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Historical Catch Estimate Reconstruction for the Indian Ocean based on Shark Fin Trade Data

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Summary

This paper presents alternative estimates of catches of blue and oceanic whitetip sharks in the Indian Ocean based on shark fin trade data. This method was previously applied to the Atlantic Ocean for use in blue and shortfin mako shark assessments, as well as to the Western and Central Pacific Ocean for use in oceanic whitetip and silky shark assessments. The method involves multiple assumptions and is best utilized as an alternative (i.e. for comparison) to catch estimates prepared from more traditional data sources. Estimates were constructed using four steps. First, estimates by species (in number and biomass based on Hong Kong shark fin auction data and extrapolated to the global trade) in 2000 were reconstructed using triangular distributions in a Bayesian model and Markov chain Monte Carlo (MCMC) methods. These estimates were then adjusted using annual imports into Hong Kong for 1980-2011. Figures were then further adjusted based on the diminishing share of Hong Kong's shark fin trade as compared to the total global trade in recent years. Finally, these adjusted global estimates were scaled in a number of ways (by ocean area (km^2), by target species catch, by longline effort and by import country of origin statistics) to represent potential shark catches in the Indian Ocean. It is important to note that these estimates capture only a portion of the potential shark mortality (i.e. only those sharks' whose fins are internationally traded).

1 Introduction

The Indian Ocean Tuna Commission (IOTC) must find ways of overcoming the lack of historical catch data in order to assess the status of shark species, in particular blue (*Prionace glauca*) and oceanic whitetip (*Carcharhinus longimanus*) sharks (IOTC 2014a). This paper adapts and applies a methodology used to produce estimates of catches of sharks utilised in the shark fin trade for the International Commission for the Conservation of Atlantic Tunas (Clarke 2008) and the Western and Central Pacific Fisheries Commission (Clarke 2009). These estimates are not direct substitutes for species-specific catch time series primarily because they capture only a portion of the potential shark mortality, i.e. only those sharks' whose fins are internationally traded. As a result, figures produced by this study should be considered minimum estimates of shark mortality in the Indian Ocean. Nevertheless, they may be useful for comparison with other, more conventional sources of catch data or as minimum plausible estimates if other catch series are not available.

2 Materials and Methods

2.1 Data Sources

The algorithm for estimating the Indian Ocean shark catch represented in historical shark fin trade data is based on Clarke (2008, 2009). It consists of four data components, each of which is discussed separately below:

1. Estimates, by species, of the number and biomass of sharks used in the global shark fin trade in 2000 (the "anchor point" estimates);
2. A standardized estimate of the quantity of shark fins imported to Hong Kong for each year of interest before and after 2000;
3. An estimate of the Hong Kong market share, relative to the global market, for each year of interest before and after 2000;
4. Estimates of the proportion of the global total of shark fins that are derived from the Indian Ocean (calculated using several alternative methods).

2.1.1 Data Source 1

The "anchor point" estimates of the number and biomass of sharks used in the global shark fin trade are taken from Clarke et al. (2006a). That study used matches of Chinese trade names and taxa from market sampling and genetic testing (Clarke et al. 2006b), in combination with 18 months of Hong Kong auction records to impute missing data and produce an annual estimate of traded fin weights by species and fin size category. These fin weights were then converted to number of sharks and biomass using a series of conversion factors. For each species, three independent estimates based on dorsal, pectoral and caudal fins, respectively, were produced and extrapolated using trade data to represent the global market. A composite estimate for all fin types was then produced using a mixture distribution computed with the density function for each fin position weighted proportional to its precision. Since a probabilistic modelling framework was applied, the results were presented as probability intervals.

Of the eleven categories of species, or groups of species, presented in that study, this analysis uses the results for blue and oceanic whitetip sharks only. These estimates are based on the shark fin trade as of 2000 when Hong Kong imported 6,788 t of fins and was estimated to control 44-59% of the global market (Clarke 2004a, Clarke et al. 2006a) An excerpt of the relevant species-specific anchor point estimates from Clarke et al. (2006a) is provided in Table 1.

2.1.2 Data Source 2

Standardized estimates of the quantity of shark fin imported by Hong Kong in each year since 1980 were prepared from unpublished Hong Kong government records (HKSARG 2012). Prior to 1998, Hong Kong recorded imports of shark fins in dried or frozen ("salted") categories without distinguishing between processed and unprocessed fins. In order to avoid double-counting fins returning to Hong Kong after processing in Mainland China, imports from the Mainland prior to 1998 were subtracted from total imports following methods used by TRAFFIC (1996). In 1998 Hong Kong established separate customs codes for dried and frozen (i.e. the latter listed as "salted" in commodity coding lists), processed and unprocessed fins. After 1998, only unprocessed dried and frozen fins were included in the annual totals. All frozen fin weights were normalized for water content by multiplying by 0.25 (Clarke 2004a).

Although the data series continues through to the present, changes in the commodity coding scheme in 2012, in parallel with reports of a sharp drop in both market demand and price, suggest that Hong Kong import data after 2011 may not reflect trends in shark catches to the same extent as prior data (Clarke & Dent 2014, Eriksson & Clarke 2015). For this reason, only data prior to 2012 were used in the estimation. The adjusted annual imports of shark fin to Hong Kong are shown in Table 2.

