number is riskier) values for 11 species of pelagic elasmobranchs by fleet. From SCRS/ 2008/138.

A)

ICCAT fleet	Species										
	BTH	BSH	ALV	LMA	OCS	PST	POR	SPL	SMA	FAL	SPZ
USA	0.20	0.08	0.05	0.23	0.15	0.03	0.03	0.14	0.27	0.33	0.07
Venezuela	0.30	0.14	0.17	0.12	0.32	0.00	0.00	0.00	0.23	0.37	0.00
Brazil	0.22	0.22	0.00	0.33	0.24	0.16	0.00	0.14	0.35	0.47	0.13
Uruguay	0.26	0.21	0.15	0.38	0.00	0.10	0.14	0.11	0.41	0.00	0.09
Portugal	0.61	0.33	0.00	0.35	0.51	0.00	0.14	0.04	0.51	0.52	0.12
Namibia	0.001	0.04	0.00	0.03	0.00	0.00	0.03	0.01	0.02	0.00	0.02
Combined	0.82	0.54	0.01	0.58	0.72	0.02	0.28	0.17	0.79	0.69	0.35

B)

ICCAT fleet	Species										
	BTH	BSH	ALV	LMA	OCS	PST	POR	SPL	SMA	FAL	SPZ
USA	6	6	3	5	5	3	5	3	5	5	5
Venezuela	3	5	1	6	3	5	6	7	6	4	7
Brazil	5	3	5	4	4	1	6	2	4	3	2
Uruguay	4	4	2	2	6	2	3	4	3	6	4
Portugal	2	2	5	3	2	5	2	5	2	2	3
Namibia	7	7	5	7	6	5	4	6	7	6	6
Combined	1	1	4	1	1	4	1	1	1	1	1

Table 3. Productivity values ranked from lowest to highest.

Species	Productivity (r)	Productivity rank
BTH	0.010	1
SMA	0.014	2
LMA	0.014	3
POR	0.053	4
SMA (2004)	0.073	5
FAL	0.076	6
OCS	0.087	7
SPL	0.090	8
SPZ	0.124	9
ALV	0.141	10
PST	0.169	11
BSH	0.301	12
CRO	-	-

Table 4. Status (proportion alive at gear retrieval) and disposition (proportion released alive) of pelagic elasmobranch species by nation based on scientific observer programs. Status information was only available for two Contracting Parties.

Species	Code	Status		Disposition					
		USA	VEN	USA	VEN	BRA	URU	POR	NAM
Prionace glauca	BSH	0.82	0.73	0.78	0	0.002	0.05	0	0
Carcharhinus falciformis	FAL	0.44	0.58	0.37	0	0.01		0.03	
Carcharhinus longimanus	OCS	0.72	0.86	0.64	0	0.09	0.02	0.03	
Isurus oxyrinchus	SMA	0.69	0.87	0.27	0	0.004	0.01	0.02	
Lamna nasus	POR	0.71		0.68			0.14	0	
Isurus paucus	LMA	0.52	0.78	0.45	0		0	0	
Alopias vulpinus	ALV	0.68	0.53	0.59	0		0.04		
Alopias superciliosus	BTH	0.59	0.79	0.55	0	0.28	0.29	0.01	
Pteroplatytrygon violacea	PST	1.00		0.82		0.41	0.68		
Sphyrna lewini	SPL	0.44		0.38			0		
Sphyrna zygaena	SPZ	0.30		0.29			0.07	0.01	
Pseudocarcharias kamoharai	CRO	0.72		0.56		0.26		0	

Table 5. Proportional change in fishing mortality (F) that could be achieved by live release of sharks for two fleets based on observer data. Decrease in F was calculated by subtracting the proportion currently release alive (disposition in Table 2.4) from the proportion that are alive at gear retrieval (status in Table 2.4) and dividing by those that could be potentially released alive (i.e. status).

	Proportion decrease in F	
Species	**USA**	**Venezuela**
BTH	0.068	1.00
SMA	0.609	1.00
LMA	0.135	1.00
POR	0.042	-
FAL	0.159	1.00
OCS	0.111	1.00
SPL	0.136	-
SPZ	0.033	-
ALV	0.132	1.00
PST	0.18	-
BSH	0.049	1.00
CRO	0.222	-

Table 6. Recovery ratios of major shark species by source of information (usually tagging Nation).

	Data source	**Released (at sea)**	**Recovered**	**Total released**	**%recovery ratio**	**Remarks**
BSH	iccat.db	2681	193	2874	7%	
	EC.IRL	16020	784	16804	5%	
	JPN	1	28	29	97%	incomplete
	URY	319	2	321	1%	
	USA	93924	6454	100378	6%	
BSH Total		**112945**	**7461**	**120406**	**6%**	
POR	iccat.db	19	4	23	17%	
	USA	1274	160	1434	11%	
POR Total		**1293**	**164**	**1457**	**11%**	
SMA	iccat.db	887	124	1011	12%	
	URY	6		6	0%	
	USA	6022	794	6816	12%	
SMA Total		**6915**	**918**	**7833**	**12%**	

Table 7a. Changes to the ICCAT Task-I database resulting from a comparison to Eurostat databases.

Species	Year	Flag	Area	GearCode	Quantity added from Eurostat (t)
BSH	2003	EC.Denmark	NORTH	UNCL	5.04
BSH	2004	EC.Denmark	NORTH	UNCL	1.03
BSH	1999	EC.France	NORTH	UNCL	233
BSH	2002	EC.France	NORTH	UNCL	112.02
BSH	2003	EC.United Kingdom	NORTH	UNCL	3.8
BSH	2004	EC.United Kingdom	NORTH	UNCL	6.21
BSH	2000	EC.Ireland	NORTH	UNCL	22
BSH	2003	EC.Ireland	NORTH	UNCL	1.84
BSH	2004	EC.Ireland	NORTH	UNCL	0.1
BSH	2005	EC.Ireland	NORTH	UNCL	0.24
SMA	2003	EC.United Kingdom	NORTH	UNCL	0.73
SMA	2004	EC.United Kingdom	NORTH	UNCL	0.81

Table 7b. Blue and shortfin mako shark catches in the ICCAT Task-I database.

Year	BSH	SMA
1971	0	200
1972	0	168
1973	0	263
1974	0	346
1975	0	389
1976	0	92
1977	0	465
1978	4	299
1979	12	313
1980	0	474
1981	226	978
1982	87	1,631
1983	767	821
1984	339	1,574
1985	500	3,683
1986	1,525	1,909
1987	1,643	1,000
1988	1,858	1,539
1989	1,828	1,629
1990	3,054	1,323
1991	4,313	1,312
1992	3,557	1,533
1993	9,594	2,948
1994	16,586	2,097
1995	14,469	3,024
1996	16,072	1,949
1997	43,582	5,364
1998	39,822	4,787
1999	39,316	4,079
2000	43,264	4,796
2001	37,784	4,644
2002	34,862	4,985
2003	40,036	7,497
2004	39,938	5,854
2005	45,441	6,796
2006	44,952	6,583
2007	14,461	4,033

Table 8a. Blue and shortfin mako shark catch series (t) resulting from application of the method of estimating catches using the ICCAT Task-I data and the ratio of tunas to shark catch. Partitioning into North and South management units was accomplished using longline effort ratios from the ICCAT Task-I database.

Year	Blue shark, Total	Blue shark, North	Blue shark, South	Shortfin mako shark, Total	Shortfin mako shark, North	Shortfin mako shark, South
1971	30,370	25,332	5,038	4,213	3,717	496
1972	30,852	25,274	5,578	3,597	3,014	583
1973	38,304	30,163	8,141	4,502	3,322	1,180
1974	31,373	27,593	3,780	3,848	3,345	503
1975	41,679	37,993	3,686	4,767	4,280	487
1976	35,244	31,411	3,833	3,667	3,038	629
1977	40,635	35,396	5,239	4,266	3,642	624
1978	32,380	27,506	4,874	3,895	3,241	655
1979	25,926	20,108	5,818	3,032	2,402	630
1980	34,418	27,202	7,216	4,336	3,253	1,082
1981	38,061	29,968	8,093	4,091	3,079	1,011
1982	50,880	33,318	17,562	5,621	3,614	2,006
1983	47,734	42,717	5,017	5,095	4,209	885
1984	47,058	39,644	7,414	5,636	4,480	1,156
1985	58,819	43,572	15,247	8,867	6,900	1,967
1986	65,942	55,374	10,568	7,711	6,589	1,121
1987	66,815	58,923	7,892	7,275	6,336	940
1988	64,619	50,284	14,335	7,660	5,985	1,675
1989	52,204	33,242	18,962	6,394	4,098	2,296
1990	53,689	36,129	17,560	5,908	3,852	2,056
1991	58,166	38,966	19,200	6,311	4,114	2,197
1992	54,364	38,307	16,057	5,800	3,871	1,928
1993	63,796	45,057	18,739	7,654	5,364	2,290
1994	63,911	41,925	21,986	7,657	4,510	3,147
1995	66,079	43,885	22,194	10,337	6,202	4,135
1996	63,086	42,760	20,326	7,610	4,790	2,820
1997	55,720	37,813	17,907	6,140	3,792	2,348
1998	50,998	34,617	16,381	6,451	4,255	2,196
1999	53,216	33,105	20,111	5,756	3,311	2,445
2000	51,063	31,021	20,042	6,066	2,955	3,110
2001	49,730	27,713	22,017	8,754	2,855	5,899
2002	43,926	25,983	17,943	7,852	3,521	4,331
2003	44,010	26,493	17,517	9,736	4,206	5,530
2004	41,817	25,510	16,307	9,161	3,689	5,472
2005	47,478	25,707	21,771	8,562	3,807	4,754
2006	52,988	26,795	26,193	8,141	3,564	4,577

Table 8b. Total shark fin trade-based estimates (t) for the Atlantic based on the medians resulting from the effort-scaling method described in SCRS/2008/139 and partitioned into North and South management units based on effort in the ICCAT Task-I database.

Year	Blue shark, Total	Blue shark, North	Blue shark, South	Shortfin mako shark, Total	Shortfin mako shark, North	Shortfin mako shark, South
1980	23,300	11,392	11,908	2,261	1,105	1,156
1981	23,310	12,528	10,782	2,263	1,216	1,047
1982	27,400	13,972	13,428	2,660	1,356	1,304
1983	24,430	13,923	10,507	2,372	1,352	1,020
1984	27,960	15,982	11,978	2,714	1,551	1,163
1985	28,610	14,720	13,890	2,777	1,429	1,348
1986	32,000	18,265	13,735	3,106	1,773	1,333
1987	33,210	14,906	18,304	3,223	1,447	1,776
1988	30,890	13,312	17,578	2,999	1,292	1,707
1989	32,260	14,268	17,992	3,132	1,385	1,747
1990	35,500	14,543	20,957	3,445	1,411	2,034
1991	47,080	21,847	25,233	4,586	2,128	2,458
1992	57,380	27,604	29,776	5,589	2,689	2,900
1993	55,830	20,497	35,333	5,437	1,996	3,441
1994	66,140	27,341	38,799	6,442	2,663	3,779
1995	71,020	31,977	39,043	6,917	3,114	3,803
1996	85,650	40,539	45,111	8,359	3,956	4,403
1997	87,090	42,765	44,325	8,499	4,173	4,326
1998	84,910	43,228	41,682	8,286	4,218	4,068
1999	100,200	49,068	51,132	9,777	4,788	4,989
2000	115,600	51,183	64,417	11,280	4,994	6,286
2001	120,700	56,859	63,841	11,700	5,512	6,188
2002	107,700	46,826	60,874	10,440	4,539	5,901
2003	124,400	47,695	76,705	12,060	4,624	7,436
2004	99,330	46,509	52,821	9,629	4,509	5,120
2005	92,160	52,759	39,401	8,934	5,114	3,820
2006	98,920	61,845	37,075	9,590	5,996	3,594

Table 9. Catch-per-unit-effort data for blue shark (North) as given in SCRS documents (*other sources).

Area	North	North	North	North	North	North	North	North	North	North	North	North
Fishery	US LPS	US-Tour	US-Log	US-Obs	JPLL-N	IRL-Rec	US-Obs/Crs*	CAN-LL1	CAN-LL2	VEN-LL	ESP-LL-N	CH/TA-LLN
SCRS/2008/	136	/2007/70	137	137	149	130	-	147	147	95	129	153
num/weight	number	number	number	number	number	number	number	number	number	number	weight*	number
Standardized	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes
Year	index	index	index	index	index	index	index	index	index	index	index	index
1957							0.99240506					
1958							0.48607595					
1959							1.12405063					
1960							1.19493671					
1961							1.1443038					
1962							1.51898734					
1963							0.70886076					
1964							0.88101266					
1965							1.56962025					
1966							1.28607595					
1967							1.44810127					
1968							1.32658228					
1969							1.98481013					
1970							0.98227848					
1971					0.49127		1.09367089					
1972					0.833308		1.95443038					
1973					0.6214							
1974					1.475601							
1975					1.236233		0.89113924					
1976					0.555738		0.75949367					
1977					1.22131		1.84303797					
1978					1.284584		1.07341772					
1979					0.502612		0.87088608					
1980					1.292344	1.098532	0.84050633					
1981					1.370542	0.561845	1.06329114					0.9328018
1982					1.220713	0.704403	0.78987342					1.1871575
1983					1.238621	1.563941	1.02278481					0.9726959
1984					0.861961	1.148847	0.68860759					0.8057933
1985					0.988509	0.654088	0.74936709					0.6666564
1986	0.307692		3.326708		0.918669	1.090147	0.48607595					0.5886228
1987	0.223269		2.346102		1.072079	0.779874	0.50632911					0.5712615
1988	0.401186		1.506982		0.778391	0.771488	0.44556962					1.0174229
1989	0.325833		1.297378		1.063722	0.880503	0.81012658					1.127224
1990	0.310483		1.216303		1.036263	1.509434	0.95189873					4.6600382
1991	0.500959	0.17162	1.549534		1.046411	1.199161	1.23544304					2.8755772
1992	0.659341	0.213228	1.439216	0.632616	1.188479	1.027254	0.63797468					7.0201625
1993	0.185592	0.421727	1.579652	0.89647	1.603343	1.752621	0.96202532					2.8971249
1994	0.722135	0.373906	1.408396	0.791487	1.671392	1.324948	0.99240506			0.313003		1.9154097
1995	0.936334	0.617206	1.3732	0.813676	1.344874	1.15304	0.73924051	9.152363	2.111935	0.349827		1.1379671
1996	2.324786	0.872645	1.449547	0.746278	1.392031	1.471698	0.47594937	1.070844	1.815196	0.087457		1.6802623
1997	1.384267	0.982428	1.327496	1.254061	1.281003	1.610063	1.26582278	0.908213	0.197171	0.994246	0.888362	1.0047405
1998	0.937729	1.399889	1.073414	1.36395	1.085211	0.951782	1.17468354	1.846392	1.926397	1.463751	0.882139	1.03383
1999	0.784232	0.810796	0.843147	0.591634	0.790927	0.771488	0.76962025	0.677036	1.175802	0.72267	1.028007	1.0740011
2000	0.893773	0.806887	0.755943	0.790355	0.842859	0.666667	0.78987342	0.568359	0.700629	0.819333	1.201492	0.8874284
2001	0.506541	0.482855	0.606225	0.216985	0.777197	0.918239		0.547241	5.803127	0.759494	1.210235	0.9921505
2002	0.475144	0.288561	0.551766	0.218344	0.72825	0.477987		0.621809	10.26593	0.455696	1.033434	1.1398449
2003	1.091226	0.270427	0.493981	0.180683	0.973586	0.696017		0.647046	1.900159	0.313003	1.252446	1.238318
2004	0.968428	0.425142	0.631791	0.813902	0.783764	0.30608		0.779481	5.793279	0.243959	0.985193	1.0765561
2005	0.440956	0.211746	0.398722	0.258043	0.89897	0.406709		2.432061	5.033378	0.041427	0.933636	1.2016253

2006	0.322344	0.13276	0.470516	0.436386	1.160424	0.658281		1.119505	10.16822	0.115075	0.985917	0.9767592
2007	0.648875		0.513943	0.849224				1.095557	10.50001	0.331415	1.072931	

Table 10. Catch-per-unit-effort data for blue shark (South) as given in SCRS documents (*other sources).

Area	South	South	South	South	South	South	South
Fishery	UR-LL	BR-LL	BR-Nat	BR-Sao	JPLL-S	ESP-LL-S	CH-TA-LLS
SCRS/2008/	141	154	/2007/85	/2007/84	149	129	153
num/weight	number	number	number	number	number	weight*	number
standardized	yes	yes	yes	yes	yes	yes	yes
year	index	index	index	index	index	index	index
1957							
1958			1.184				
1959			1.44				
1960			1.216				
1961			1.152				
1962			1.248				
1963							
1964							
1965							
1966							
1967							
1968							
1969							
1970							
1971				1.022782	0.701845		
1972				1.165016	0.466028		
1973				1.136589	0.973617		
1974				1.607512	0.742937		
1975				1.660546	0.560822		
1976				1.364758	0.605183		
1977				1.408939	4.286715		
1978		0.902041		1.131914	2.856409		
1979		0.446433		1.368738	2.532337		
1980		1.022821		1.319256	2.452487		
1981		0.601197		1.565064	0.882559		0.50732603
1982		0.713641		1.127051	1.771188		0.49974621
1983		0.890943		1.090648	1.509689		0.53518962
1984		0.934829		0.85514	1.636703		0.60213183
1985		0.756208		1.001717	1.307028		0.54379426
1986		0.915206	0.576	1.04171	1.688069		0.55458391
1987		0.917108	0.8	1.321581	1.486341		0.51691683
1988		0.947256	1.952	1.652516	1.552183		0.47132188
1989		0.68531	1.216	1.25236	1.192622		0.44854374
1990			1.248	1.402446	1.171609		0.68945448
1991		0.939119	1.216	1.172613	1.180481		0.54539917
1992	1.193798	0.589852	0.608	0.966655	1.252393		0.54543785
1993	0.574505		0.544	0.784045	1.200093		0.74912624
1994	1.761413	0.602258	0.64	0.892402	1.341583		1.0421676
1995	1.777778	1.039142	0.48	1.1793	1.007238		1.99500157
1996	2.29199	1.289539	1.088	0.71847	0.876955		1.72800619
1997	1.277347	0.999292	1.024	0.63895	0.92692	0.905358	1.00691755
1998	1.850129	1.524697	1.12	1.230801	1.071212	0.954271	0.69102071
1999	0.795004	0.734998	0.704	1.113017	0.981088	0.960851	1.17415706
2000	0.077519	0.741013	1.152	1.017231	1.02078	1.17952	1.12790467

2001	0.472007	1.682265	0.672	0.712782	0.854541	1.055348	0.95033959
2002	0.663221	1.665314	0.736	0.504442	0.767219	0.979666	0.91278853
2003	1.300603		0.448	0.526625	1.134719	0.8876	0.8353854
2004	1.174849	1.710395	1.184	0.819103	0.814849	0.893916	0.9363788
2005	0.939707	1.743884	1.408	1.090932	0.861546	1.010557	0.98286322
2006	0.815676	1.583344		0.738507	1.057203	1.026835	0.86133469
2007	2.47373					1.056854	

Table 11. Catch-per-unit-effort data for shortfin mako shark (North) as given in SCRS documents.

Area	North	North	North	North	North	North	North	North	North
Fishery	US LPS	US-MRFSS	US-Tourn	US-Log	US-Obs	JPLL-N	CAN-LL	ESP-LL-N	CH-TA-LLN
SCRS/2008/	136	/2007/70	/2007/70	137	137	149	148	129	153
num/weight	number	number	number	number	number	number	number	number	number
standardized	yes	yes	yes	yes	yes	yes	yes	yes	yes
year	index	index	index	index	index	index	index	index	index
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981		0.40386803							1.0345396
1982		0.88735533							1.1533097
1983		0.29228841							1.1000278
1984		0.41648399							1.0494717
1985		0.96561765							0.9905726
1986	0.840696	1.72178327		1.992989					0.9698808
1987	0.716149	0.51937641		1.992989			0.315956		0.9440932
1988	0.318744	0.78104089		1.572305			0.418539		0.9758537
1989	0.459679	0.95164784		1.817704			0.191013		0.9457523
1990	0.501468	1.2489918		1.449606			0.482398	1.68	0.9617985
1991	0.478525	1.08800941	0.823897	1.293602			1.708528	1.2	1.1382827
1992	0.544076	1.99085425	1.558729	1.524978	1.747546		1.631781	1.3513043	1.0860911
1993	0.64732	2.85571646	1.419073	1.323401	1.435732		1.203789	0.9130435	0.9621303
1994	0.62028	1.3107911	1.704262	1.255039	0.845363	1.511381	2.226845	0.9234783	1.0649254
1995	0.939843	1.63910204	1.42611	1.135846	1.305463	1.402124	2.057198	0.626087	1.0975866
1996	0.681734	1.27726839	0.229917	1.013146	0.728953	0.473445	0.612417	1.2469565	1.0427878
1997	0.752202	0.85208472	0.388833	0.927257	0.918813	0.61912	0.742984	0.7826087	1.0711827
1998	1.123387	1.60499119	0.126662	0.885188	0.575124	0.801214	0.720706	0.9130435	0.9947204
1999	1.678115	0.65512173	0.309554	0.869413	0.740039	0.691958	0.75148	0.8504348	0.959689
2000	1.002936	0.9214707	0.229223	0.914987	1.281903	0.382398	0.525188	0.8869565	0.9580299
2001	1.05128	0.98860123	0.428857	0.850131	0.807945	0.965099	0.646726	0.8504348	0.9396135
2002	1.257767	0.71639101	2.775492	0.886941	1.022751	1.165402	0.789731	0.9913043	0.9564182
2003	0.83578	0.41562823	1.112437	0.969325	0.842592	1.201821	0.852601	1.2834783	0.9920895
2004	1.390509	0.99178496	1.87254	1.139351	1.858413	1.584219	0.798936	1.4086957	0.9572714
2005	0.666166	0.62676469	1.396113	1.153374	1.072641	1.201821	1.275188	1.2365217	0.9656856
2006	0.748925		3.062655	0.899211	1.578473	1.748103	0.709789	1.0852174	0.9848841
2007	0.773506			1.340929	1.682411		0.720162	1.6121739	

Table 12. Catch-per-unit-effort data for shortfin mako shark (South) as given in SCRS documents.

Area	South	South	South	South	South
Fishery	UR-LL	BR-LL	JPLL-S	ESP-LL-S	CH-TA-LLS
SCRS/2008/	142	154	149	129	153
num/weight	number	number	number	number	number
standardized	yes	yes	yes	yes	yes
year	index	index	index	index	index
1971					
1972					
1973					
1974					
1975					
1976					
1977					
1978		0.373254			
1979		0.23737			
1980		0.564124			
1981		0.218583			0.99951298
1982	0.981718	0.188877			0.99082569
1983	0.685558	0.115625			1.02668053
1984	0.449726	0.069865			1.12129309
1985	0.40585	0.271771			1.02762824
1986	0.499086	0.573337			0.99998684
1987	0.531993	0.327452			0.99161544
1988	0.087751	0.750679			0.74110539
1989	0.510055	0.605085			0.65091546
1990	0.937843			1.031884	0.83050557
1991	0.850091	0.778594		0.8	0.80160057
1992	0.992687	0.817715		1.008696	0.7513722
1993	1.595978			1.043478	0.8995301
1994	1.716636	0.897383	1.974078	1.066667	0.98166454
1995	2.051188	0.651947	1.435693	1.217391	1.12855883
1996	0.948812	0.524206	0.801595	1.217391	1.07959407
1997	0.09872	0.195139	0.9332	0.869565	1.16204441
1998	0.833638	1.836053	0.717846	0.672464	1.13171785
1999	0.723949	0.213476	0.693918	0.544928	0.95907757
2000	1.480804	0.40935	1.040877	0.881159	0.95876167
2001	0.142596	0.799344	0.4666	1.113043	0.94296658
2002	1.228519	2.062989	1.112662	1.089855	0.92859305
2003	0.191956		0.358923	1.089855	0.97076593
2004	1.497258	1.512704	1.471585	1.031884	0.8917905
2005	1.085923	1.897409	0.993021	1.205797	0.86446501
2006	0.784278	2.213581	2.27318	1.008696	0.84108828
2007	0.608775			0.950725	

Table 13. Weights based on relative area fished used for weighting various CPUE indices.

BSH-N weighted squares

year	Uslog	JPLL	IRREC	USOLD	VENLL	ESPLL
1957				1		
1958				1		
1959				1		
1960				1		
1961				1		
1962				1		
1963				1		
1964				1		
1965				1		
1966				1		
1967				1		
1968				1		
1969				1		
1970				1		
1971		0.68		0.32		
1972		0.65		0.35		
1973		1.00				
1974		1.00				
1975		0.65		0.35		
1976		0.64		0.36		
1977		0.58		0.42		
1978		0.54		0.46		
1979		0.55		0.45		
1980		0.54	0.02	0.45		
1981		0.59	0.01	0.40		
1982		0.58	0.01	0.41		
1983		0.53	0.02	0.46		
1984		0.58	0.01	0.41		
1985		0.60	0.01	0.39		
1986	0.43	0.55	0.02			
1987	0.41	0.58	0.01			
1988	0.44	0.54	0.01			
1989	0.43	0.55	0.01			
1990	0.43	0.56	0.01			
1991	0.40	0.59	0.01			
1992	0.41	0.58	0.01			
1993	0.45	0.54	0.01			

BSH-S weighted squares

year	ESLL	URLL	BRLL	JLLL
1971				1
1972				1
1973				1
1974				1
1975				1
1976				1
1977				1
1978			0.31	0.69
1979			0.22	0.78
1980			0.18	0.82
1981			0.09	0.91
1982			0.17	0.83
1983			0.20	0.80
1984			0.14	0.86
1985			0.18	0.82
1986			0.24	0.76
1987			0.27	0.73
1988			0.24	0.76
1989			0.15	0.85
1990				1.00
1991			0.19	0.81
1992		0.11	0.32	0.57
1993		0.16		0.84
1994		0.08	0.24	0.68
1995		0.09	0.29	0.62
1996		0.12	0.35	0.53
1997	0.32	0.08	0.23	0.38
1998	0.28	0.08	0.25	0.38
1999	0.30	0.09	0.27	0.35
2000	0.27	0.09	0.27	0.37
2001	0.29	0.09	0.26	0.36
2002	0.35	0.09	0.28	0.28
2003	0.46	0.11		0.43
2004	0.37	0.08	0.22	0.34
2005	0.30	0.11	0.32	0.27
2006	0.31	0.11	0.32	0.26
2007	0.75	0.25		

SMA-N weighted squares

year	USlog	JPLL	ESPLL
1986	1		
1987	1		
1988	1		
1989	1		
1990	0.66		0.34
1991	0.62		0.38
1992	0.63		0.37
1993	0.63		0.37
1994	0.34	0.44	0.22
1995	0.32	0.47	0.21
1996	0.29	0.46	0.25
1997	0.30	0.44	0.26
1998	0.25	0.48	0.27
1999	0.24	0.48	0.28
2000	0.21	0.50	0.29
2001	0.24	0.50	0.26
2002	0.23	0.50	0.27
2003	0.22	0.50	0.28
2004	0.19	0.53	0.28
2005	0.20	0.54	0.26
2006	0.20	0.52	0.27
2007	0.43		0.57

SMA-S weighted squares

year	ESLL	URLL	BRLL	JLLL
1978			1.00	
1979			1.00	
1980			1.00	
1981			1.00	
1982		0.24	0.76	
1983		0.25	0.75	
1984		0.25	0.75	
1985		0.24	0.76	
1986		0.26	0.74	
1987		0.24	0.76	
1988		0.24	0.76	
1989		0.25	0.75	
1990	0.78	0.22		
1991	0.46	0.14	0.40	
1992	0.35	0.16	0.48	
1993	0.76	0.24		
1994	0.23	0.06	0.18	0.53
1995	0.23	0.07	0.22	0.48
1996	0.26	0.09	0.26	0.40
1997	0.32	0.08	0.23	0.38
1998	0.28	0.08	0.25	0.38
1999	0.30	0.09	0.27	0.35
2000	0.27	0.09	0.27	0.37
2001	0.29	0.09	0.26	0.36
2002	0.35	0.09	0.28	0.28
2003	0.46	0.11		0.43
2004	0.37	0.08	0.22	0.34
2005	0.30	0.11	0.32	0.27
2006	0.31	0.11	0.32	0.26
2007	0.75	0.25		

1994	0.42	0.55	0.01		0.01	
1995	0.39	0.58	0.01		0.02	
1996	0.38	0.60	0.01		0.01	
1997	0.29	0.43	0.01		0.01	0.25
1998	0.25	0.47	0.01		0.01	0.27
1999	0.22	0.45	0.01		0.05	0.26
2000	0.20	0.46	0.01		0.06	0.27
2001	0.22	0.47	0.01		0.07	0.24
2002	0.22	0.47	0.01		0.04	0.25
2003	0.21	0.47	0.01		0.04	0.27
2004	0.18	0.49	0.01		0.06	0.26
2005	0.18	0.48	0.01		0.10	0.23
2006	0.19	0.49	0.01		0.07	0.25
2007	0.37				0.13	0.50

Table 14. Weights based on relative catch used for weighting various CPUE indices.

BSH-N weighted catch

year	Uslog	JPLL	IRREC	USOLD	VENLL	ESPLL
1957				1		
1958				1		
1959				1		
1960				1		
1961				1		
1962				1		
1963				1		
1964				1		
1965				1		
1966				1		
1967				1		
1968				1		
1969				1		
1970				1		
1971		0.99		0.01		
1972		0.99		0.01		
1973		1.00				
1974		1.00				
1975		1.00		0.00		
1976		0.95		0.05		
1977		0.95		0.05		
1978		0.92		0.08		
1979		0.69		0.31		
1980		0.88	0.00	0.12		
1981		0.94	0.00	0.06		
1982		0.91	0.00	0.09		
1983		0.83	0.00	0.17		
1984		0.80	0.00	0.20		
1985		0.80	0.00	0.20		
1986	0.34	0.66	0.00			
1987	0.22	0.78	0.00			
1988	0.27	0.73	0.00			
1989	0.21	0.79	0.00			
1990	0.25	0.75	0.00			
1991	0.32	0.68	0.00			

BSH-S weighted catch

year	ESLL	URLL	BRLL	JLLL
1971				1
1972				1
1973				1
1974				1
1975				1
1976				1
1977				1
1978			0.32	0.68
1979			0.17	0.83
1980			0.13	0.87
1981			0.08	0.92
1982			0.04	0.96
1983			0.18	0.82
1984			0.06	0.94
1985			0.03	0.97
1986			0.08	0.92
1987			0.11	0.89
1988			0.08	0.92
1989			0.07	0.93
1990				1.00
1991			0.06	0.94
1992		0.01	0.18	0.81
1993		0.01		0.99
1994		0.01	0.07	0.92
1995		0.02	0.17	0.82
1996		0.05	0.15	0.80
1997	0.52	0.02	0.08	0.37
1998	0.55	0.02	0.11	0.32
1999	0.60	0.01	0.14	0.25
2000	0.64	0.00	0.17	0.19
2001	0.69	0.00	0.20	0.11
2002	0.65	0.00	0.23	0.11
2003	0.67	0.02		0.32
2004	0.65	0.02	0.14	0.19
2005	0.61	0.01	0.24	0.14

SMA-N weighted catch

year	USlog	JPLL	ESPLL
1986	1		
1987	1		
1988	1		
1989	1		
1990	0.12		0.88
1991	0.11		0.89
1992	0.01		0.99
1993	0.10		0.90
1994	0.10	0.08	0.81
1995	0.08	0.15	0.77
1996	0.07	0.26	0.68
1997	0.08	0.10	0.82
1998	0.06	0.30	0.64
1999	0.10	0.05	0.84
2000	0.12	0.03	0.85
2001	0.09	0.05	0.86
2002	0.07	0.05	0.88
2003	0.06	0.07	0.87
2004	0.07	0.12	0.81
2005	0.09	0.08	0.83
2006	0.06	0.09	0.85
2007	0.06		0.94

SMA-S weighted catch

year	ESLL	URLL	BRLL	JLLL
1978			1	
1979			1	
1980			1	
1981			1	
1982		0.51	0.49	
1983		0.67	0.33	
1984		0.80	0.20	
1985		0.82	0.18	
1986		0.47	0.53	
1987		0.50	0.50	
1988		0.36	0.64	
1989		0.30	0.70	
1990	0.98	0.02		
1991	0.91	0.01	0.08	
1992	0.84	0.02	0.15	
1993	0.98	0.02		
1994	0.46	0.01	0.03	0.50
1995	0.50	0.01	0.04	0.46
1996	0.68	0.02	0.05	0.25
1997	0.76	0.03	0.08	0.13
1998	0.70	0.04	0.11	0.15
1999	0.67	0.03	0.19	0.10
2000	0.73	0.05	0.15	0.07
2001	0.71	0.04	0.24	0.01
2002	0.70	0.07	0.20	0.03
2003	0.67	0.28		0.06
2004	0.48	0.31	0.12	0.09
2005	0.40	0.26	0.29	0.05
2006	0.55	0.19	0.15	0.11
2007	0.74	0.26		

1992	0.06	0.93	0.00			
1993	0.23	0.77	0.00			
1994	0.12	0.81	0.01		0.06	
1995	0.15	0.78	0.00		0.06	
1996	0.09	0.89	0.00		0.02	
1997	0.01	0.17	0.00		0.00	0.82
1998	0.01	0.16	0.00		0.01	0.83
1999	0.00	0.10	0.00		0.01	0.89
2000	0.01	0.10	0.00		0.01	0.89
2001	0.01	0.12	0.00		0.01	0.86
2002	0.00	0.11	0.00		0.01	0.88
2003	0.00	0.13	0.00		0.00	0.86
2004	0.00	0.14	0.00		0.00	0.85
2005	0.00	0.17	0.00		0.00	0.82
2006	0.00	0.18	0.00		0.00	0.82
2007	0.00				0.00	1.00

2006	0.60	0.00	0.17	0.23
2007	0.99	0.01		

Table 15. Combined indices of abundance for blue shark and shortfin mako in the northern and southern Atlantic. The indices were constructed by averaging over various CPUE indices with either catch weighting or area weighting.

Year	BSH-N Area	BSH-N Catch	BSH-S Area	BSH-S Catch	SMA-N Area	SMA-N Catch	SMA-S Area	SMA-S Catch
1957	0.958	1.066						
1958	0.451	0.560						
1959	1.089	1.198						
1960	1.160	1.269						
1961	1.109	1.218						
1962	1.484	1.593						
1963	0.674	0.783						
1964	0.846	0.955						
1965	1.535	1.643						
1966	1.251	1.360						
1967	1.413	1.522						
1968	1.292	1.400						
1969	1.950	2.059						
1970	0.947	1.056						
1971	0.675	0.498	0.702	0.702				
1972	1.216	0.843	0.466	0.466				
1973	0.621	0.621	0.974	0.974				
1974	1.476	1.476	0.743	0.743				
1975	1.104	1.236	0.561	0.561				
1976	0.616	0.571	0.605	0.605				
1977	1.465	1.254	4.287	4.287				
1978	1.172	1.273	2.368	2.368			0.441	0.599
1979	0.652	0.639	2.159	2.247			0.305	0.463
1980	1.074	1.248	2.261	2.317			0.632	0.790
1981	1.225	1.356	0.889	0.893			0.286	0.444
1982	1.024	1.187	1.654	1.747			0.433	0.825
1983	1.131	1.215	1.456	1.472			0.315	0.737
1984	0.783	0.842	1.589	1.618			0.222	0.614
1985	0.880	0.955	1.272	1.303			0.361	0.623
1986	1.864	1.572	1.587	1.660	2.036	1.995	0.611	0.773
1987	1.495	1.249	1.427	1.469	2.036	1.995	0.434	0.665
1988	1.001	0.849	1.492	1.536	1.615	1.574	0.648	0.747
1989	1.065	1.015	1.170	1.186	1.861	1.820	0.638	0.808
1990	1.023	0.966	1.172	1.172	1.574	1.666	1.081	1.265
1991	1.160	1.057	1.202	1.190	1.304	1.223	0.867	1.033
1992	1.197	1.174	1.147	1.202	1.506	1.367	0.980	1.214
1993	1.494	1.491	1.100	1.194	1.217	0.967	1.245	1.287
1994	1.448	1.548	1.282	1.321	1.322	1.018	1.587	1.635
1995	1.254	1.272	1.188	1.087	1.177	0.797	1.292	1.432
1996	1.318	1.346	1.309	1.057	0.849	1.043	0.891	1.250
1997	1.060	0.767	1.154	1.131	0.780	0.790	0.723	1.006
1998	0.903	0.726	1.403	1.297	0.877	0.887	1.040	1.014
1999	0.753	0.795	1.089	1.188	0.802	0.857	0.569	0.711
2000	0.818	0.953	1.091	1.354	0.664	0.889	0.910	1.073
2001	0.747	0.950	1.289	1.467	0.931	0.869	0.758	1.222

2002	0.645	0.791	1.299	1.428	1.078	1.005	1.426	1.517
2003	0.809	1.007	1.198	1.191	1.198	1.272	0.716	1.025
2004	0.677	0.752	1.274	1.263	1.471	1.422	1.368	1.491
2005	0.655	0.609	1.416	1.463	1.223	1.239	1.408	1.591
2006	0.820	0.693	1.413	1.398	1.417	1.147	1.752	1.499
2007	0.583	0.835	1.671	1.399	1.543	1.609	0.932	1.099

Table 16. CPUE indices used, method used to weight the CPUE data, start year of the fishery, catch series, variations on the prior distributions, first year of catch data and inflection point of the production curve for the BSP model runs. The base case is indicated with a "*".

Blue shark North

Run	Indices	Weigh-ting	Start year	Catch series	Priors	Catch data start	Bmsy/ K
a	base = USLL-log, JLL-N, VenLL, SpLL-N, Ire, Usold	area	1950	max	Bo/K mean 1	1971	0.5
b	base + US LPS, US Tour	area	1957	max	base	1971	0.5
c	base	catch	1957	max	base	1971	0.5
d*	base	area	1957	max	base	1971	0.5
e	base - USLL-log	area	1957	max	base	1971	0.5
f	base - JLL-N	area	1957	max	base	1971	0.5
g	base – Ire	area	1957	max	base	1971	0.5
h	base – Usold	area	1957	max	base	1971	0.5
i	base – Venll	area	1957	max	base	1971	0.5
j	base - SpLL-N	area	1957	max	base	1971	0.5
k	base	area	1957	ratio	base	1971	0.5
l	base	area	1957	max	r. sd *2	1971	0.5
m	base	area	1957	max	K uniform	1971	0.5
n	base	area	1950	max	Bo/K mean 1	1997	0.5
o	base	equal	1957	max	base	1971	0.5

Blue shark South

Run	Indices	Weigh-ting	Start year	Catch series	Priors	Catch data start	Bmsy/ K
a	Base=UrLL,JLL-S,BrLL,SpLL-S	area	1950	max	Bo/K mean 1	1971	0.5
b	base + early Brazil	area	1958	max	base	1971	0.5
c	base	catch	1971	max	base	1971	0.5
d*	base	area	1971	max	base	1971	0.5
e	base-SpLL-S	area	1971	max	base	1971	0.5
f	base-UrLL	area	1971	max	base	1971	0.5
g	base-BrLL	area	1971	max	base	1971	0.5
h	base-JLL-S	area	1971	max	base	1971	0.5
i	base	area	1971	ratio	base	1971	0.5
j	base	area	1971	max	r. sd *2	1971	0.5
k	base	area	1971	max	K uniform	1971	0.5
l	base	area	1950	max	Bo/K mean 1	1997	0.5
m	base	equal	1971	max	base	1971	0.5

Mako shark North

a	Base=USLL-log, JLL-N, SpLL-N	area	1950	ratio	Bo/K mean 1	1971	0.5
b	Base + US tourn, US LPS, US MRFSS	area	1971	ratio	base	1971	0.5
c	base	catch	1971	ratio	base	1971	0.5
d*	base	area	1971	ratio	base	1971	0.5
e	base-USLL	area	1971	ratio	base	1971	0.5
f	base -JLL-N	area	1971	ratio	base	1971	0.5
g	base -SpLL-N	area	1971	ratio	base	1971	0.5
h	base	area	1971	ratio	r. sd *2	1971	0.5
i	base	area	1971	ratio	K uniform	1971	0.5
j	base	area	1950	ratio	Bo/K mean 1	1997	0.5
k	base	area	1971	ratio	base	1971	0.84 (n=17)
l	base	equal	1971	ratio	base	1971	0.5

Mako shark South

a	Base = SpLL-S,UrLL,BrLL,JLL-S	area	1950	ratio	Bo/K mean 1	1971	0.5
b	base	catch	1971	ratio	base	1971	0.5
c*	base	area	1971	ratio	base	1971	0.5
d	base-SpLL-S	area	1971	ratio	base	1971	0.5
e	base-UrLL	area	1971	ratio	base	1971	0.5
f	base-BrLL	area	1971	ratio	base	1971	0.5
g	base-JLL-S	area	1971	ratio	base	1971	0.5
h	base	area	1971	ratio	r. sd *2	1971	0.5
i	base	area	1971	ratio	K uniform	1971	0.5
j	base	area	1950	ratio	Bo/K mean 1	1997	0.5
k	base	area	1971	ratio	base	1971	0.84
l	base	equal	1971	ratio	base	1971	0.5

Table 17. Effort, in thousands of hooks.

	North	South
1950	6614.093	42.35551
1951	5034.657	32.24107
1952	4250.234	27.17343
1953	3918.643	25.08798
1954	2465.223	15.78686
1955	3127.996	19.99948
1956	2530.329	114.7554
1957	4658.534	2891.693
1958	10092.84	4785.931
1959	14462.86	12873.79
1960	14957.43	15946.67
1961	15815.98	24864.09
1962	35796.96	35425.13

1963	42795.55	35187.44
1964	62524.22	45901.38
1965	61653.47	59830.72
1966	48105.16	42358.69
1967	45556.58	39426.56
1968	47784.88	53353.33
1969	48214.26	88510.06
1970	60845.97	96060.47
1971	77638.68	93775.39
1972	84643.34	110850.2
1973	86256.18	110057.8
1974	90440.53	89910.59
1975	140591.9	88154.39
1976	148234.8	102170.6
1977	133510.2	99174.42
1978	114002.9	111111.2
1979	91090.28	118661.8
1980	103716.8	108413.6
1981	120439.8	103661.8
1982	137441.1	132093.2
1983	133415.7	100685.1
1984	142632	106901.9
1985	147921.3	139573.9
1986	174532	131242
1987	130461.8	160201.5
1988	121610.6	160586.6
1989	135933.7	171406.9
1990	141694.5	204197.4
1991	167687.7	193677.2
1992	163501.6	176371.6
1993	151025.7	260333.7
1994	183693.9	260675
1995	193424.7	236161
1996	217207.2	241702.7
1997	214042.4	221851.5
1998	225521.3	217450.6
1999	241787.6	251961.7
2000	218542.4	275047
2001	218469.7	245294.7
2002	165841.2	215592
2003	166565.1	267873.3
2004	186692.8	212026.9
2005	204496.9	152721.1
2006	212448.7	127359.9

Table 18. Inputs for age-structured production model.

					Historic		VB growth function						Length-weight				Maturity ogive										
					catch		Males			Females			relationship		Fecundity	Reproductive	Males		Females		Maximum age		Annual survivorship				
Species	Region	Indices	Weighting	Model time	period	Virgin biomass	K	Linf (TL)	t0	K	Linf (TL)	t0	Wa	Wb	(pups/yr)	frequency	a50	a95	a50	a95	Males	Females	age-0	age-0.25	age-1	age-2	age-3+
Blue	North	combined	no	1957-2007	1957-1970	U (10E7-10E13) [3]	0.18	338	-1.35	0.13	371	-1.77	3.814E-06	3.1313	37	annual	5	6.5	6	7.5	16	16	Beta(5, 2)	0.70	0.78	0.80	0.86
		base [1]	area	1957-2007																							
		base [1]	no	1957-2007																							
Mako	North	base [2]	area	1950-2007	1950-1970	U (10E7-10E10)				0.05	425	-3.71	5.243E-06	3.1407	12.5	triennial	8	10	18	20	29	32	Beta(5,2)	0.81	0.84	0.85	0.91
		combined	no	1950-2007																							

1 base = USLL-log, JLL-N, VenLL, SpLL-N, (Ire Nom), USold(to 1985)

[2] base=USLL-log, JLL-N, SpLL-N

[3] Uniform distribution (min, max)

[4] Beta distribution (constant, constant)

Table 19. Selectivity parameters for fleets that take blue and shortfin mako sharks used in the age-structured production model.

Functional form	Fleet
Blue shark North Atlantic	
1 / (1 + Exp(-(age - 3.8) / 0.5))	USA LL fishery
1 / (1 + Exp(-(age - 5.3) / 0.9))	Japan LL fishery females
1 / (1 + Exp(-(age - 5.5) / 0.9))	Japan LL fishery males
1 / (1 + Exp(-(age - 4.46) / 0.84))	US + Japan combined
1 / (1 + Exp(-(age - 2.1) / 0.7))	Spain LL fishery
1 / (1 + Exp(-(age - 3.578) / (1.13)))	USA+Japan+Spain combined
1 / (1 + Exp(-(age - 3) / (0.7))) * (1 - (1 / (1 + Exp(-(age - 6) / 0.4)))) / 0.88	Ireland fishery females
1 / (1 + Exp(-(age - 1.32) / (0.7))) * (1 - (1 / (1 + Exp(-(age - 3.5) / 0.3)))) / 0.82	Ireland fishery males
1 / (1 + Exp(-(age - 2.3) / (0.4)))	Venezuela fishery females
1 / (1 + Exp(-(age - 3.38) / (0.8)))	Venezuela fishery males
Mako shark North Atlantic	
1 / (1 + Exp(-(age - 4.3) / (0.7)))	Combined selectivity
1 / (1 + Exp(-(age - 5) / 1.3))	USA fishery selectivity
1 / (1 + Exp(-(age - 2) / 0.3))	Japan fishery females
1 / (1 + Exp(-(age - 2) / 0.3))	Japan fishery males
1 / (1 + Exp(-(age - 5.5) / (1.5)))	Spain fishery females
1 / (1 + Exp(-(age - 5.5) / (1.5)))	Spain fishery males

Table 20. Scenarios requested by the Working Group at the onset of the assessment meeting.

Species	Region	Run name	Indices	Weighting
Blue	N	Base	US LL logbook, Japanese LL, Venezuelan LL, Spanish LL, Ireland Nominal Recreational Series, US old (daSilva series to 1985)	Area
Blue	N	Sensitivity 1	add US LPS and US Tournament	Area
Blue	S	Base	Uruguay LL, Japanese LL, Brazilian LL, Spanish LL	Area
Blue	S	Sensitivity 1	add Early Brazil data	Area
Mako	N	Base	US LL logbook, Japanese LL, Spanish LL	Area
Mako	N	Sensitivity 1	add US tournament, US LPS, and US MRFSS	Area
Mako	S	Base	Uruguay LL, Japanese LL, Brazilian LL, Spanish LL	Area

Table 21. Model inputs for catch-free, age-structured production model.

Species	Region	Indices	Weighting	Historic period	Modern period	Initial depletion during historic period	Selectivities a50	Selectivities b	VB growth function K	VB growth function Linf (TL)	VB growth function t0	Length-weight relationship Wa	Length-weight relationship Wb	Fecundity (pups/yr)	Reproductive frequency	Maturity ogive a50	Max age	alpha	M(1+ to max)
Blue	North	combined	no	1956-1970	1971-2007	0	3.58	1.1	0.13	371	-1.8	3.814E-06	3.1313	37	annual	6	16	LN(12.794, 0.271, 0.1,7.5) [4]	LN(0.15,0.3,0.05,0.5)
		combined	no	1956-1970	1971-2007	10													
		combined	no	1956-1970	1971-2007	20													
		base [1, 2]	no	1956-1970	1971-2007	10													
		USLL-Log	no	1956-1970	1971-2007	10													
		JLL-N	no	1956-1970	1971-2007	10													
Blue	South	combined	no	1956-1970	1971-2007	0	3.58	1.1	0.172	332	-2.2	1.00E-06	3.2713	37	annual	5	13	LN(12.794, 0.271, 0.1,7.5)	LN(0.15,0.3,0.05,0.5)
Mako	North	combined	no	1956-1970	1971-2007	0	4.3	0.7	0.054	425	-3.71	5.24E-06	3.1407	12.5	triennial	18	32	LN(1.459,0.271,0.1,7.5)	LN(0.1,0.30,0.05,0.5)
		base [2, 3]	no	1956-1970	1971-2007	0													
		base [3]	no	1971-1985	1986-2007	0													

[1] base = USLL-log, JLL-N, VenLL, SpLL-N, (Ire Nom), USold(to 1985)

[2] did not converge

[3] base=USLL-log, JLL-N, SpLL-N

[4] Lognormal distribution (mean, CV, min, max)

Table 22. Expected values and CVs of estimated parameters of BSP model runs for North Atlantic blue shark, as described in Table 17.

	E	CV	E	CV	E	CV	E	CV	E	CV
Run	a		b		c		d*		e	
K	126235	1.69	did not		327218	1.78	124024	1.71	136955	1.63
r	0.30	0.10	converge		0.30	0.10	0.30	0.10	0.30	0.10
MSY	9488	1.70			24659	1.78	9334	1.72	10308	1.63
Bcur	126030	1.70			327017	1.78	123819	1.71	136754	1.63
Bcur/K	0.94	0.12			0.95	0.10	0.93	0.13	0.95	0.10
binit1	117024	1.71			243121	1.85	93446	1.78	125102	1.63
Bcur/binit1	1.03	0.17			1.41	0.35	1.36	0.36	1.05	0.15
Ccur/MSY	0.21	1.63			0.16	1.85	0.22	1.60	0.17	1.68
fcur/fmsy	0.15	2.63			0.11	2.67	0.17	2.57	0.12	2.30
bcur/bmsy	1.88	0.12			1.91	0.10	1.87	0.13	1.90	0.10
ccur/repy	1.13	0.07			1.13	0.05	1.14	0.07	1.13	0.04
bmsy	63117	1.69			163609	1.78	62012	1.71	68478	1.63
repy	54.76	0.05			55.05	0.04	54.68	0.05	55.02	0.03
%maxwt	0.05				0.07		0.05		0.02	
CV(wt)/CV(lp)	0.88				0.92		0.92		0.89	
Run	f		g		h		i		j	
K	109107	1.89	131567	1.67	134506	1.64	131519	1.67	129359	1.69
r	0.30	0.10	0.30	0.10	0.30	0.10	0.30	0.10	0.30	0.10
MSY	8214	1.90	9902	1.68	10122	1.65	9899	1.68	9736	1.70
Bcur	108884	1.89	131362	1.67	134303	1.65	131315	1.67	129154	1.69
Bcur/K	0.87	0.25	0.94	0.12	0.94	0.11	0.94	0.12	0.94	0.13
binit1	99904	1.90	120186	1.68	123843	1.65	120138	1.68	118166	1.70
Bcur/binit1	0.96	0.27	1.04	0.17	1.04	0.16	1.04	0.17	1.04	0.17
Ccur/MSY	0.37	1.37	0.20	1.64	0.19	1.68	0.20	1.64	0.22	1.62
fcur/fmsy	0.48	2.87	0.15	2.61	0.14	2.58	0.15	2.69	0.17	2.69
bcur/bmsy	1.74	0.25	1.88	0.12	1.89	0.11	1.88	0.12	1.87	0.13
ccur/repy	1.20	0.22	1.13	0.07	1.13	0.06	1.13	0.07	1.14	0.08
bmsy	54554	1.89	65783	1.67	67253	1.64	65759	1.67	64680	1.69
repy	52.88	0.12	54.79	0.05	54.88	0.04	54.78	0.05	54.68	0.05
%maxwt	0.08		0.02		0.01		0.02		0.02	
CV(wt)/CV(lp)	0.96		0.89		0.88		0.89		0.89	
Run	k		l		m		n		o	
K	134404	1.64	123981	1.72	did not		122815	1.73	75203	2.34
r	0.30	0.10	0.30	0.20	converge		0.30	0.10	0.30	0.10
MSY	10155	1.65	9349	1.75			9229	1.74	5664	2.35
Bcur	134309	1.64	123771	1.72			122608	1.74	74950	2.35
Bcur/K	0.97	0.06	0.93	0.14			0.93	0.14	0.75	0.38
binit1	102299	1.72	93728	1.79			113597	1.75	58368	2.41
Bcur/binit1	1.42	0.34	1.35	0.36			1.02	0.18	1.07	0.48
Ccur/MSY	0.08	1.80	0.22	1.60			0.23	1.60	0.64	0.98
fcur/fmsy	0.05	2.19	0.18	2.78			0.19	2.80	0.94	1.71
bcur/bmsy	1.95	0.06	1.86	0.14			1.86	0.14	1.50	0.38
ccur/repy	0.98	0.03	1.14	0.09			1.14	0.09	1.30	0.26
bmsy	67202	1.64	61990	1.72			61407	1.73	37602	2.34
repy	27.50	0.03	54.59	0.06			54.68	0.06	49.74	0.17
%maxwt	0.07		0.04				0.03		0.49	
CV(wt)/CV(lp)	0.92		0.92				0.88		1.09	

Table 23. Expected values and CVs of estimated parameters of BSP model runs for South Atlantic blue shark, as described in Table 16.

	E	CV	E	CV	E	CV	E	CV	E	CV
Run	a		b		c		d*		e	
K	9842364	1.98	10202483	1.94	7703230	2.34	8403117	2.22	10859064	1.88
r	0.30	0.10	0.30	0.10	0.30	0.10	0.30	0.10	0.30	0.10
MSY	738967	1.99	765824	1.96	582088	2.35	631612	2.23	812771	1.89
Bcur	9842218	1.98	10202338	1.94	7703076	2.34	8402962	2.22	10858907	1.88
Bcur/K	0.99	0.03	0.99	0.03	0.97	0.06	0.98	0.06	1.00	0.00
binit1	9113119	2.00	9443273	1.96	6968688	2.35	7487059	2.23	9211853	1.89
Bcur/binit1	1.08	0.11	1.08	0.11	1.09	0.13	1.11	0.14	1.20	0.14
Ccur/MSY	0.03	2.67	0.03	2.64	0.08	1.92	0.06	2.30	0.00	1.91
fcur/fmsy	0.01	2.88	0.01	2.88	0.05	2.10	0.04	2.74	0.00	1.92
bcur/bmsy	1.98	0.03	1.98	0.03	1.94	0.06	1.95	0.06	2.00	0.00
ccur/repy	0.82	0.02	0.82	0.02	0.80	0.68	0.80	0.48	0.78	0.83
bmsy	4921182	1.98	5101241	1.94	3851615	2.34	4201559	2.22	5429532	1.88
repy	45.16	0.02	45.17	0.02	46.97	0.24	47.62	0.33	49.77	0.46
%maxwt	0.09		0.09		0.01		0.00		0.07	
CV(wt)/CV(lp)	0.89		0.89		0.13		0.18		1.19	
Run	f		g		h		i		j	
K	10855812	1.88	10823965	1.88	10331160	1.93	7892176	2.30	8470821	2.20
r	0.30	0.10	0.30	0.10	0.30	0.10	0.30	0.10	0.30	0.20
MSY	812472	1.89	810639	1.89	771938	1.95	593696	2.31	637171	2.26
Bcur	10855654	1.88	10823807	1.88	10331004	1.93	7892088	2.30	8470625	2.20
Bcur/K	1.00	0.00	1.00	0.00	1.00	0.00	0.97	0.08	0.98	0.06
binit1	9200779	1.89	9178088	1.90	9027072	1.95	7033016	2.31	7564904	2.22
Bcur/binit1	1.20	0.14	1.20	0.14	1.16	0.14	1.11	0.14	1.11	0.14
Ccur/MSY	0.00	1.91	0.00	1.91	0.01	1.81	0.10	2.43	0.06	2.30
fcur/fmsy	0.00	1.92	0.00	1.91	0.00	1.82	0.07	3.25	0.04	2.76
bcur/bmsy	2.00	0.00	2.00	0.00	2.00	0.00	1.95	0.08	1.95	0.06
ccur/repy	0.78	0.82	0.78	0.82	0.79	1.01	1.12	0.86	0.79	2.20
bmsy	5427906	1.88	5411982	1.88	5165580	1.93	3946088	2.30	4235411	2.20
repy	49.80	0.47	49.69	0.46	49.01	0.44	24.81	0.57	56.31	2.06
%maxwt	0.07		0.07		0.06		0.00		0.01	
CV(wt)/CV(lp)	1.20		1.19		NA		0.16		0.17	
Run	k		l		m					
K	49705718	0.58	2462320	2.17	8776391	2.15				
r	0.30	0.10	0.30	0.10	0.30	0.10				
MSY	3738991	0.59	184785	2.17	660477	2.17				
Bcur	49705534	0.58	2462169	2.17	8776238	2.15				
Bcur/K	1.00	0.00	0.98	0.06	0.98	0.04				
binit1	44181799	0.59	2276271	2.18	7841136	2.17				
Bcur/binit1	1.14	0.12	1.07	0.13	1.12	0.13				
Ccur/MSY	0.00	39.24	0.07	2.07	0.05	2.32				
fcur/fmsy	0.00	43.12	0.04	2.39	0.03	2.53				
bcur/bmsy	2.00	0.00	1.95	0.06	1.97	0.04				
ccur/repy	0.79	27.15	0.81	0.04	0.80	0.74				
bmsy	24852859	0.58	1231160	2.17	4388196	2.15				
repy	59.25	0.77	46.03	0.04	47.64	0.31				
%maxwt	0.01		0.01		0.01					
CV(wt)/CV(lp)	0.71		0.88		0.19					

Table 24. Expected values and CVs of estimated parameters of BSP model runs for North Atlantic shortfin mako shark, as described in Table 16.

	E	CV	E	CV	E	CV	E	CV	E	CV	E	CV
Run	a		b		c		d*		e		f	
K	434	0.46	634	0.33	539	0.41	532	0.42	577	0.38	517	0.43
r	0.0140	0.29	0.0145	0.29	0.0142	0.29	0.0141	0.29	0.0143	0.29	0.0141	0.29
MSY	1.51	0.55	2.29	0.44	1.89	0.50	1.87	0.51	2.05	0.48	1.81	0.52
Bcur	267	0.73	364	0.52	273	0.69	266	0.71	309	0.63	252	0.74
Bcur/K	0.55	0.33	0.56	0.34	0.48	0.44	0.47	0.45	0.51	0.40	0.46	0.47
binit1	393	0.47	452	0.42	371	0.50	365	0.50	403	0.47	352	0.51
Bcur/binit1	0.60	0.32	0.77	0.19	0.66	0.29	0.66	0.30	0.71	0.25	0.64	0.32
Ccur/MSY	3.00	0.47	1.92	0.51	2.43	0.55	2.47	0.55	2.22	0.55	2.57	0.55
fcur/fmsy	3.66	0.94	2.10	0.85	3.59	1.06	3.77	1.09	2.95	1.06	4.18	1.12
bcur/bmsy	1.09	0.33	1.12	0.34	0.96	0.44	0.95	0.45	1.03	0.40	0.92	0.47
ccur/repy	3.49	0.50	2.36	0.49	3.09	0.62	3.17	0.63	2.77	0.59	3.36	0.66
bmsy	217	0.46	317	0.33	269	0.41	266	0.42	289	0.38	259	0.43
repy	1.24	0.42	1.87	0.46	1.52	0.52	1.50	0.53	1.67	0.51	1.44	0.55
%maxwt	0.087		0.005		0.003		0.002		0.002		0.002	
CV(wt)/CV(lp)	0.89		0.93		0.50		0.48		0.69		0.43	
Run	g		h		i		j		k		l	
K	528	0.42	531	0.42	626	0.35	96818	2.02	489	0.47	561	0.38
r	0.0141	0.29	0.0145	0.58	0.0140	0.29	0.0139	0.28	0.0141	0.29	0.0142	0.29
MSY	1.85	0.51	1.87	0.71	2.19	0.45	335.90	2.13	5.36	0.55	1.98	0.48
Bcur	262	0.72	267	0.71	324	0.63	91748	2.03	310	0.75	294	0.63
Bcur/K	0.47	0.45	0.48	0.45	0.50	0.45	0.84	0.24	0.60	0.46	0.51	0.40
binit1	361	0.51	366	0.50	415	0.49	87316	2.05	333	0.56	390	0.47
Bcur/binit1	0.65	0.31	0.66	0.31	0.72	0.25	0.93	0.24	0.83	0.34	0.70	0.24
Ccur/MSY	2.50	0.55	2.93	0.74	2.05	0.55	1.04	1.56	0.90	0.57	2.26	0.52
fcur/fmsy	3.90	1.10	4.53	1.28	2.99	1.13	1.20	2.39	1.91	1.16	2.86	0.83
bcur/bmsy	0.94	0.45	0.95	0.45	1.00	0.45	1.67	0.24	0.72	0.46	1.02	0.40
ccur/repy	3.23	0.64	3.77	0.83	2.70	0.62	1.05	99.67	1.84	0.98	2.75	0.50
bmsy	264	0.42	266	0.42	313	0.35	48409	2.02	410	0.47	281	0.38
repy	1.48	0.53	1.49	0.69	1.72	0.50	58.86	3.36	3.19	0.62	1.61	0.48
%maxwt	0.002		0.003		0.002		0.041		0.003		0.003	
CV(wt)/CV(lp)	0.46		0.46		0.50		0.86		0.40		0.63	

Table 25. Expected values and CVs of estimated parameters of BSP model runs for South Atlantic shortfin mako shark, as described in Table 16.

Run	a		b		c*		d		e		f	
	E	CV	E	CV	E	CV	E	CV	E	CV	E	CV
K	1215830	1.75	1066175	1.92	1097720	1.88	1100662	1.88	1106858	1.87	995492	2.00
r	0.01	0.28	0.01	0.29	0.01	0.29	0.01	0.29	0.01	0.29	0.01	0.29
MSY	4290	1.86	3856	2.01	4036	1.97	4058	1.97	4099	1.96	3507	2.10
Bcur	1130349	1.76	710491	2.04	704934	2.00	698495	2.00	695961	2.00	710000	2.11
Bcur/K	0.92	0.08	0.66	0.33	0.64	0.33	0.63	0.33	0.63	0.34	0.70	0.32
binit1	1051212	1.78	607550	2.14	591970	2.11	583611	2.11	578884	2.11	625516	2.19
Bcur/binit1	1.08	0.09	1.20	0.16	1.23	0.16	1.24	0.16	1.24	0.16	1.15	0.16
Ccur/MSY	0.21	2.69	0.26	2.69	0.22	2.77	0.21	2.77	0.20	2.79	0.42	2.57
fcur/fmsy	0.13	3.04	0.25	3.19	0.21	3.19	0.20	3.17	0.19	3.18	0.42	3.35
bcur/bmsy	1.83	0.08	1.31	0.33	1.27	0.33	1.26	0.33	1.25	0.34	1.39	0.32
ccur/repy	0.55	17	0.25	250	0.23	208	0.18	266	0.18	263	0.36	195
bmsy	607915	1.75	533087	1.92	548860	1.88	550331	1.88	553429	1.87	497746	2.00
repy	1007.96	2.48	2707.79	2.28	2994.31	2.18	3054.52	2.17	3118.96	2.15	2189.15	2.49
%maxwt	0.289		0.007		0.009		0.007		0.009		0.001	
CV(wt)/CV(lp)	0.96		0.30		0.40		0.42		0.45		0.15	
Run	g		h		i		j		k		l	
K	1119441	1.86	1090950	1.88	49911603	0.58	1054343	1.89	1057495	1.93	1194246	1.78
r	0.01	0.29	0.02	0.58	0.01	0.29	0.01	0.29	0.02	0.28	0.02	0.29
MSY	4159	1.95	4564	2.22	183536	0.67	3869	2.01	12533	2.02	4674	1.86
Bcur	704323	1.99	712820	2.00	31910550	0.69	741382	2.00	828675	2.01	679995	1.90
Bcur/K	0.63	0.34	0.65	0.32	0.64	0.33	0.69	0.28	0.78	0.28	0.57	0.33
binit1	585668	2.10	583879	2.12	26726577	0.78	579916	2.16	543697	2.12	535271	2.02
Bcur/binit1	1.25	0.16	1.28	0.24	1.26	0.15	1.36	0.22	1.57	0.21	1.32	0.15
Ccur/MSY	0.20	2.77	0.24	3.09	0.00	33.94	0.19	2.50	0.09	2.74	0.11	2.72
fcur/fmsy	0.19	3.14	0.23	3.54	0.00	27.58	0.16	2.87	0.12	3.15	0.11	2.84
bcur/bmsy	1.25	0.34	1.30	0.32	1.28	0.33	1.38	0.28	0.93	0.28	1.14	0.33
ccur/repy	0.19	286	0.40	42	0.00	695	0.33	27	0.23	3.86	0.12	251
bmsy	559720	1.86	545475	1.88	24955801	0.58	527172	1.89	885880	1.93	597123	1.78
repy	3160.20	2.14	3311.49	2.40	137364.93	0.84	2613.02	2.25	6758.11	2.48	3938.12	1.96
%maxwt	0.017		0.020		0.011		0.159		0.014		0.035	
CV(wt)/CV(lp)	0.45		0.51		0.86		1.02		0.43		0.72	

Table 26. Decision table for the shortfin mako shark North Atlantic base case (run blue north d). Bfin is biomass at the time horizon. P is probability. E is expected value.

Time horizon	Harvest rate policy	E(Bfin /K)	E(Bfin/ Bmsy)	P(Bfin< 0.2K)	P(Bfin> Bmsy)	P(Bfin> Bcur)	P(Ffin< Fcur)	P(Bcur> Bref)	P(Bfin< 0.01K)
10 -year	HR= 0	0.5	1	0.09	0.5	1	1	0.36	0
	Hrmsy	0.47	0.95	0.11	0.46	0.62	0.93	0.08	0
	HRmsy* 3.77	0.4	0.81	0.15	0.33	0	0.38	0	0
20 -year	HR= 0	0.53	1.06	0.07	0.55	1	1	0.69	0
	Hrmsy	0.48	0.95	0.09	0.47	0.62	0.93	0.15	0
	msy* 3.77	0.35	0.7	0.19	0.19	0	0.38	0	0
30 -year	HR= 0	0.56	1.12	0.06	0.6	1	1	0.86	0
	Hrmsy	0.48	0.96	0.08	0.48	0.62	0.93	0.22	0
	HRmsy* 3.77	0.31	0.61	0.23	0.05	0	0.38	0	0

Table 27. Model results for the blue shark in the North Atlantic.

	RUN A	RUN C
Virgin Biomass (Kg)(mode)	861,081,745	1.923E+09
Virgin Biomass (Kg) (mean)	3,998,995,688 CV=0.8	
Historical Catch (kg) (mode)	28,691,170	23812955
Historical catches (Kg) (mean)	23,139,539. CV=0.27	
Survival at low densities (y^{-1}) (mode)	0.773	0.80
Survival at low densities (y^{-1}) (mean)	0.72 CV=0.20	
Relative current stock (mode)	0.30	0.72
Relative current stock (mean)	0.67 CV= 0.35	

Table 28. Model results for the mako shark in the North Atlantic.

	RUN D	RUN E
Virgin Biomass (Kg) (mode)	195,083,926	241,803,899
Virgin Biomass (mean)	2,534,863,459 CV=1.2	
Historical Catch (Kg) (mode)	1,365,953.	1,056,896
Historical catches (mean)	1,697,951 CV=0.52	
Survival at low densities (y^{-1}) (mode)	0.83	0.82
Survival at low densities (mean)	0.717 CV=0.20	
Relative current stock (mode)	0.45	0.59
Relative current stock (mean)	0.73 CV= 0.32	

Table 29. Blue shark catch-free model estimates (CV). F_{modern} refers to the fishing mortality in the first year for which data are available; F_{hist} refers to the fishing mortality in the first year of the model run.

Model	starting year	Objective Function	$SSBcurr/SSB_0$	SSBcurr/SSBmsy	Fcurr	Fcurr/Fmsy	Fmodern	Fhist	Fmsy	SPRmsy	M	alpha
North Stock; 10% depletion in 1971	1956	-4.61E+01	8.31E-01 (0.111)	2.73E+00 (0.542)	1.99E-02 (0.0164)	1.33E-01 (0.111)	5.24E-03	0	1.49E-01 (0.0226)	3.04E-01	1.50E-01 (0.044)	1.38E+01 (3.45)
North Stock; 20% depletion in 1971	1956	-5.33E+01	8.27E-01 (.109)	2.72E+00 (0.531)	2.03E-02 (0.0156)	1.36E-01 (0.106)	1.46E-02	0	1.49E-01 (0.0226)	3.04E-01	1.50E-01 (0.0439)	1.38E+01 (3.45)
North Stock; virgin conditions in 1971	1956	-4.61E+01	8.33E-01 (0.109)	2.74E+00 (0.543)	1.96E-02 (0.0162)	1.31E-01 (0.111)	1.35E-06	0	1.49E-01 (0.0226)	3.53E-01	1.50E-01 (0.044)	1.38E+01 (3.45)
South Stock; virgin conditions in 1971	1956	-4.47E+01	8.61E-01 (0.104)	2.80E+00 (0.396)	1.73E-02 (0.0152)	8.66E-02 (0.0781)	9.00E-07	0	2.00E-01 (0.0493)	3.89E-01	1.52E-01 (0.0446)	8.50E+00 (3.76E-04)

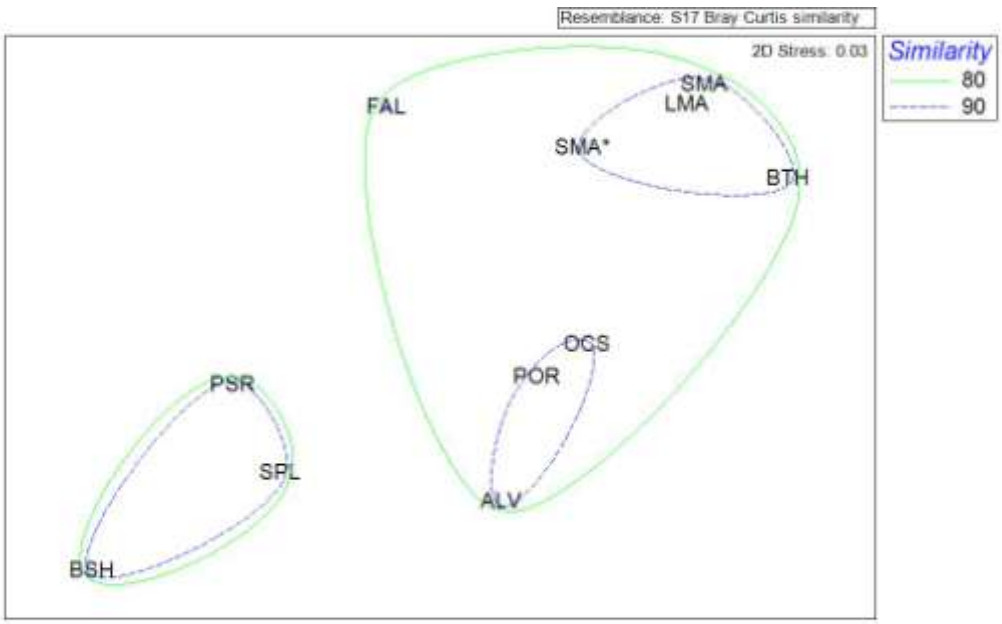
Table 30. Mako shark catch-free model estimates (CV). F_{modern} refers to the fishing mortality in the first year for which data are available; F_{hist} refers to the fishing mortality in the first year of the model run.

Model	Indices used	starting year	Objective Function	$SSBcurr/SSB_0$	SSBcurr/SSBmsy	Fcurr	Fcurr/Fmsy	Fmodern	Fhist	Fmsy	SPRmsy	M	alpha
North Stock; virgin conditions in 1956	combined index	1956	-4.80E+01	7.28E-01 (0.164)	1.65E+00 (0.533)	2.08E-02 (0.0167)	4.82E-01 (0.388)	9.38E-07	0	4.31E-02	6.62E-01	1.49E-01 (0.0438)	2.45 (0.393)
North Stock; virgin conditions in 1971	USLL-log, JPLL-N, and SpLL-N	1971	-1.49E+01	5.63E-01 (0.315)	1.26E+00 (0.772)	3.50E-02 (0.0363)	6.98E-01 (0.725)	3.41E-03	0	5.01E-02	6.70E-01	1.01E-01 (0.0201)	2.49 (0.404)

Table 31 Estimated catches (t) of Porbeagle reported to ICCAT.

Stock	Flag	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
total		584	1141	706	664	706	813	956	971	1283	1944	2588	1886	2673	2119	1548	1885	1495	1403	1489	1026	905	669	740	570	503	476
north		584	1141	706	664	706	813	955	971	1283	1943	2588	1885	2671	2116	1544	1857	1475	1393	1470	1024	892	618	719	538	465	473
south								1	0		1	0	1	2	3	3	28	19	10	18	1	13	51	19	30	37	3
Medit.														0	0	1	0	1	0	1	1	0	0	2	2	1	0
AN	Canada	1	9	20	26	24	59	83	73	78	329	813	919	1575	1353	1051	1334	1070	965	902	499	237	142	232	202	192	93
	EC.Denmark	84	45	38	72	114	56	33	33	46	85	80	91	93	86	72	69	85	107	73	76	42					
	EC.España															31	50	49	18	26	48	109	53	22	14	34	
	EC.France	199	791	411	254	260	280	446	341	551	300	496	633	820	565	267	315	219	240	410	361	461	303	413	276	194	354
	EC.Germany																		0	17	1	3					
	EC.Ireland																		8	1	6	3					
	EC.Netherlands																										0
	EC.Portugal						3	3	2	2	1	0							0	7	4	10	101	50	14	6	0
	EC.Sweden	6	5	9	10	8	5	3	3	2	2	4	3	2	2	1	1	1	1	1	1						
	EC.United Kingdom	1	2	5	12	6	3	3	15	9					0			1	6	8	12	10			24	11	26
	Faroe Islands	259	256	126	210	270	381	373	477	550	1189	1149	165	48	44	8	9	7	10								
	Iceland	1		1								1		1	5	3	2	3	3	2	4	2	0	1	0	1	
	Japan															5	4										
	Norway	33	33	96	80	24	25	11	25	43	32	41	24	24	26	28	17	27	32	22	11	14	19		8	27	
	U.S.A.	0		0	0	0	1	0	2	2	5	4	50	108	35	78	56	13	3	1	1	1	0	1	0	0	0
AS	Benin																4	0	4								
	Chile													1			0										
	EC.Bulgaria										0																
	EC.España							0			1			0	0	0	5	4	2	14	1	5	17	7	0	3	
	EC.Poland								0			0	0	1													
	EC.Portugal																							4	2		
	Falklands												0		0	0	0	1	0	0	0	0					
	Japan							1					1	0	0	3	14	0	1								
	Seychelles																	0									
	Uruguay														3		5	14	3	4		8	34	8	28	34	3
MED	EC.Italy																							2	1	1	
	EC.Malta													0	0	1	0	1	0	1	1	0	0	0	1		0

A



B

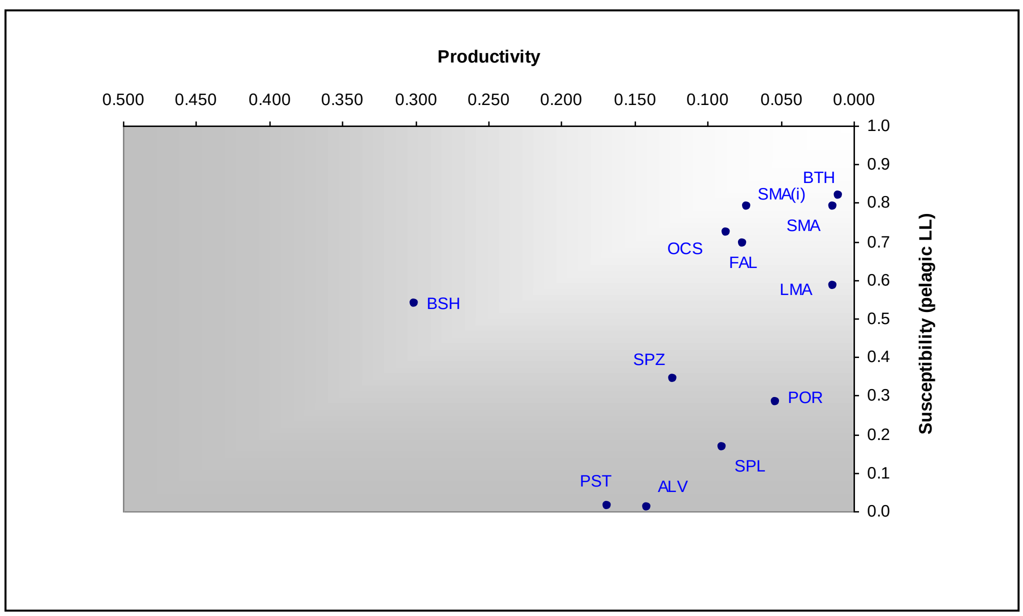


Figure 1. A. Results of the multidimensional ERA from SRCS 2008/140; level of risk increases from lower left to upper right. B. Results of ERA from SCRS 2008/138 for all fleets with available observer data; level of risk increases from lower left to upper right.

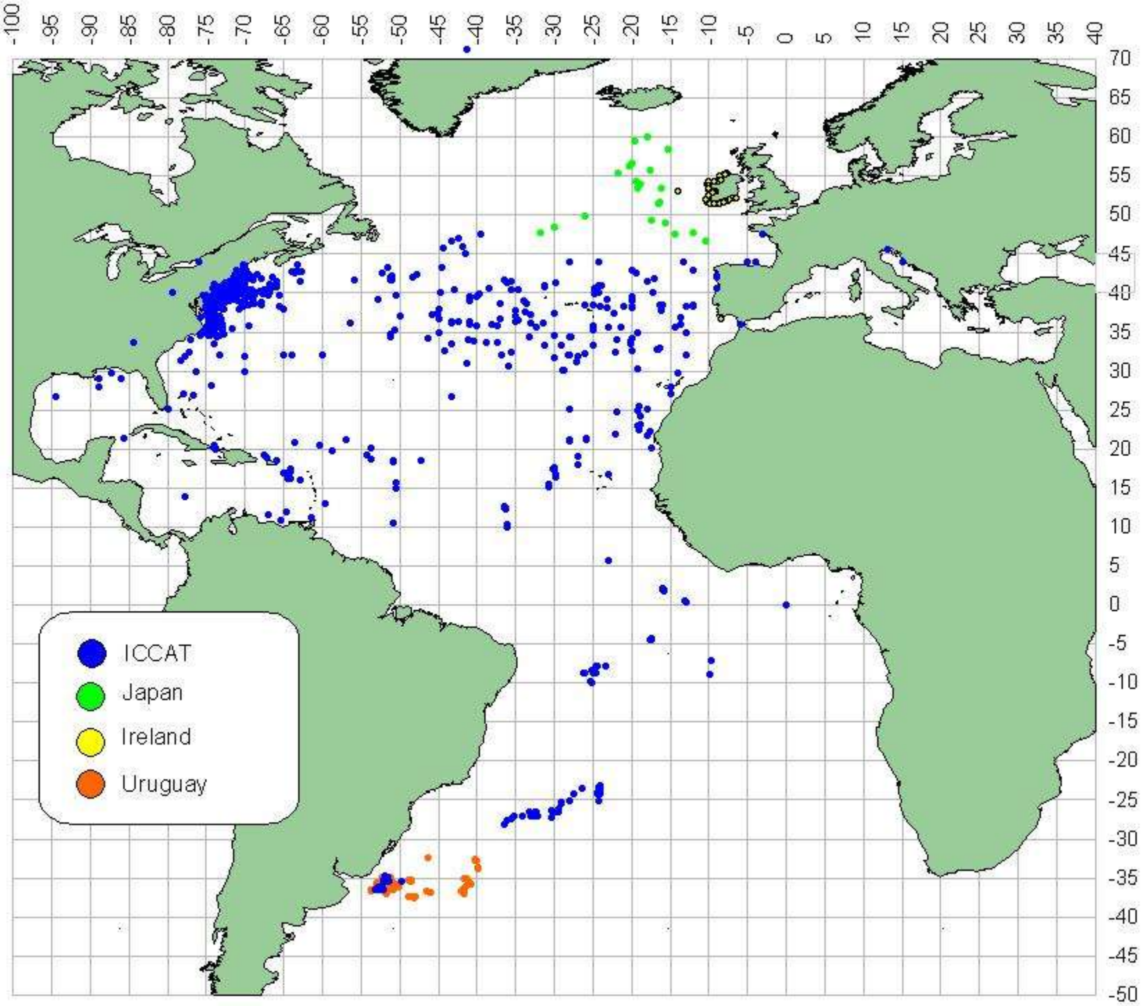


Figure 2. Tagging information for blue sharks held at the ICCAT Secretariat.

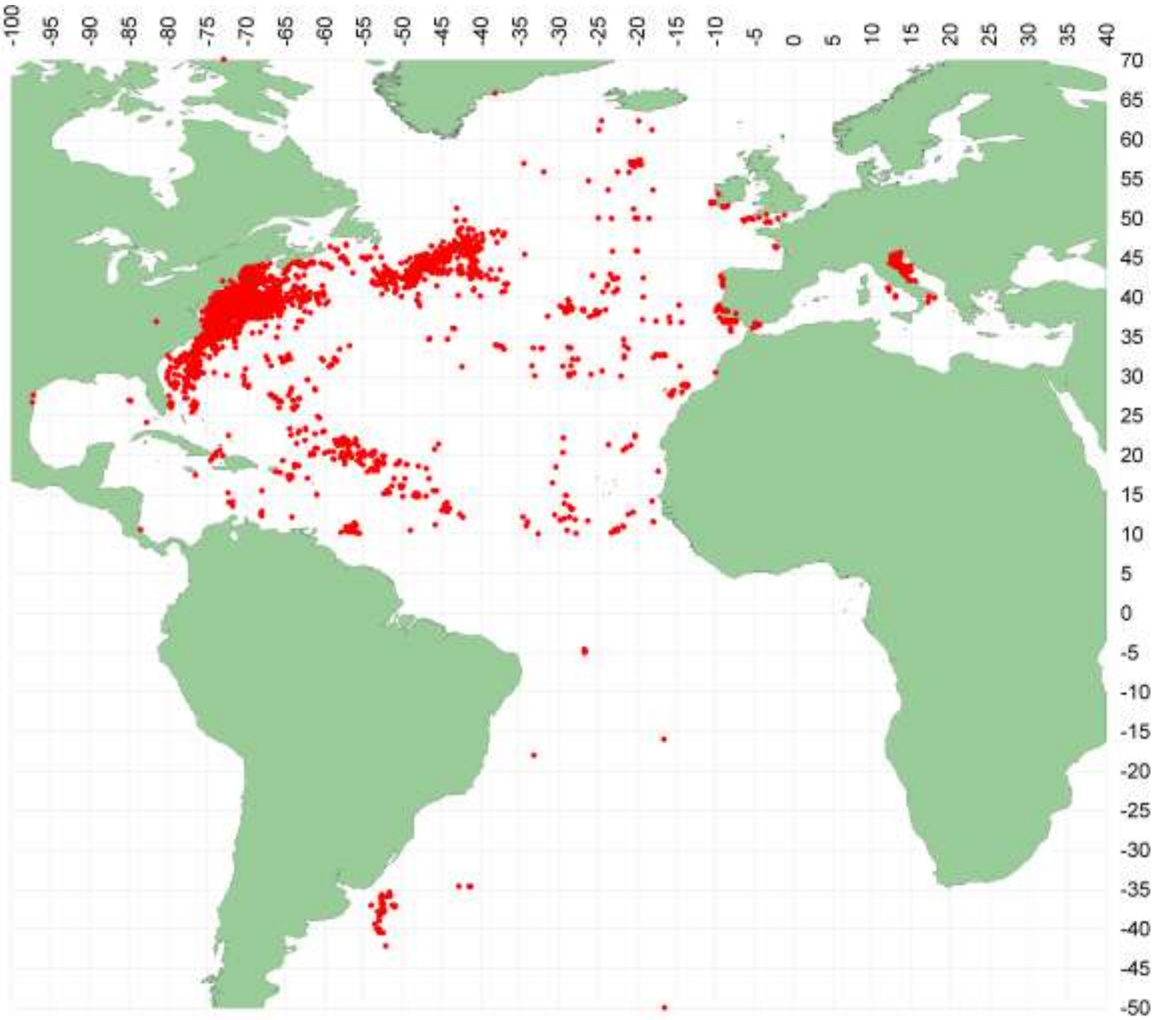


Figure 3. Tagging information for blue sharks from the USA .

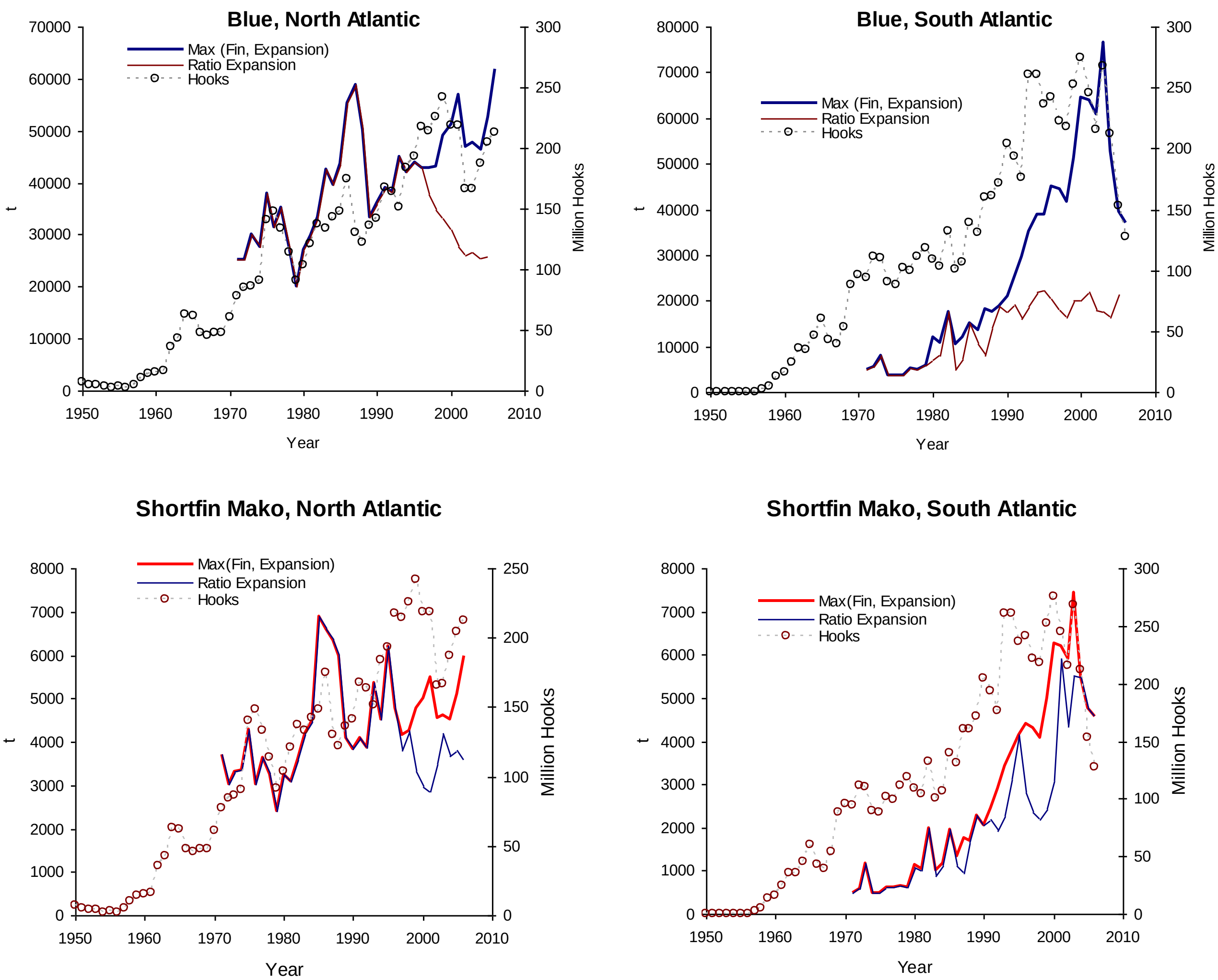
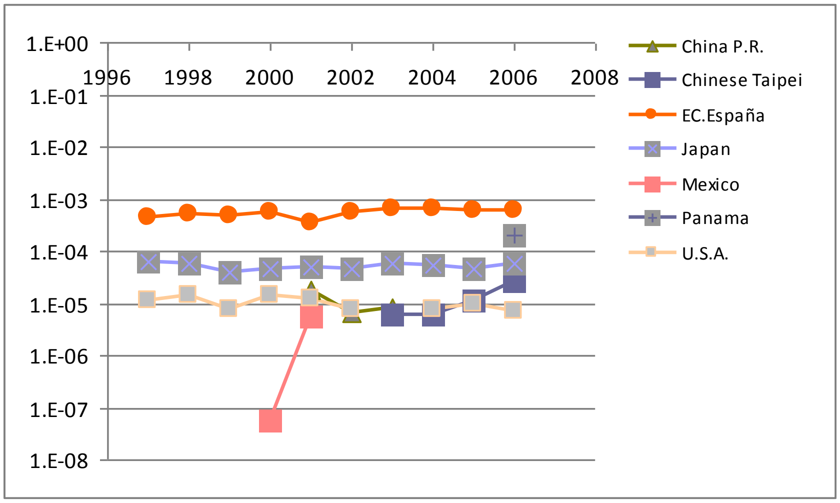


Figure 4. Catch series for blue and shortfin mako sharks in the North and South Atlantic, 1971-2006, used in the BSP modelling runs. One series is based on expanding catches in the ICCAT Task-I database using tuna to shark catch ratios ("Ratio Expansion"), and one series is based on taking the maximum of these estimates and the shark fin trade-based estimates ("Max"). Longline hooks fished per year for the North and South Atlantic, 1950-2006, are also shown on each plot.



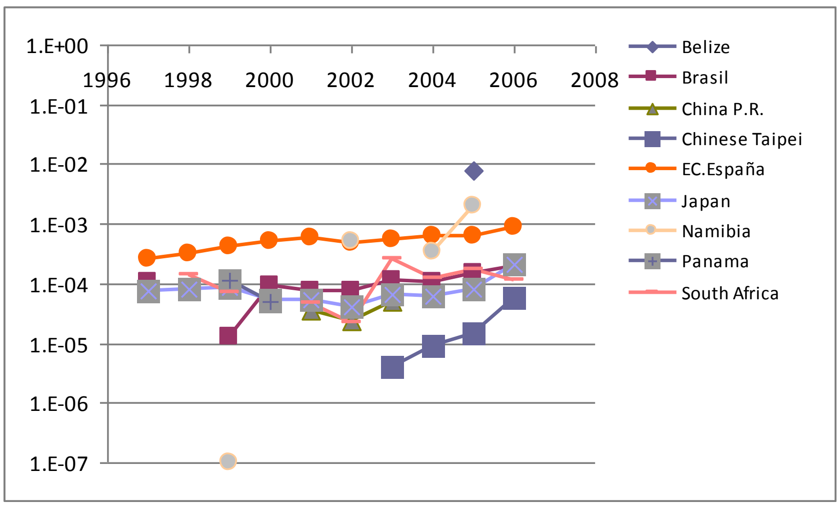
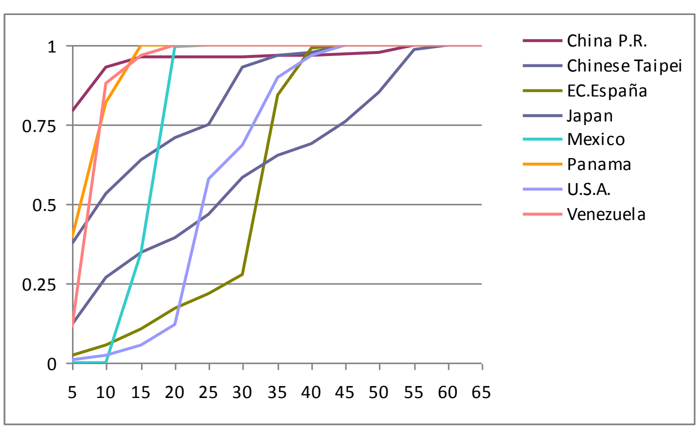


Figure 5. Log scale BSH t per hook reported for different fleets operating in the North Atlantic (upper) and South Atlantic (lower), indicating fleet-specific differences of an order of magnitude or more in the nominal catch rates of blue sharks, for certain fleets.



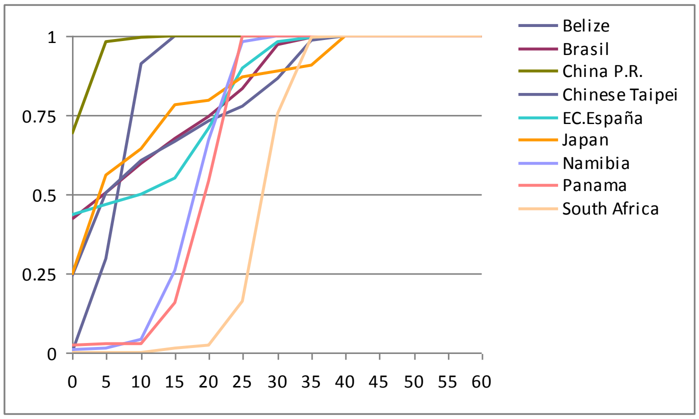


Figure 6. Cumulative proportion of effort fished in 1997-2007 by latitude (x axis) for the fleets indicated in the north (upper) and south (lower) Atlantic.

Cluster	BSH CPUE
1 (ALB)	0.048948
2 (SWO)	0.463463
3 (YFT)	0.093105
4 (RSK)	0.090527
5 (BET)	0.059262
6 (Various)	0.08782

Fleet	**BSH CPUE**
BRA	**0.393547**
ESP	**0.352776**
JPN	**0.132947**
PAN	**0.127875**
STV	**0.056623**
TAI	**0.067237**

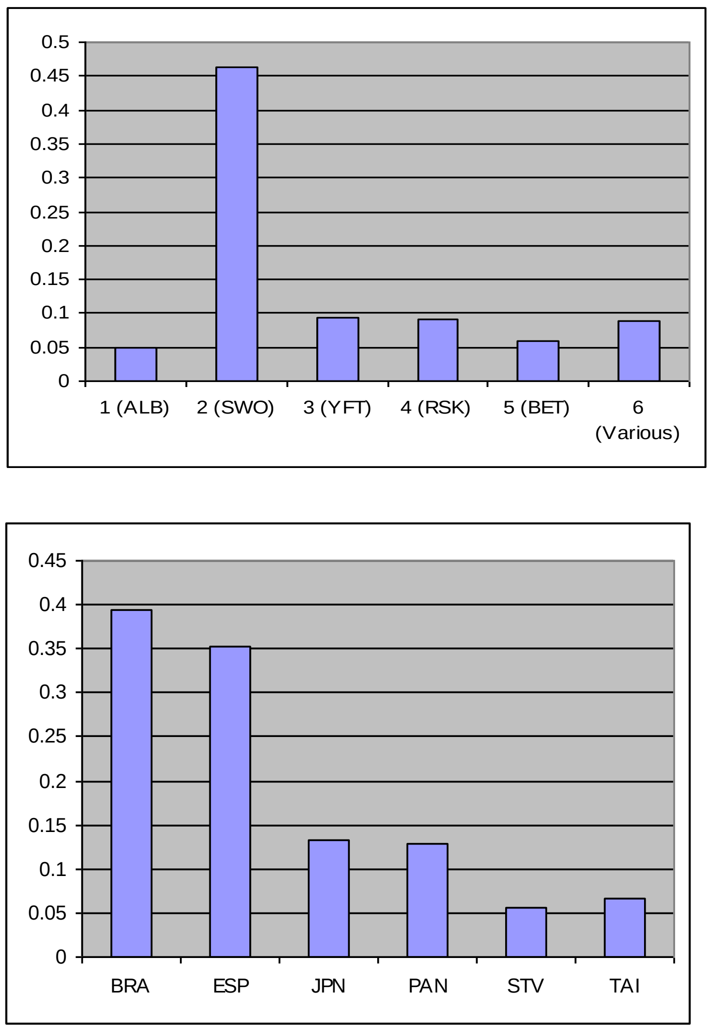


Figure 7. Comparison of blue shark nominal catch rates in Brazilian national and leased fleets, in number of fish per 100 hooks based on set-by-set logbook data, depending on targeting (cluster, upper panel) and fleet (lower panel).

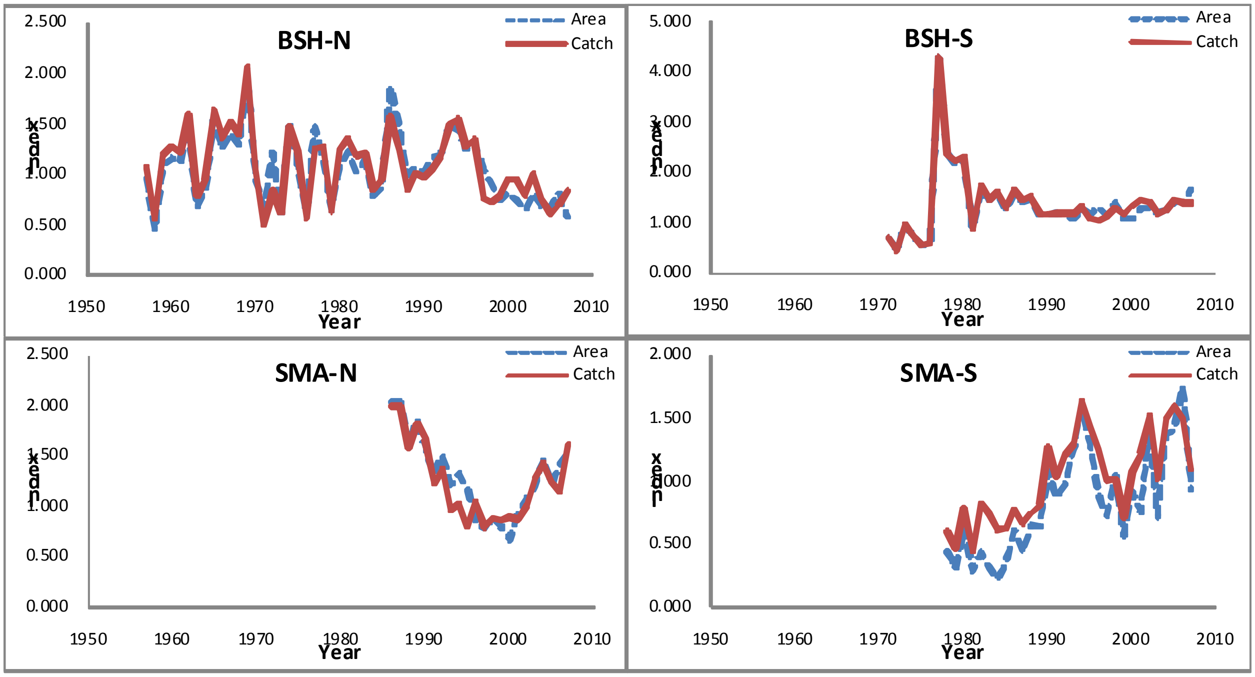


Figure 8 Combined indices of abundance for shortfin mako and blue shark.

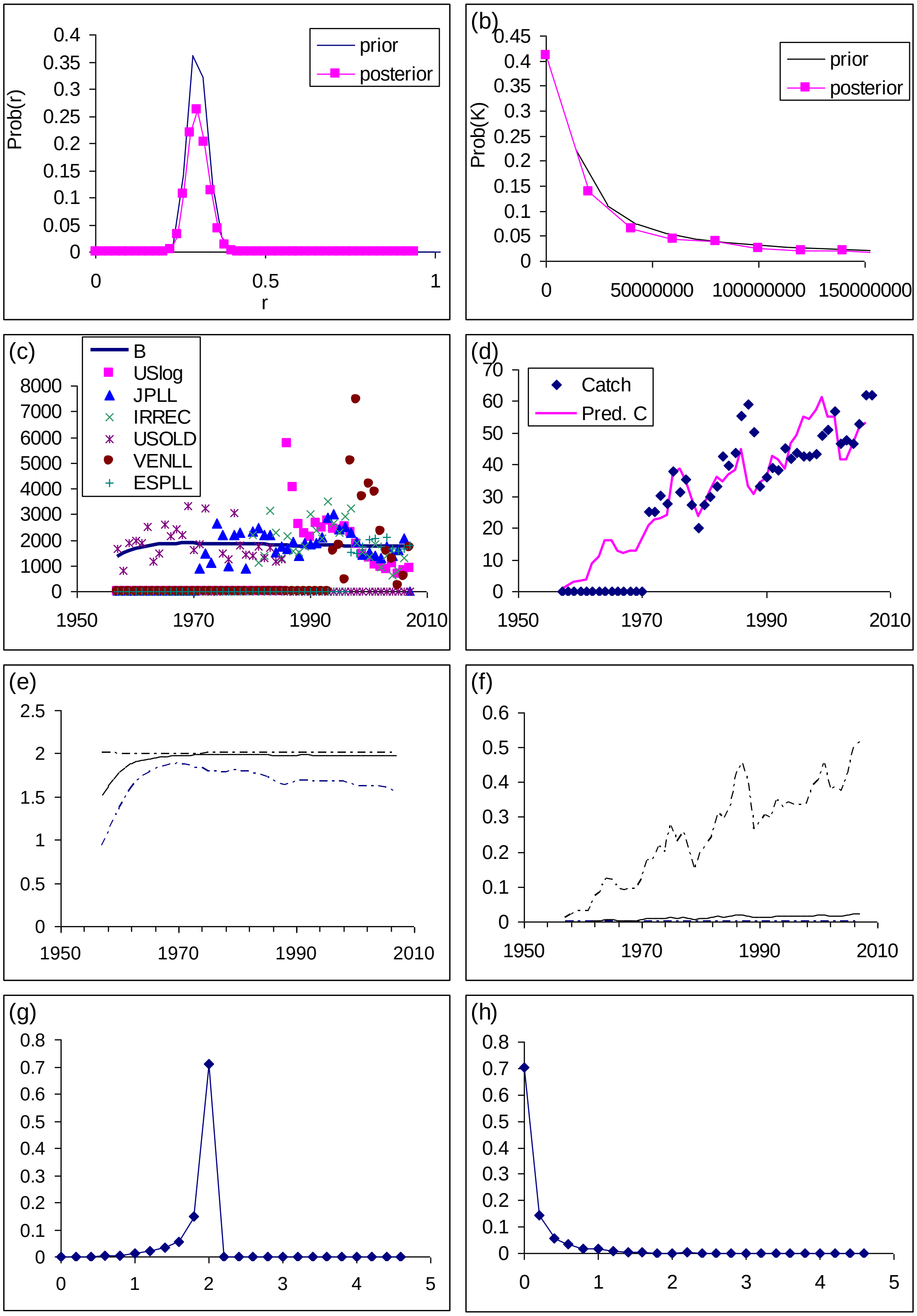


Figure 9. BSP model results for the blue shark base case in the North Atlantic (run d): (a) prior and posterior of *r*, (b) prior and posterior of *K*, (c) posterior mode biomass projections and CPUE series in biomass units (1000 mt), (d) observed and predicted catches (1000 mt), (e) median and 80% credibility intervals for B/Bmsy, (f) median and 80% C. I. for F/Fmsy, (g) posterior distribution of B_{2008}/Bmsy and (h) posterior distribution of F_{2008}/Fmsy.

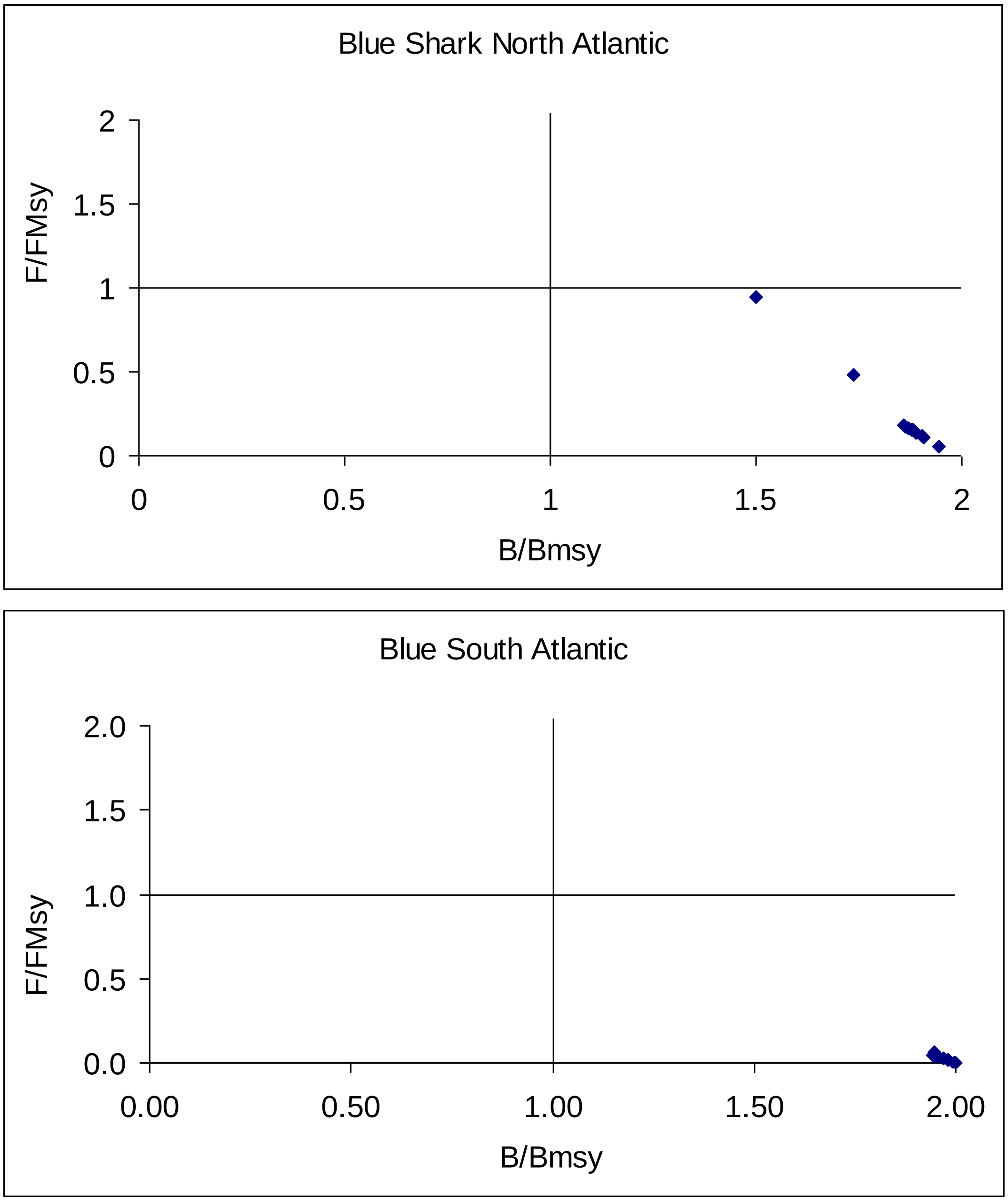


Figure 10. Expected values of the current (2008) biomass and fishing mortality rates relative to the MSY values calculated from the BSP model sensitivity analyses described in tables 16, 22 and 23.

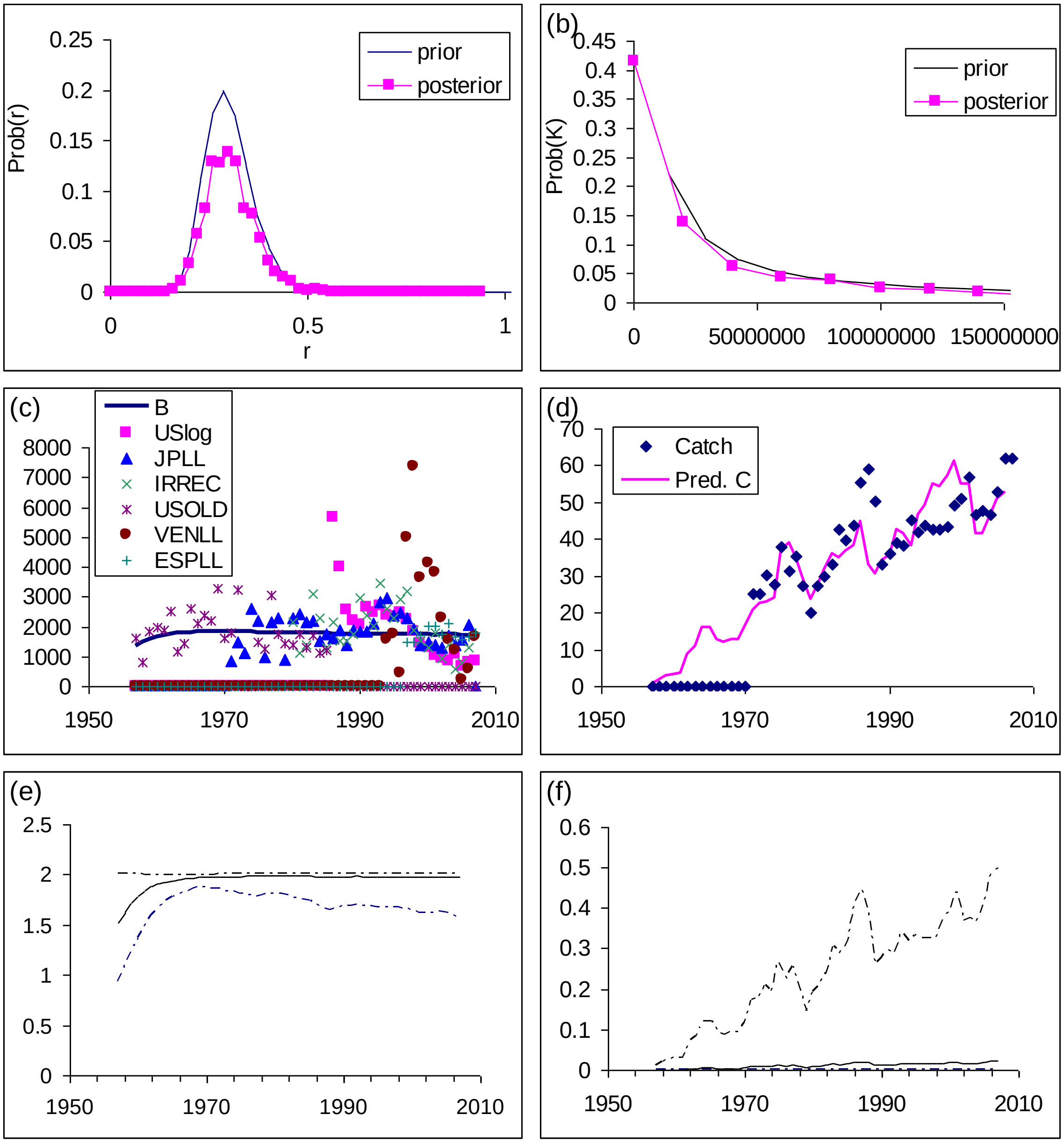


Figure 11. BSP model results for the blue shark sensitivity analysis in the North Atlantic (run "l") with a more diffuse prior for r: (a) prior and posterior of *r*, (b) prior and posterior of *K*, (c) posterior mode biomass projections and CPUE series in biomass units (1000 mt), (d) observed and predicted catches (1000 mt), (e) median and 80% credibility intervals for B/Bmsy, (f) median and 80% C. I. for F/Fmsy.

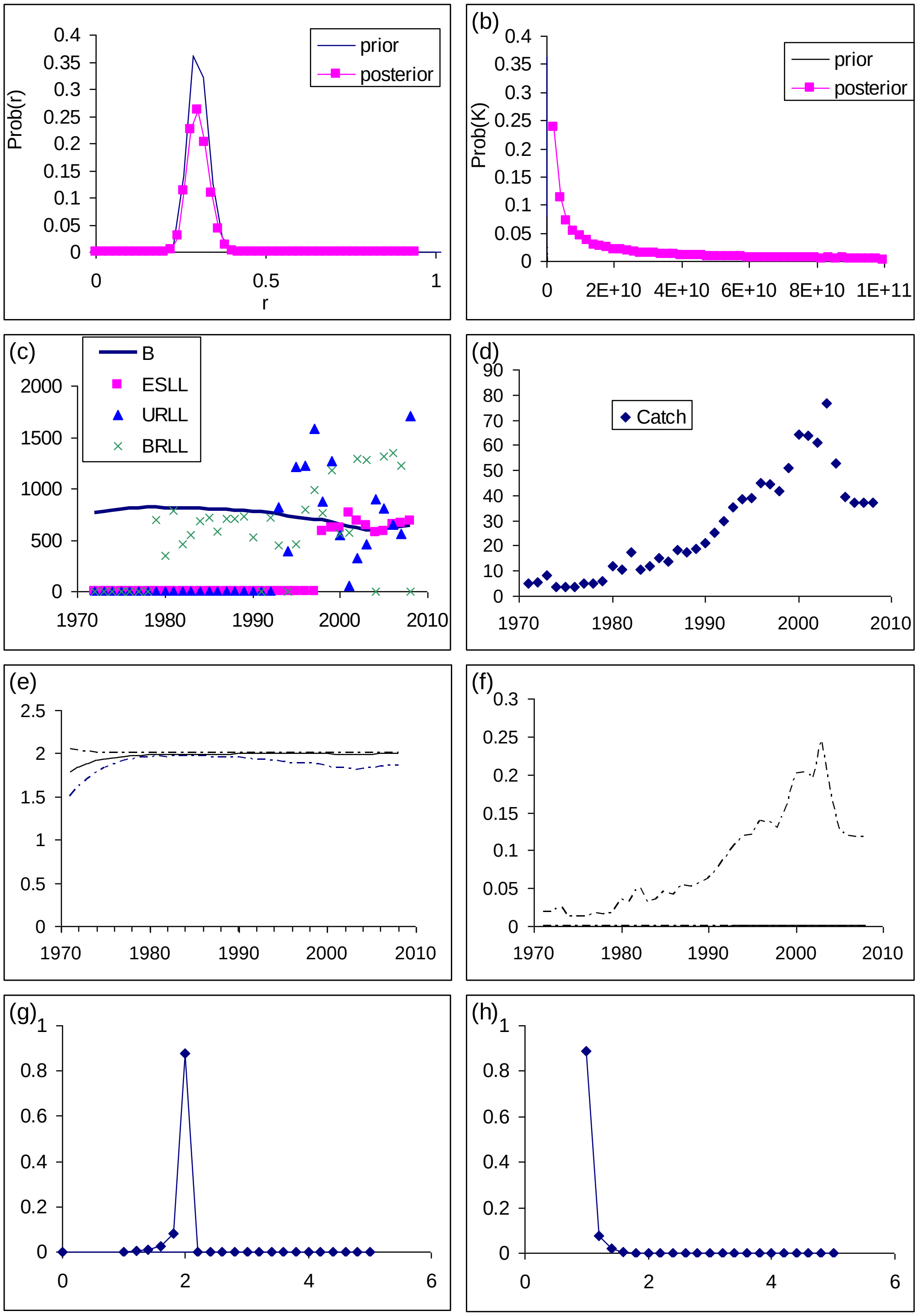


Figure 12. BSP model results for the blue shark base case in the South Atlantic (run d): (a) prior and posterior of *r*, (b) prior and posterior of *K*, (c) posterior mode biomass projections and CPUE series in biomass units (1000 mt), (d) observed catches (1000 mt), (e) median and 80% credibility intervals for B/Bmsy, (f) median and 80% C. I. for F/Fmsy, (g) posterior distribution of B_{2008}/Bmsy and (h) posterior distribution of F_{2008}/Fmsy.

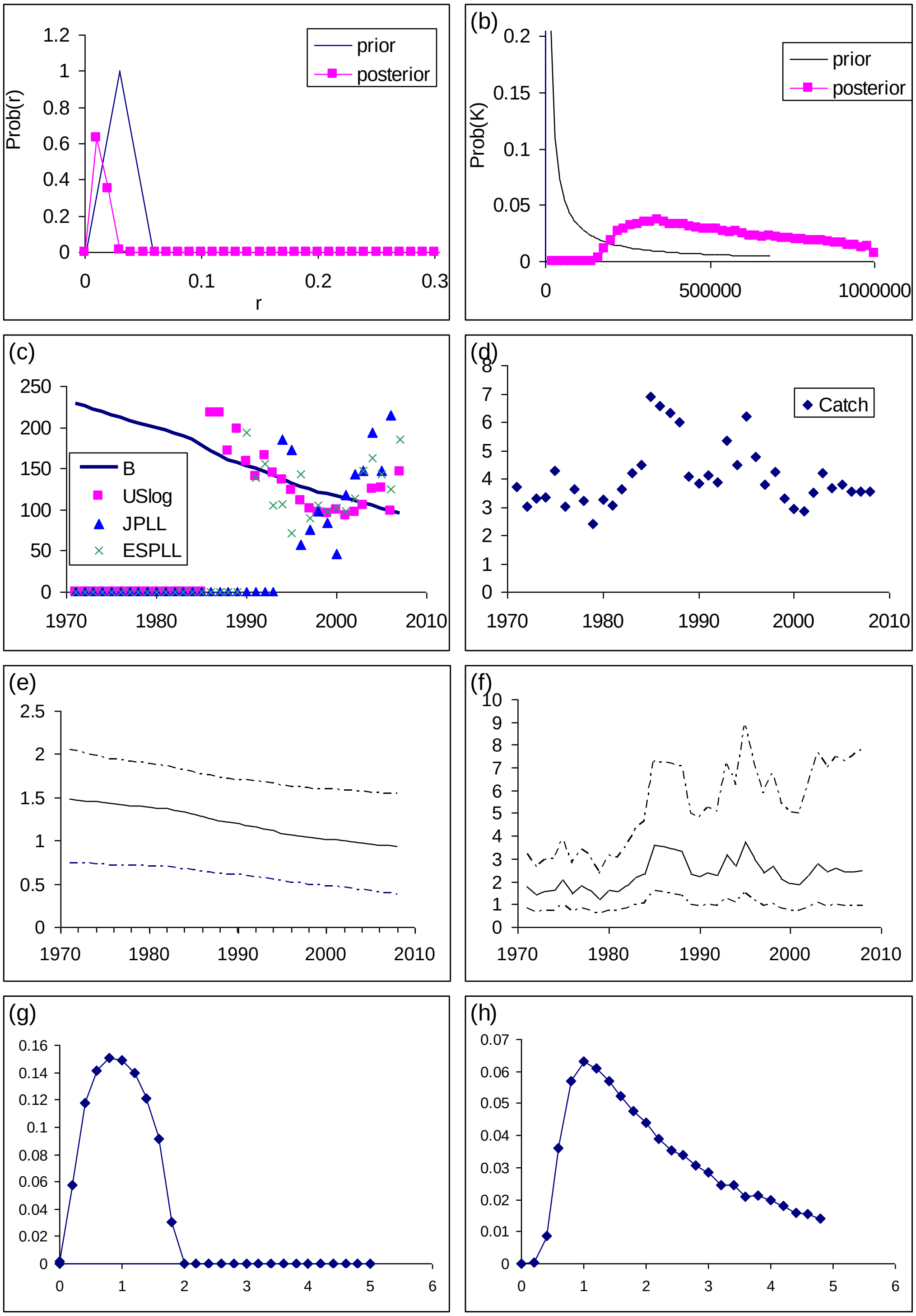
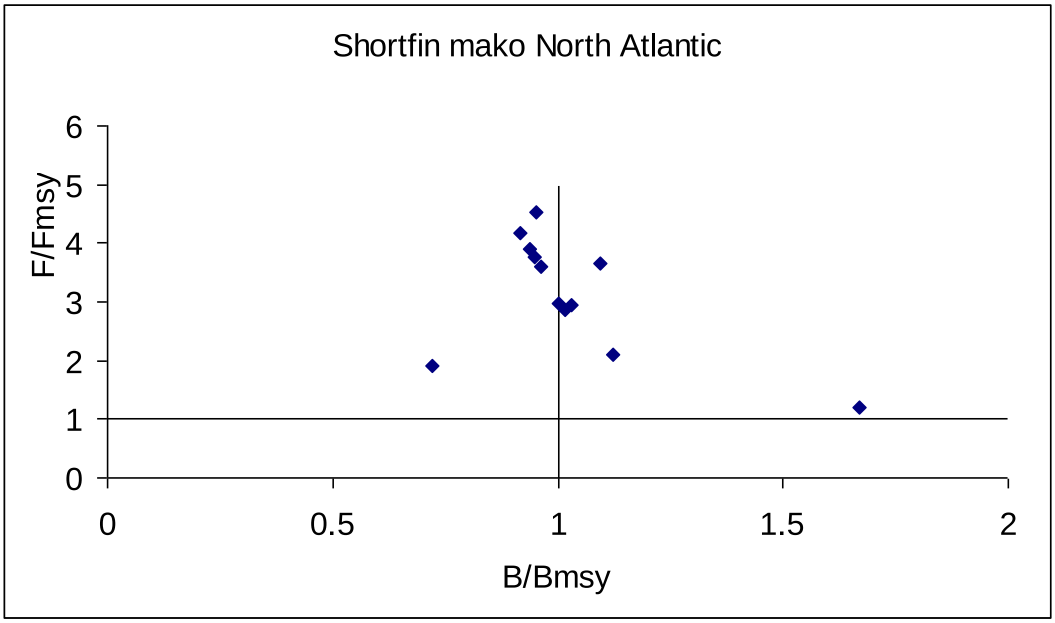


Figure 13. BSP model results for the shortfin mako shark base case in the North Atlantic (run d): (a) prior and posterior of *r*, (b) prior and posterior of *K*, (c) posterior mode biomass projections and CPUE series in biomass units (1000 mt), (d) observed catches (1000 mt), (e) median and 80% credibility intervals for B/Bmsy, (f) median and 80% C. I. for F/Fmsy, (g) posterior distribution of B_{2008}/Bmsy and (h) posterior distribution of F_{2008}/Fmsy.



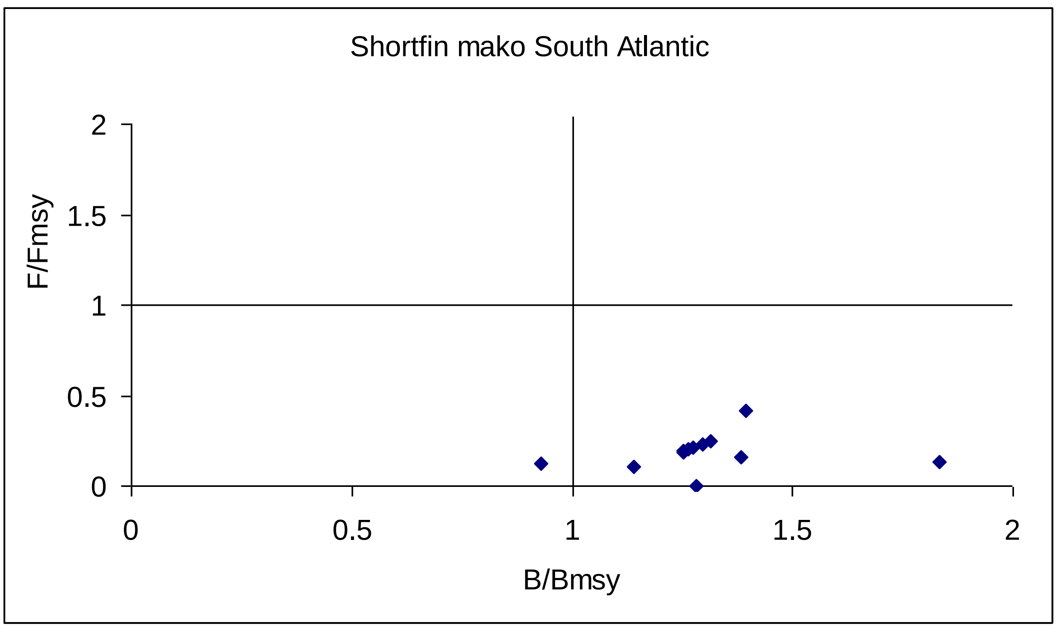


Figure 14. Current (2008) biomass and fishing mortality rate and biomass relative to the MSY levels, for the runs described in tables 16, 24 and 25 for shortfin mako sharks.

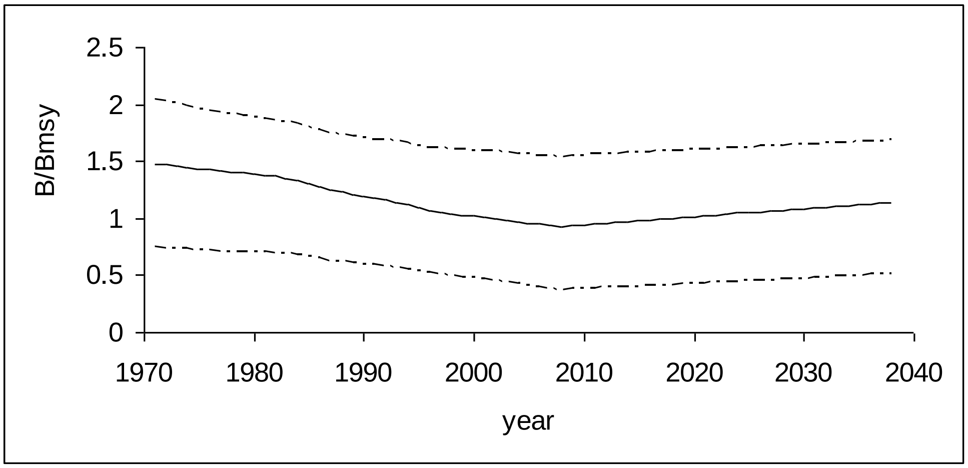


Figure 15. Projected biomass of shortfin mako shark, North Atlantic base case, with no fishing after 2008. The biomass trend through 2008 is the same as in Figure 13.

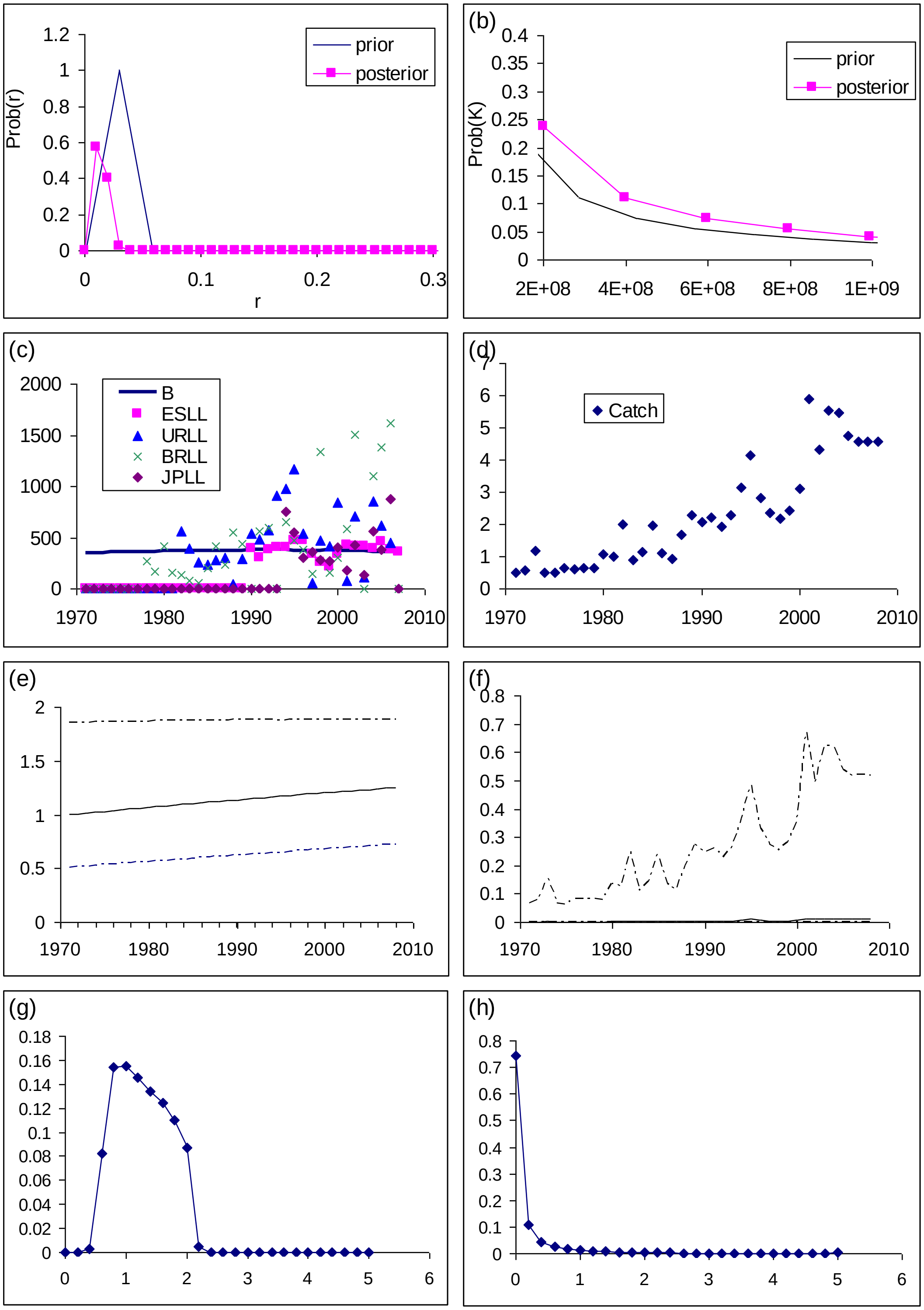


Figure 16. BSP model results for the shortfin mako shark base case in the South Atlantic (run c): (a) prior and posterior of *r*, (b) prior and posterior of *K*, (c) posterior mode biomass projections and CPUE series in biomass units (1000 mt), (d) observed catches (1000 mt), (e) median and 80% credibility intervals for B/Bmsy, (f) median and 80% C. I. for F/Fmsy, (g) posterior distribution of B_{2008}/Bmsy and (h) posterior distribution of F_{2008}/Fmsy.

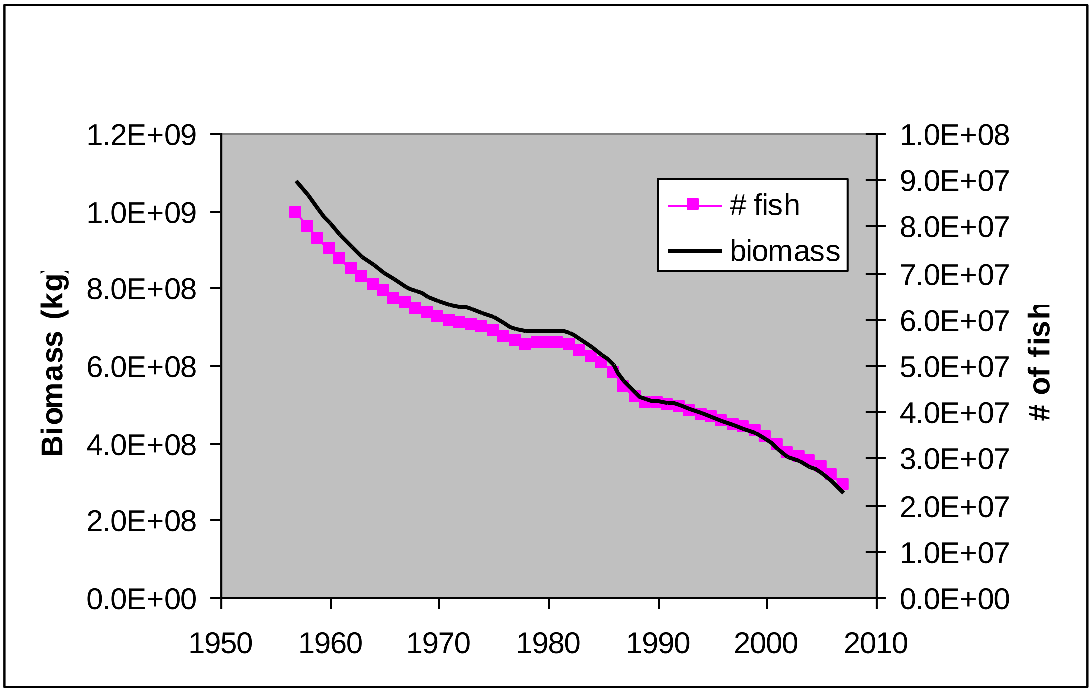


Figure 17. Model predictions for North Atlantic blue shark stock size for the values of the estimated parameters at the mode of the joint posterior pdf (RUN A).

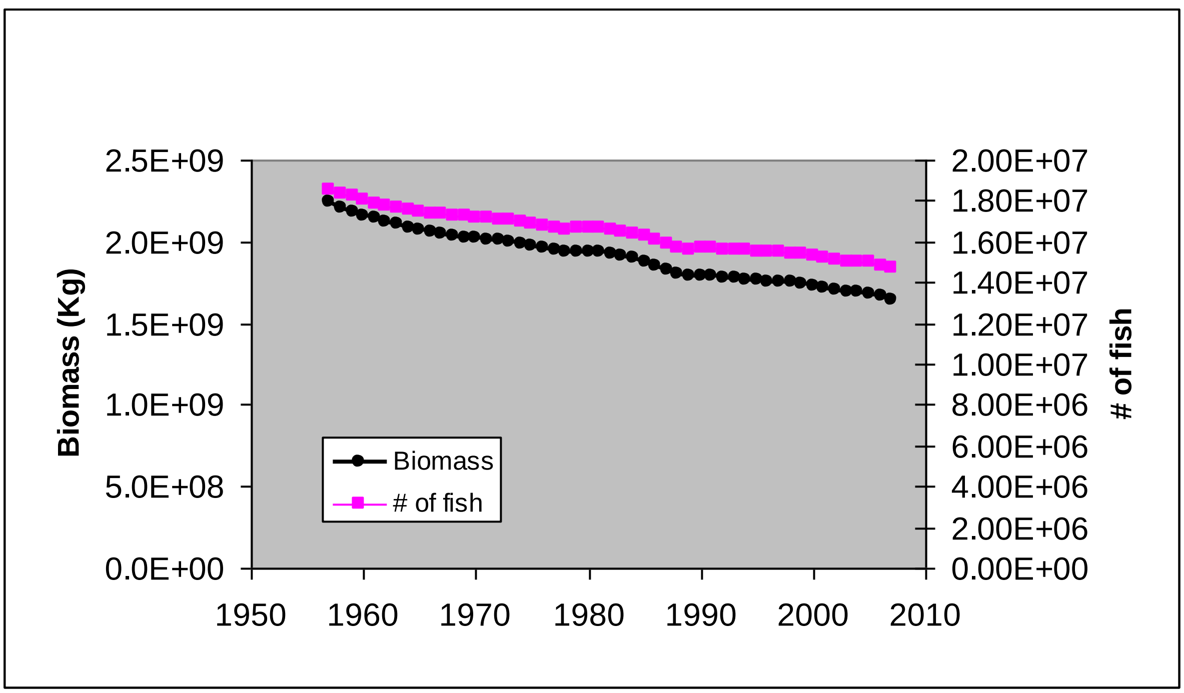


Figure 18. Model predictions for North Atlantic blue shark stock size for the values of the estimated parameters at the mode of the joint posterior pdf (RUN C).

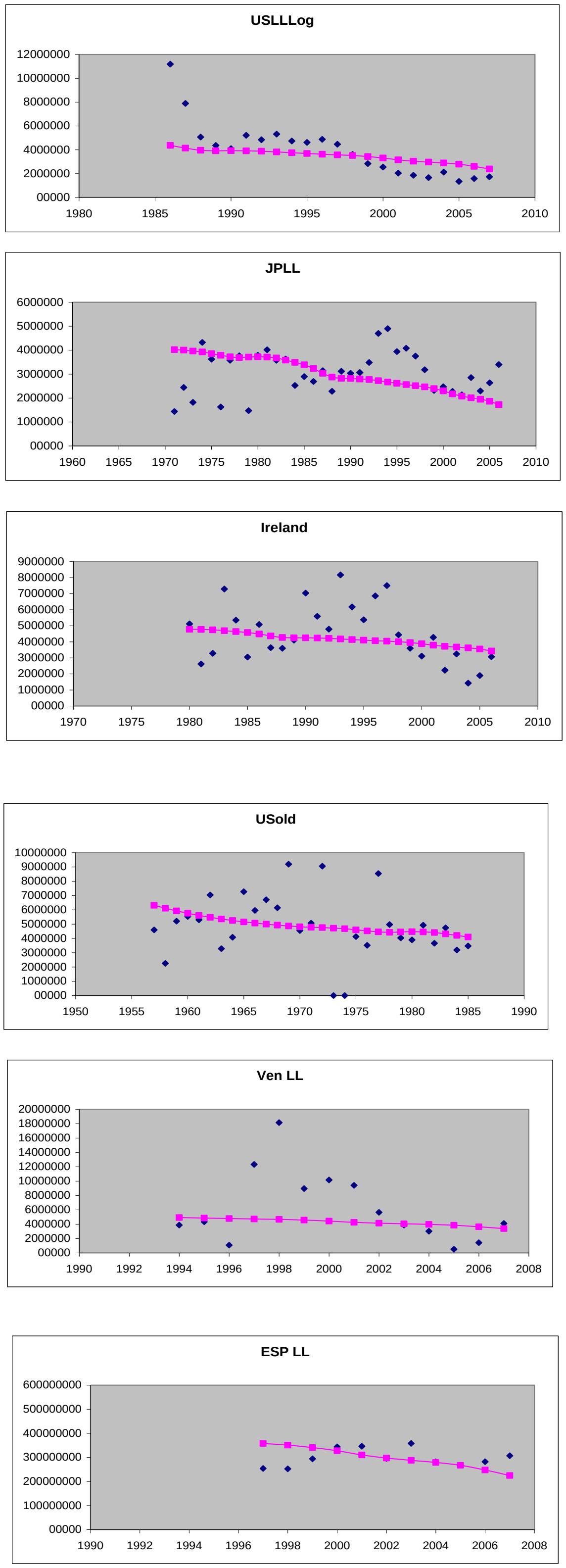


Figure 19. Model fit to North Atlantic blue shark CPUEs for the values of the estimated parameters at the mode of the joint posterior pdf (RUN A). Diamonds: CPUE points, Squares connected with a line: model prediction for exploited stock size.

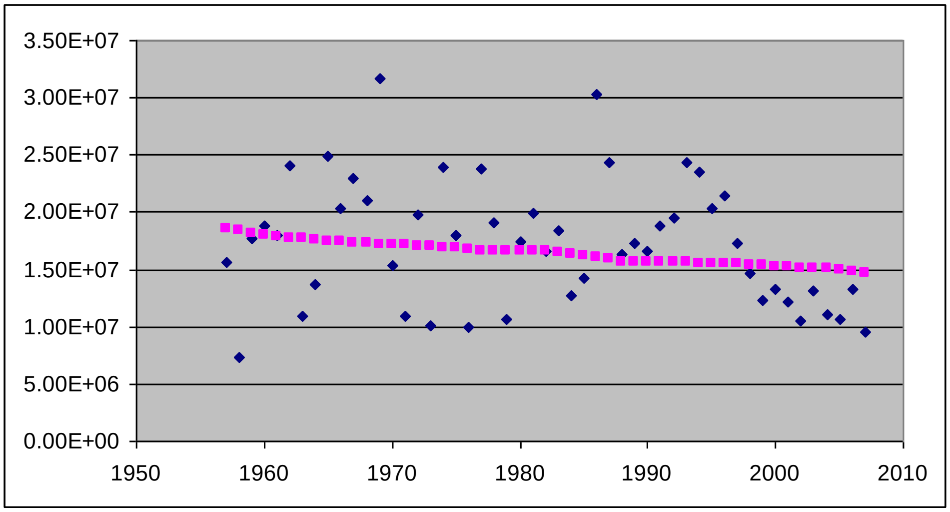


Figure 20. Model fit to North Atlantic blue shark CPUEs for the values of the estimated parameters at the mode of the joint posterior pdf (RUN C). Diamonds: CPUE points, Squares connected with a line: model prediction for exploited stock size.

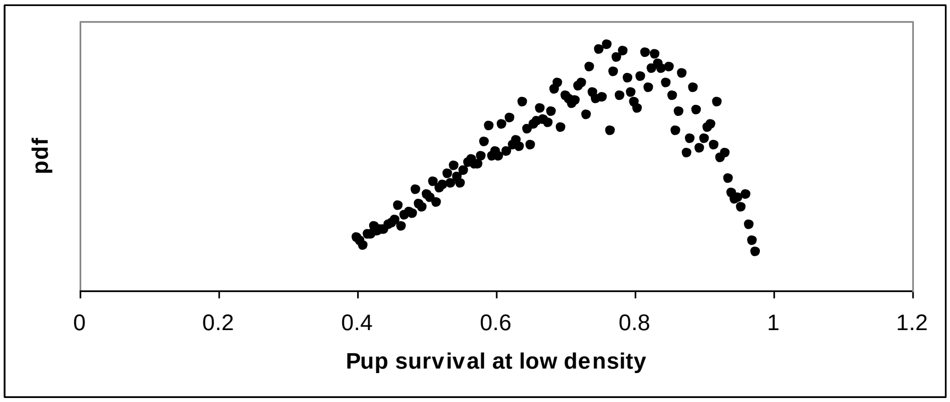


Figure 21. Posterior pdf for pup survival for RUN A (North Atlantic blue shark).

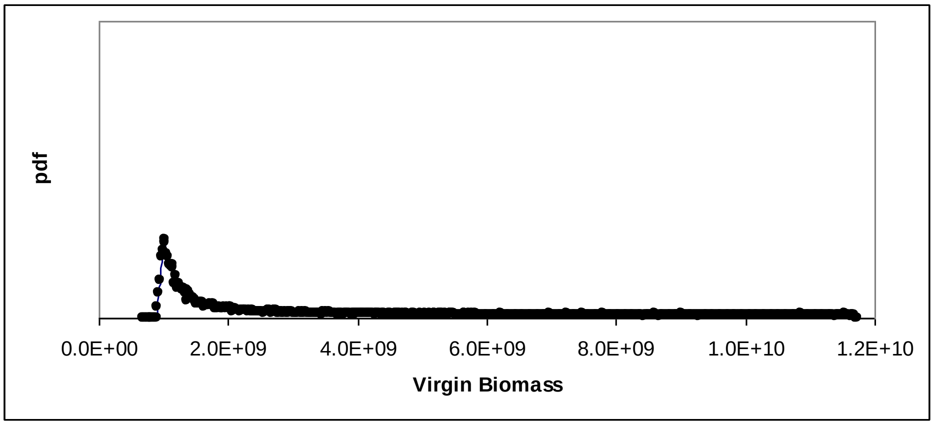


Figure 22. Posterior pdf for virgin biomass (kg) for RUN A (North Atlantic blue shark).

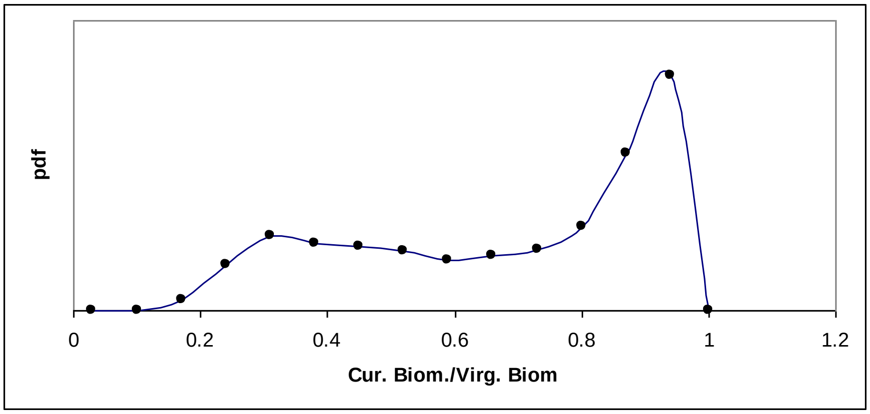


Figure 23. Posterior pdf for relative stock size for RUN A (North Atlantic blue shark).

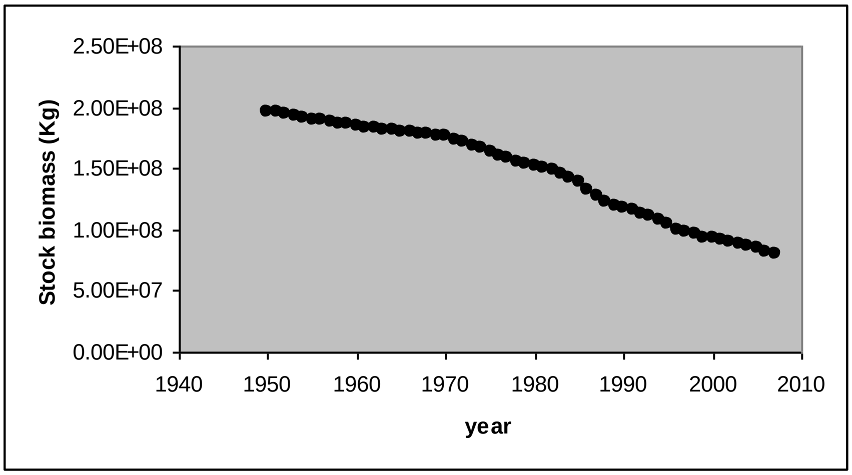


Figure 24. Model predictions for North Atlantic shortfin mako stock size for the values of the estimated parameters at the mode of the joint posterior pdf (RUN D).

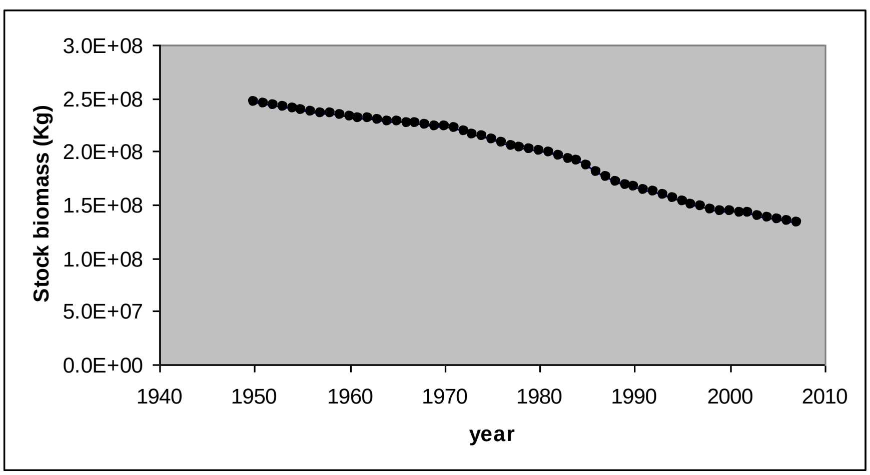


Figure 25. Model predictions for North Atlantic stock size for the values of the estimated parameters at the mode of the joint posterior pdf (RUN E).

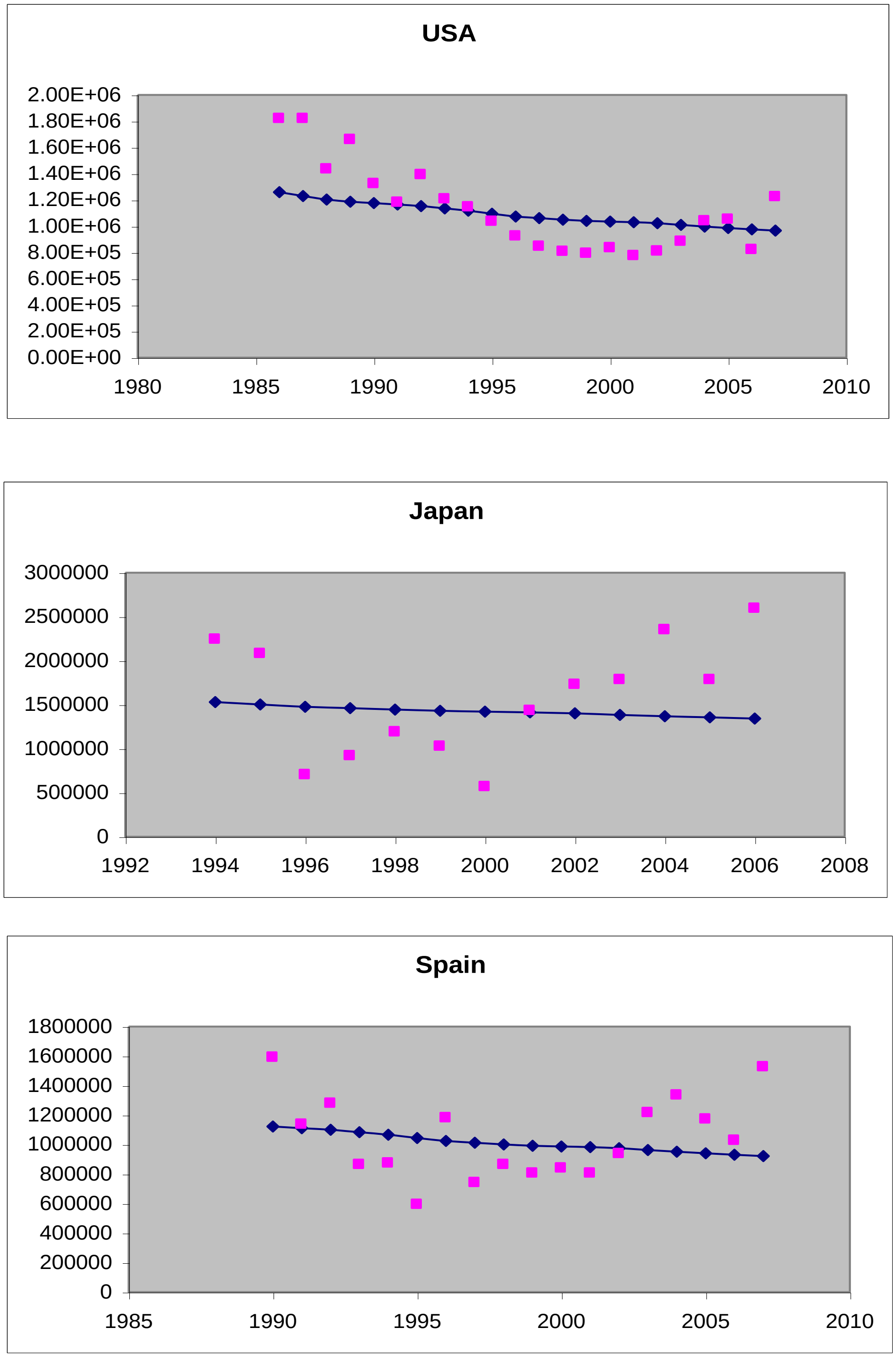


Figure 26. Model fit to North Atlantic shortfin mako CPUEs for the values of the estimated parameters at the mode of the joint posterior pdf (RUN D). Squares: CPUE points, diamonds connected with a line: model prediction for exploited stock size.

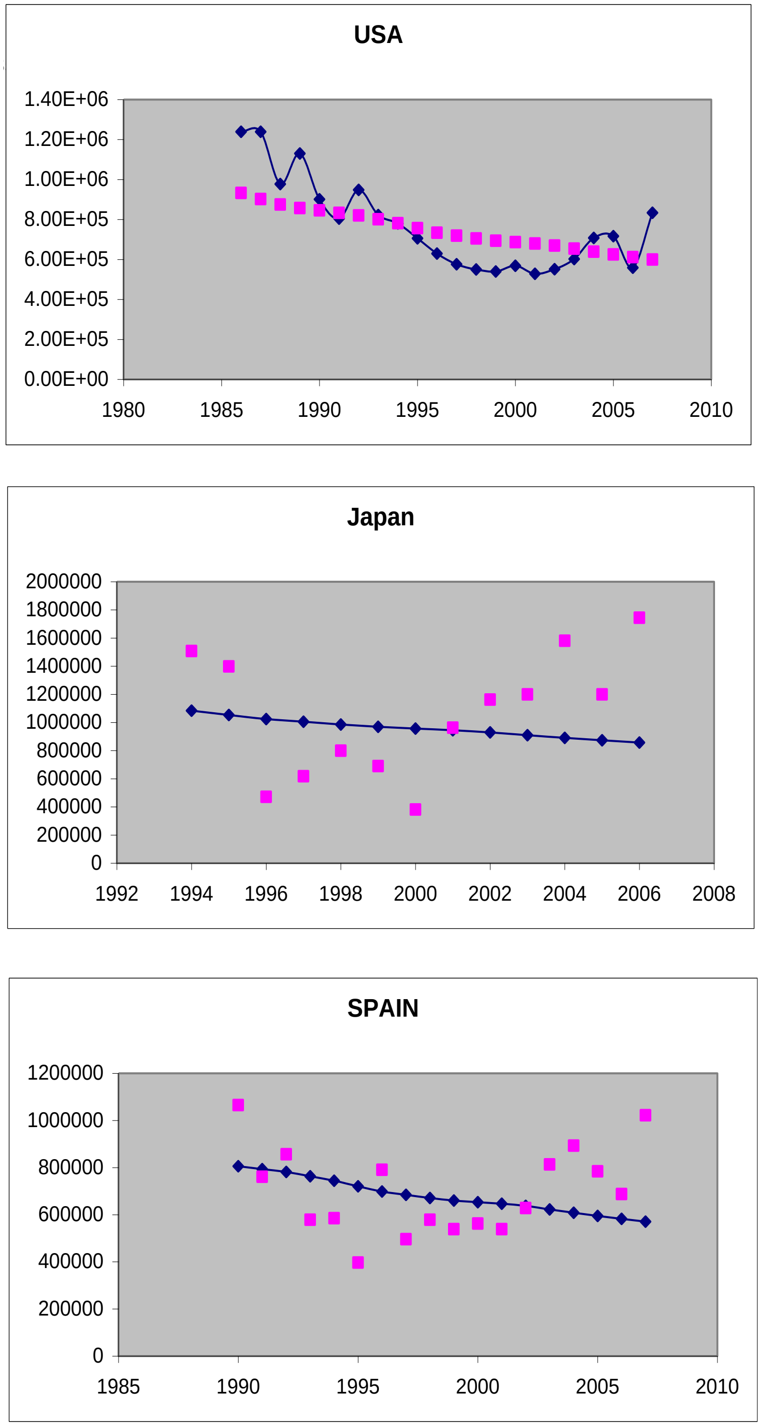


Figure 27. Model fit to North Atlantic shortfin mako CPUEs for the values of the estimated parameters at the mode of the joint posterior pdf (RUN E). Squares: CPUE points, diamonds connected with a line: model prediction for exploited stock size.

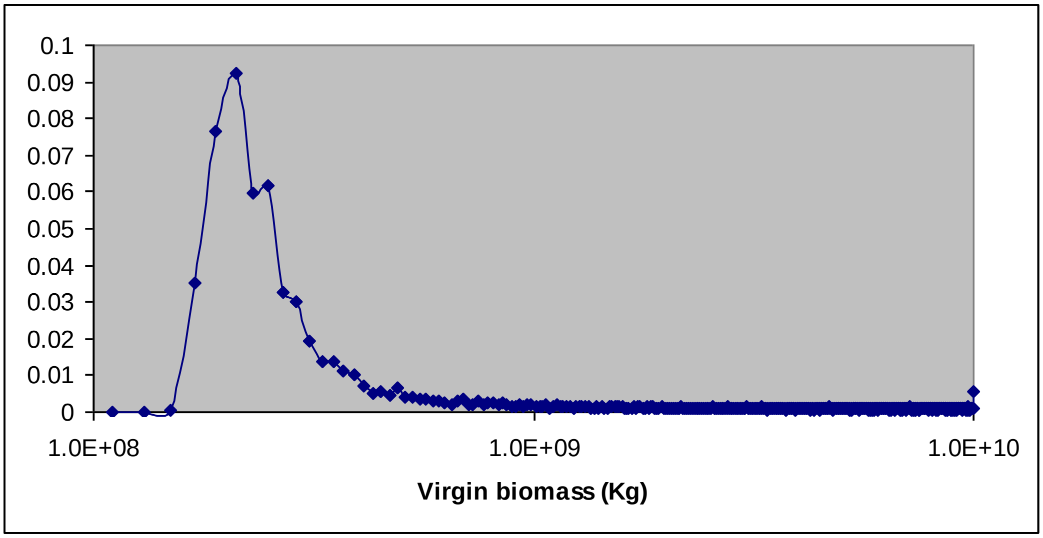


Figure 28. Posterior pdf for virgin biomass for RUN D (North Atlantic shortfin mako).

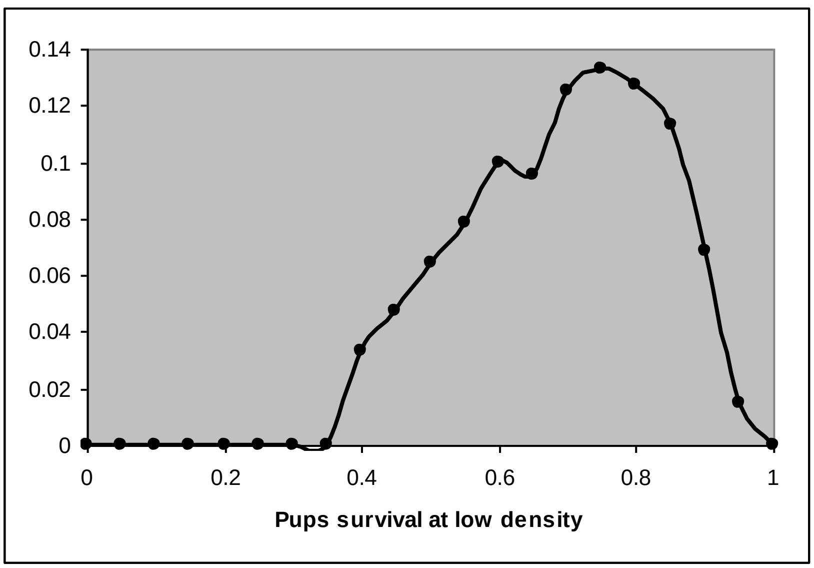
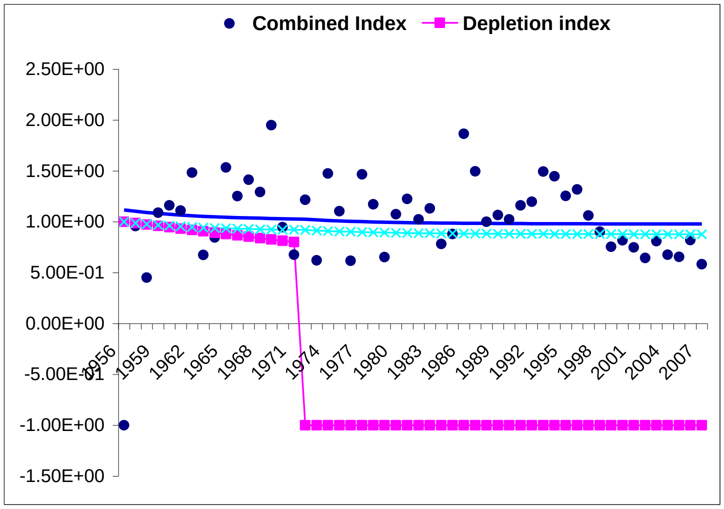
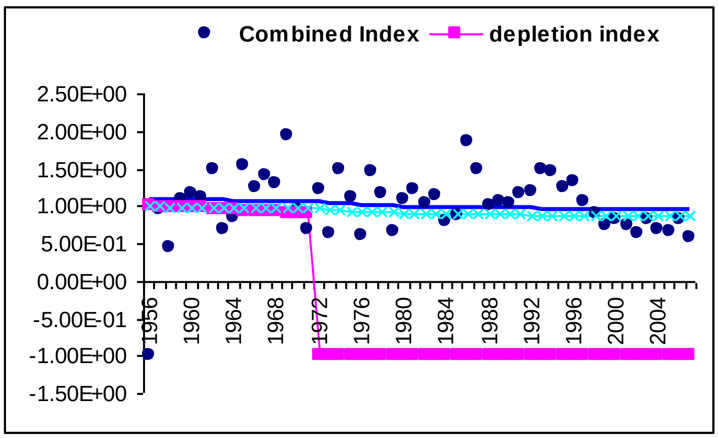


Figure 29. Posterior pdf for pup survival for RUN D (North Atlantic shortfin mako).

a)



b)



c)

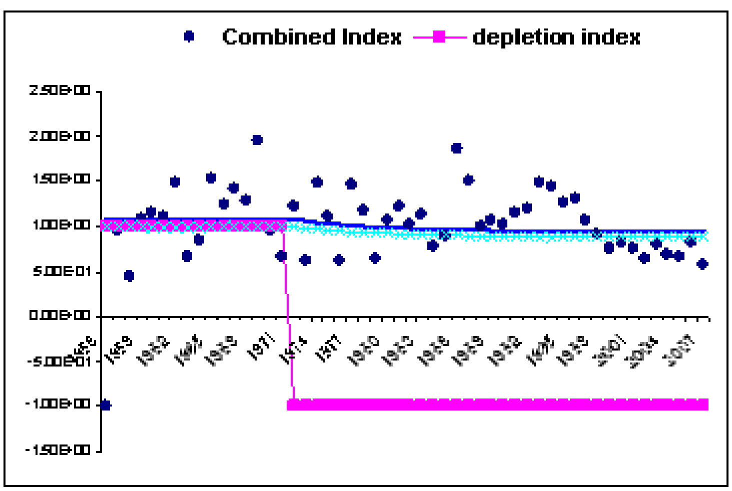


Figure 30. Fits to the combined index and historical depletion index based on the depletion scenarios a) 20%, b) 10%, and c) virgin conditions in 1971 for North Atlantic blue shark. The solid line is the fit to the combined index and the hatched line is the fit to the historical depletion index.

a)
b)
c)

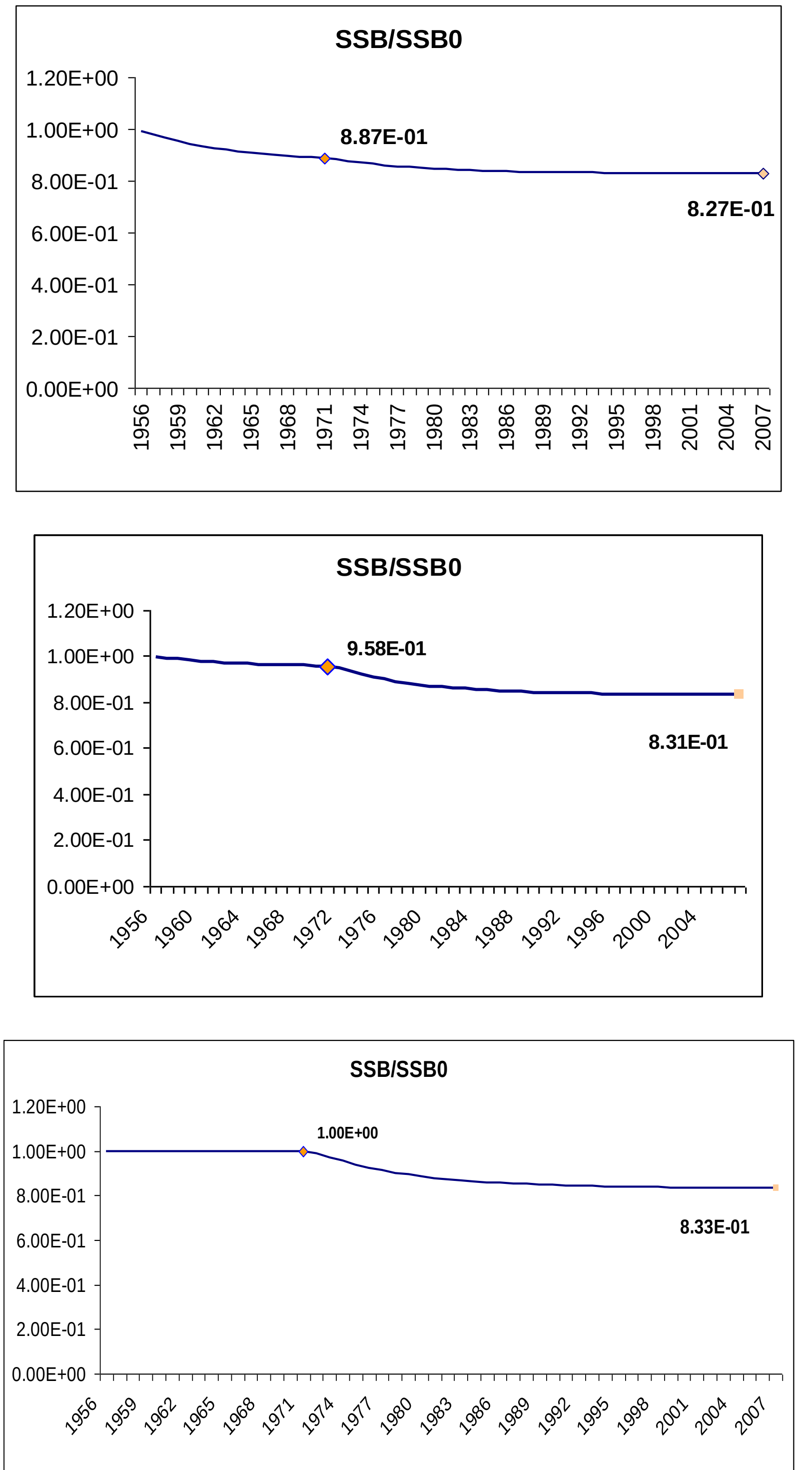


Figure 31. The relative SSB plots for the three depletion scenarios, a) 20%, b) 10%, and c) virgin depletion in 1971 for North Atlantic blue shark.

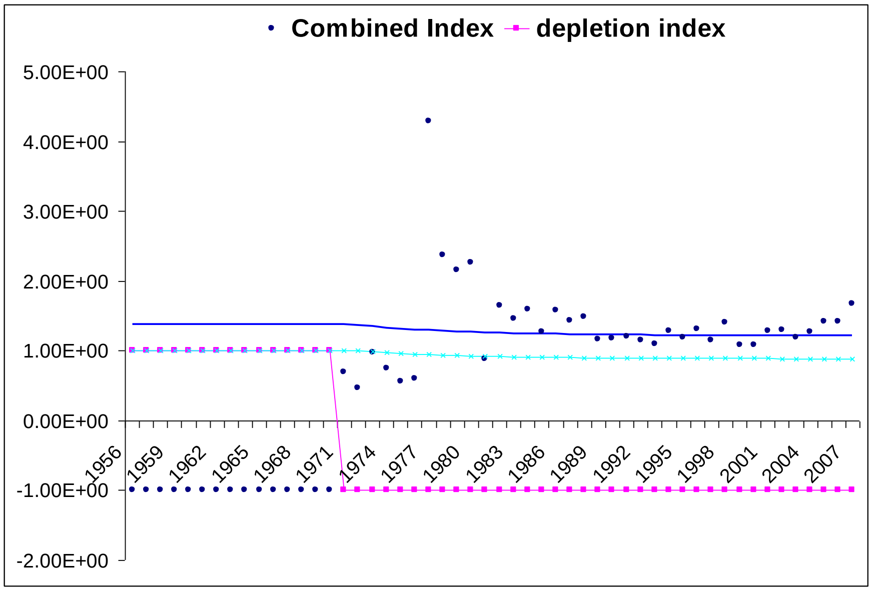


Figure 32. Fit to the combined index and the historical depletion index (virgin conditions in 1971) for South Atlantic blue shark. The solid line is a fit to the combined index and the hatched line is the fit to the historical depletion index.

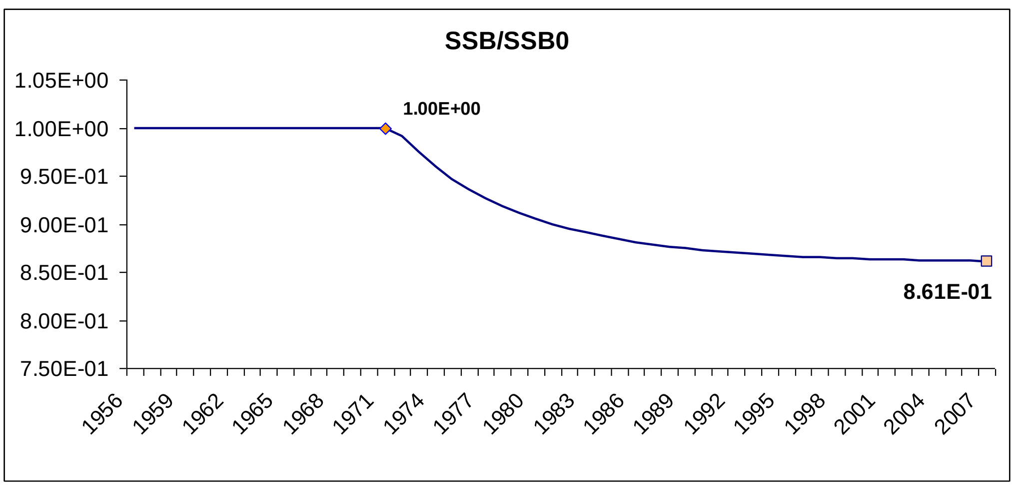
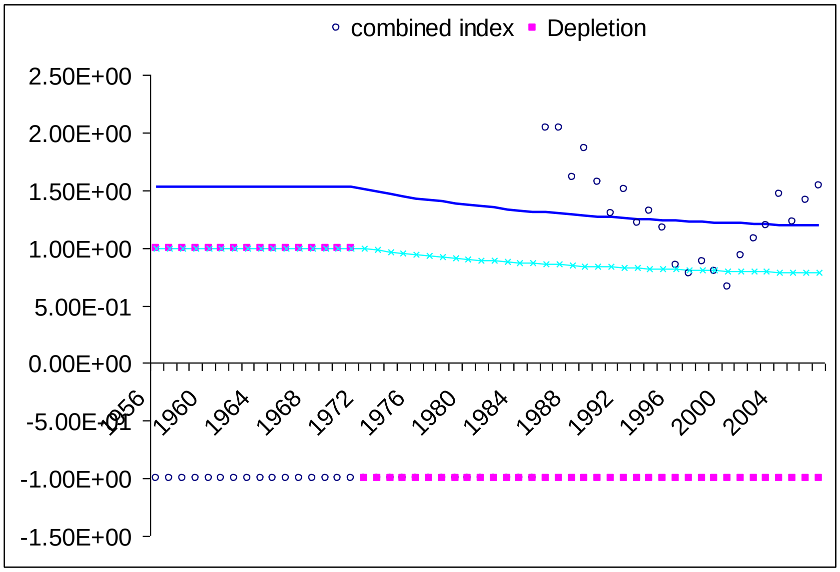


Figure 33. The relative depletion of the blue shark stock in the South Atlantic.

a)



b)

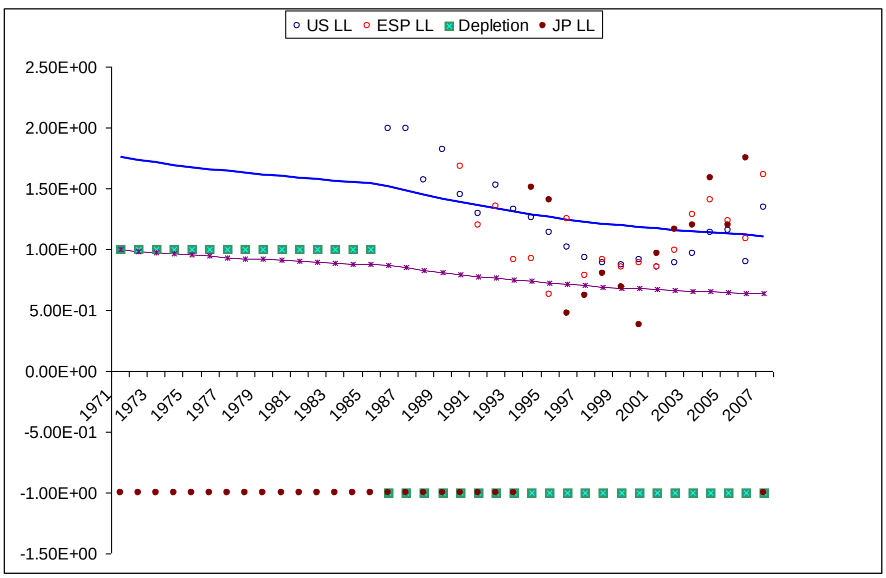
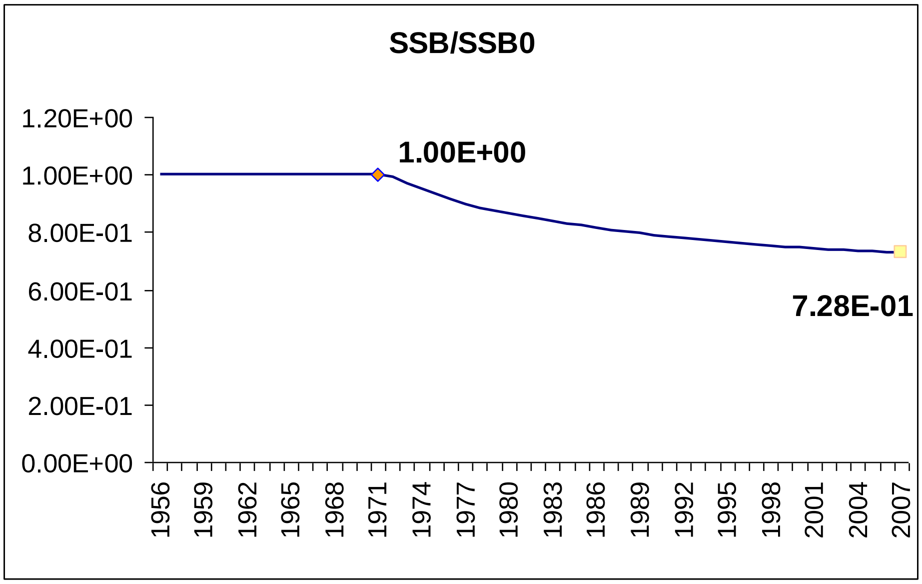


Figure 34. a) Model fit to the combined index and the historical depletion index for the North Atlantic mako shark. b) Model fit to the base case indices with a truncated time line (the model begins in 1971 rather than 1956). The solid line is a fit to the combined index and the hatched line is the fit to the historical depletion index.

a)



b)

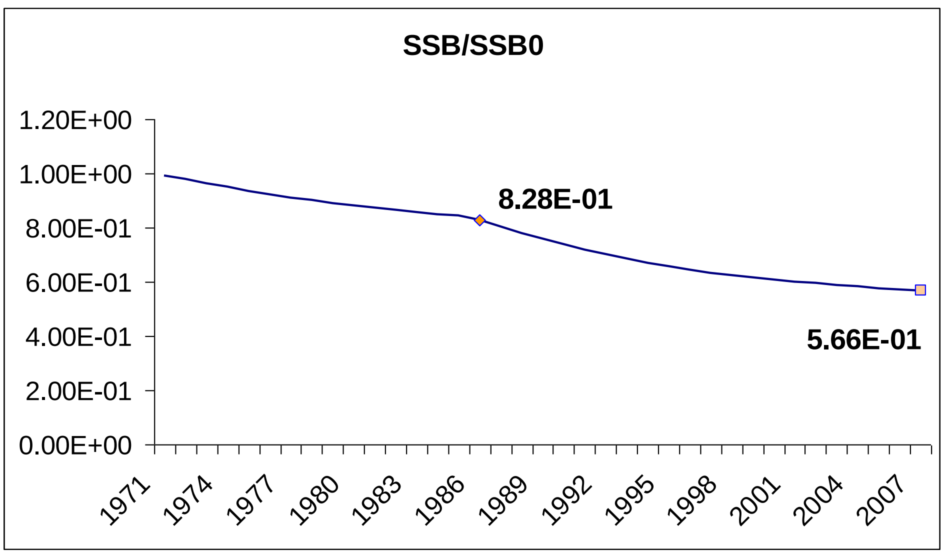


Figure 35. The relative depletion calculated using a) the model fit to the combined index and the historical depletion index for the North Atlantic mako shark, or b) the model fit to the base case indices with a truncated time line (The model begins in 1971 rather than 1956).

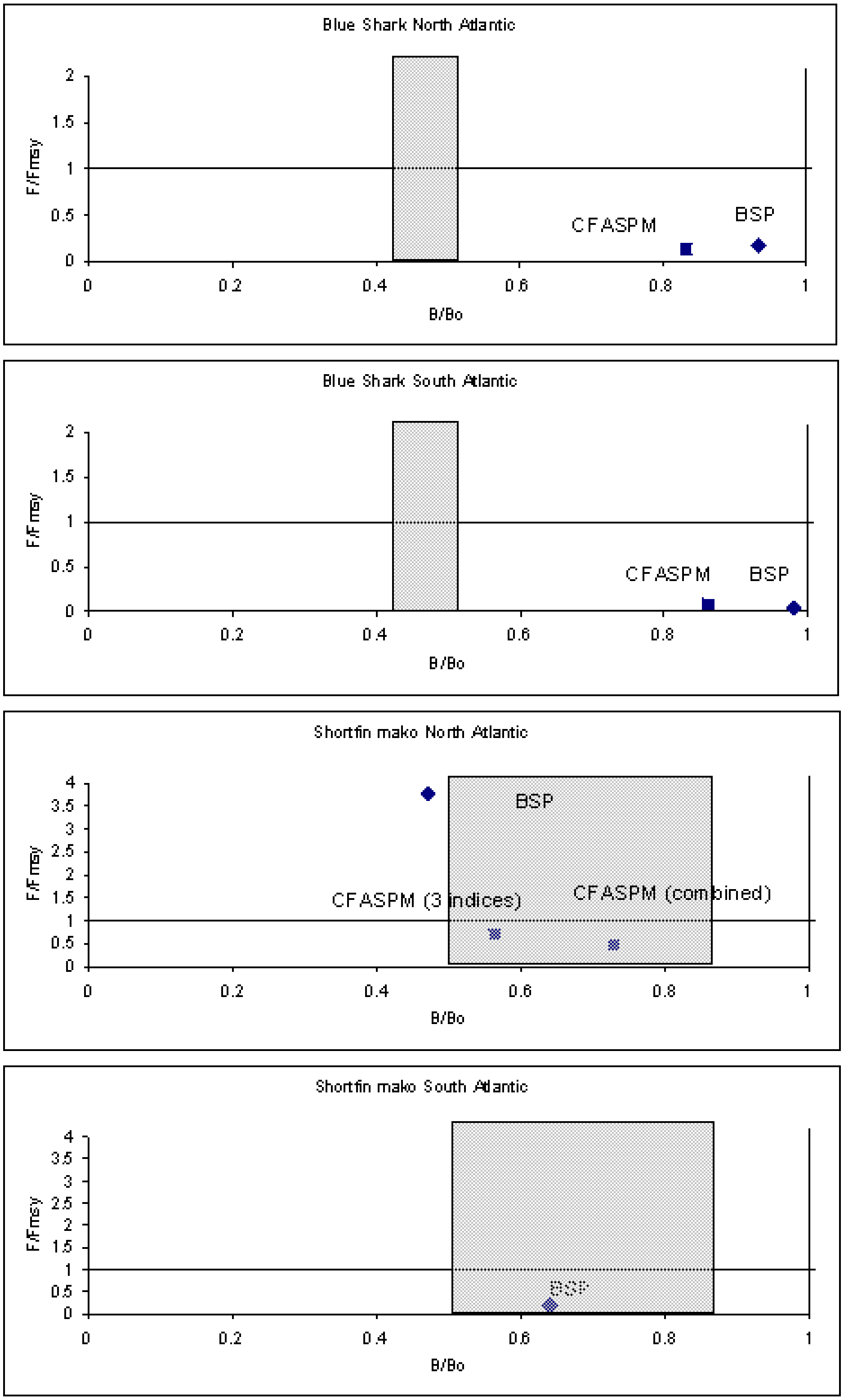


Figure 36. Phase plots summarizing base scenario outputs for blue shark (BSH) and shortfin mako (SMA). BSP=Bayesian surplus production model; CFASPM=catch-free, age-structured production model

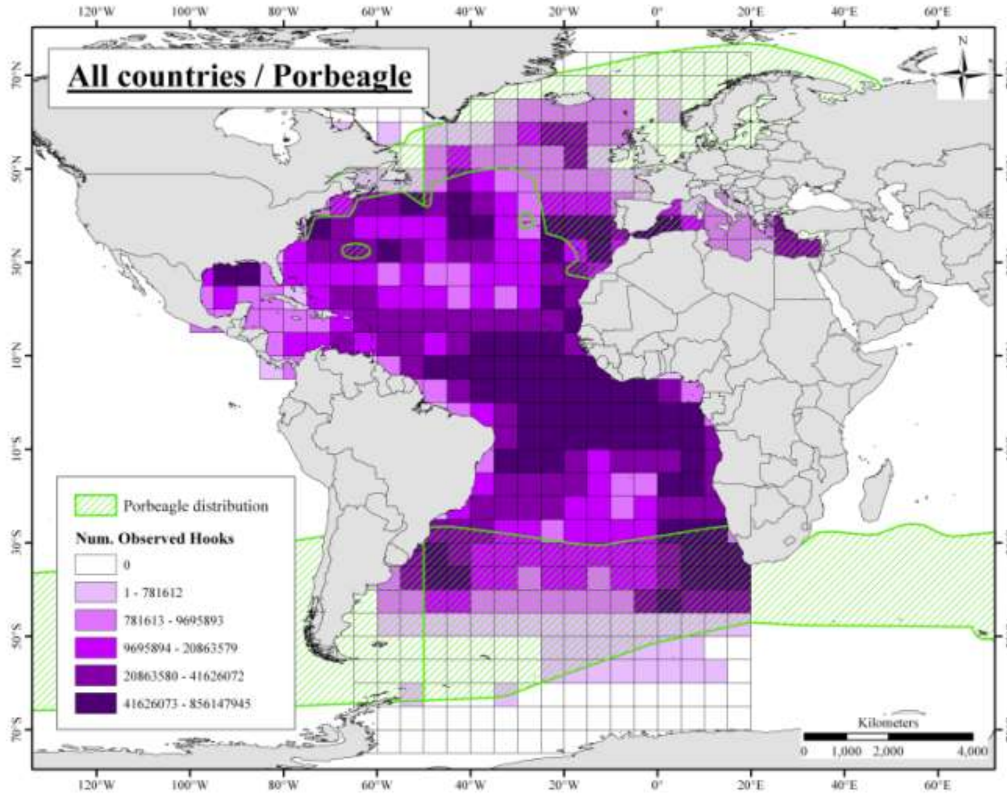


Figure 37. Distribution of porbeagle shark in the Atlantic and other ocean areas (from Global Marine Species Assessment/IUCN),, compared against the distribution of estimated pelagic longline fishing effort (hooks fished from 1950-2006 by 5x5) in the Convention area.

Appendix 1

AGENDA

1 Opening, adoption of agenda and meeting arrangements
2 Review of Biological Information and Ecological Risk Assessment.
3 Review of Tagging data and conversion factors (fin to body weight).
4 Review of fishery statistics: Effort and Catch data, including size frequencies and fisheries trends
5 Relative abundance indices and other fishery indicators
6 Methods and other data relevant to the assessment
   6.1 Bayesian surplus production (BSP) model
   6.2 Age Structured Production model (ASPM)
   6.3 Catch-Free Age Structured Production model
7 Stock status results
   7.1 Bayesian surplus production (BSP) model
   7.2 Age Structured Production model (ASPM)
   7.3 Catch-Free Age Structured Production model
   7.4 Stock Status Summary
8 Recommendations
      8.1 Research and Statistics
      8.2 Management
9 Other matters
10 Adoption of the report and closure

Appendix 2

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Appendix 3

LIST OF DOCUMENTS

SCRS/2008/045 Scientific estimations of by-catch landed by the Spanish surface longline fleet targeting swordfish (*Xiphias gladius*) in the Atlantic Ocean with special reference to the years 2005 and 2006. Mejuto, J., B. García-Cortés, A. Ramos-Cartelle and J. M. de la Serna.

SCRS/2007/070 Indices of blue, mako and thresher shark abundance derived from U.S. Atlantic recreational fishery data. Babcock, E.A. and G. Skomal.

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SCRS/2008/128 Ratios between the wet fin weight and body weights of blue shark (*Prionace glauca*) in the Spanish surface longline fleet during the period 1993-2006. Mejuto, J., B. García-Cortés, A. Ramos-Cartelle and J.M. de la Serna.

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SCRS/2008/149	Standardized CPUE for blue shark and shortfin mako caught by the Japanese tuna longline fishery in the Atlantic Ocean. Matsunaga, H.
SCRS/2008/150	Estimation of catches for blue shark and shortfin mako by the Japanese tuna longline fishery in the Atlantic Ocean, 1994-2006. Matsunaga, H.
SCRS/2008/151	Tag and release of pelagic shark species by the observers on Japanese tuna longline vessels in the Atlantic Ocean. Matsunaga, H.
SCRS/2008/152	A preliminary asessment of the French fishery targeted porbeagle shark (*Lamna nasus*) in the Norteast Atlantic Ocean:biology and catch statistics. Jung, A.
SCRS/2008/153	Preliminary estimates of blue and mako sharks bycatch and CPUE of Taiwanese longline fishery in the Atlantic ocean. Kwang-Ming Liu1, Shoou-Jeng Joung, and Wen-Pei Tsai
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SCRS/2008/156	Shark bycatch observation in the ICCAT waters by Chineses longline observer in 2007 DAI, X. and R. Jiang
SCRS/2008/158	Description of European Union surface longline fleet operating in the Atlantic Ocean and compilation of detailed EUROSTAT data on shark catches by EU fleets in the Atlantic. Oceana

Appendix 4

Standardized catch per unit effort of blue shark caught by Irish recreational fleet

Generalized linear models were fitted to positive catch rates of Irish recreational fleet databases. There are too few catches equal to zero (< 2%), hence they were discarded. Factors considered were “year”, “skipper” and “area”. Normal and gamma distributions and three link functions (identity, log, inverse) were attempted when modeling catch rate as calculated in number per fishing day. The Akaike and Bayesian information criteria were used for model selection (Akaike, 1974; Schwarz, 1978). Selection of explanatory factors was accomplished starting with a saturated model and hypotheses tests wre used to verify if dropping each term results in a significant increase in deviance. Interactions were dropped and tested first. Main effect of a factor (*e.g.* skipper) was discarded only if all interactions including that factor were already discarded. Gamma distribution, log link function and factors year and area were in the selected model. Predicted standardized CPUE were similar to the nominal ones. There is no trend until mid-1990s, but there is a decreasing trend from 1997 to 2005.

Data

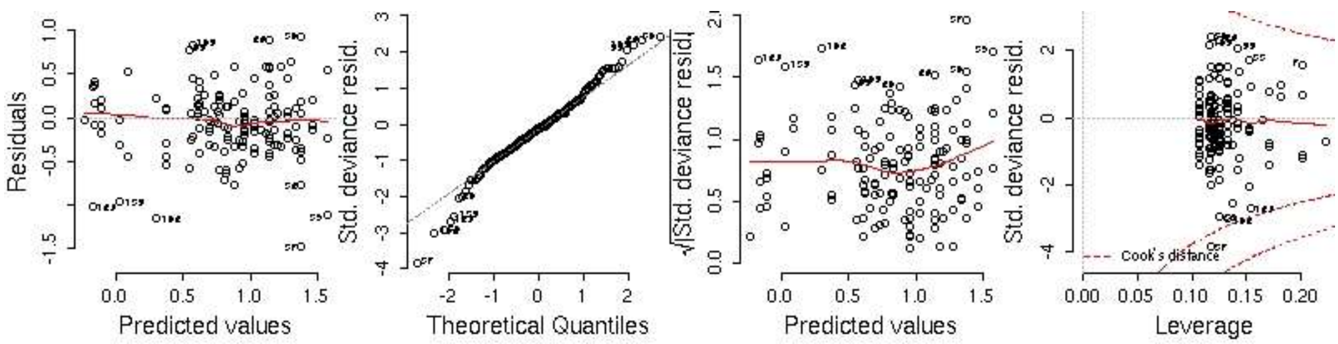
catch => number of fish caught each year
effort => fishing days in each year
cpue => number/fishing day
skipper
area => VIa, VIIb, VIIg and VIIj

Generalized linear model
cpue ~ year + area   AIC = 417.197   BIC = 474.1441
family = gamma link = log

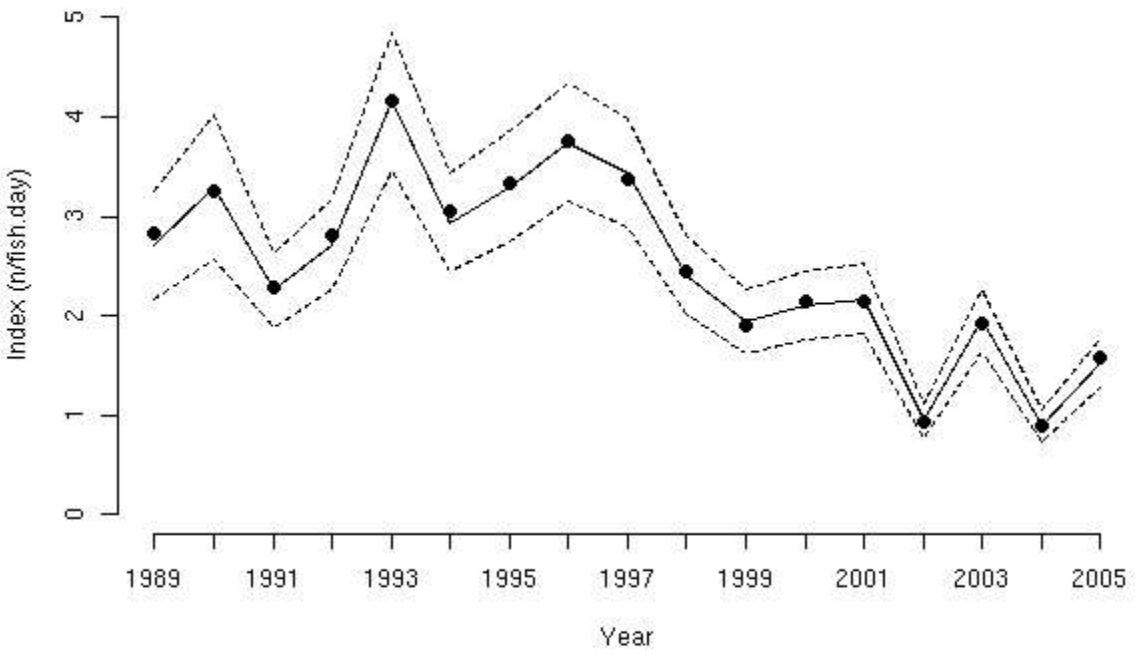
ANOVA

	Df	Deviance	Resid. Df	Resid. Dev	F	Pr(>F)	Dev.Exp1	Dev.Exp2
NULL	NA	NA	147	47.97	NA	NA	NA	NA
yearf	16	22.97	131	25	8.61	6.72E-014	93.97	47.88
areaf2	2	1.47	129	23.52	4.42	0.01	6.03	3.08

Diagnostic Plots



Standardized CPUE



year	index	se.index	nominal
1989	2.71	0.28	2.83
1990	3.3	0.37	3.25
1991	2.26	0.19	2.28
1992	2.71	0.23	2.81
1993	4.16	0.35	4.17
1994	2.94	0.25	3.06
1995	3.3	0.28	3.33
1996	3.75	0.3	3.76
1997	3.43	0.28	3.38
1998	2.41	0.2	2.45
1999	1.94	0.16	1.9
2000	2.1	0.18	2.14
2001	2.17	0.18	2.14
2002	0.94	0.08	0.94
2003	1.96	0.16	1.93
2004	0.89	0.08	0.89
2005	1.52	0.12	1.57