2.1.3 Data Source 3

Hong Kong's share of the global shark fin trade was studied in detail for 1996-2000 and was calculated from empirical data to range from 44-59% (Clarke et al. 2006a). Since reliable empirical data for estimating Hong Kong's market share in previous and subsequent years (i.e. 1980-1995 and 2001-2011) are lacking, ranges of values for these years were specified based on expert judgment.

Difficulties in estimating Hong Kong's share of the global trade in previous years (i.e. 1980-1995) are mainly due to the lack of access to customs statistics, especially for Mainland China. Nevertheless, a general understanding of trade patterns in Hong Kong during the 1980s (Clarke et al. 2007) suggests that Hong Kong's market share was higher in 1980-1995 than during 1996-2000. The earliest accounts of the shark fin trade state that Hong Kong's share of world imports was 50% (Tanaka 1994, based on data through 1990) or 85% (Vannuccini 1999, based on 1992 data). A range of 65-80% was thus selected for the period 1980-1990. A transitional period for the shark fin trade in Hong Kong occurred in 1991-1995 as demand began to rise appreciably in Mainland China. It is likely that Hong Kong's share began to drop, but not to the extent observed in the period 1996-2000 (i.e. 44-59%), thus a range of 50-65% was selected.

Estimation of Hong Kong's market share since 2000 is less plagued by data gaps but still subject to a number of potential biases. Previous analysis has shown that Hong Kong imports of shark fin rose at a rate of 6% per year from 1992-2000 (Clarke 2004a), but afterwards showed a nearly level but slightly declining linear trend (Clarke et al. 2007). Hong Kong shark fin traders attribute this trend to a loss of market share to Mainland China. While this explanation is supported by the well-known liberalization of the Mainland China economy just prior to and as a result of entry to the World Trade Organization in December 2001 (WTO 2014), Mainland China's shark fin imports do not show a strong trend of increase since 2000. One reason for this lack of trend may be that in 2000 Mainland China began importing frozen shark fins under a category previously used only for frozen shark meat and therefore from 2000 onward frozen fins, which comprise a substantial portion of the trade, are no longer distinguishable in the statistics (Clarke 2004b). Complications in trade reporting by Mainland China and their implications for assessing global trade in shark fins are discussed in detail in Clarke et al. (2007). On balance it was considered that even without strong evidence of increasing imports by Mainland China, it was likely that Hong Kong's share of global trade declined sharply after 2000. A range of 30-50% was thus specified for 2001-2006 to account for the initial decline, and a lower range of 25-40% was specified for 2007-2011 as the trend is believed to have become even more pronounced.

2.1.4 Data Source 4

Four methods were used for proportioning global fin trade-based catch estimates to Indian Ocean-specific quantities. As one of the methods requires country-specific import records and as these records are only available from 1998 onward, this index extends only from 1998-2011. The other indices extend over the full period (1980-2011) but as described below they have various inherent biases acting over the entire time series or over portions of the time series. Therefore, when patterns appear in results derived from one proportioning method only, careful consideration of the credibility of that particular proportioning method is warranted.

The first proportioning method is based on calculating the area of potential habitat within the Indian Ocean relative to its potential habitat in the world ocean as a whole. This method assumes that each shark species is evenly distributed throughout global waters between the northern-most and southern-most extent of its range. For simplicity, the wide-ranging blue shark was considered to be distributed between 50°N-50°S worldwide, while the oceanic whitetip shark was considered to be distributed between 30°N-30°S based on indicative ranges given in Compagno (1984). The global area of habitat for the blue shark (50°N-50°S) was considered to be 287.84 million km^2 (Clarke et al. 2006). (Recent re-evaluation of the global area of habitat between 30°N-30°S as provided in Clarke (2008) suggests these require recalculation but this was not possible without access to a geographic information system; area-based proportioning is thus not applied for oceanic whitetip shark). To obtain the area of blue shark habitat in the Indian Ocean, the area between 30°N-30°S was first calculated using the Google Maps' "measure area" function to measure the perimeter of the ocean basin corresponding to the IOTC area of competence (except for the southern perimeter which for this analysis was fixed at 30°S), and then subtracting the land area of Madagascar and Sri Lanka[1]. To this area of 39.62 million km^2 was then added the IOTC area of competence between 30°S and 50°S minus the area of Tasmania to produce a total area of 62.24 million km^2[2,3]. The area-based ratio for the blue shark was thus calculated as:

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[1] The Google Maps area calculation for the Indian Ocean 30°N-30°S was 40,270,835 km^2 and the land areas of Madagascar and Sri Lanka according to Wikipedia are 587,040 km^2 and 65,610 km^2, respectively.

[2] The Google Maps area calculation for the Indian Ocean 30°S-50°S was 22,688,765 km^2 and the land area of Tasmania according to Wikipedia is 68,401 km^2.

[3] For reference, Wikipedia gives the surface area of the entire Indian Ocean (based on a southern boundary of 60°S) as 73.556 million km^2.

Blue shark: $\frac{62.24\ Mkm^2}{287.84\ Mkm^2}$=0.216

No plot is shown for the first proportioning method because the ratio is constant throughout the time series.

The second proportioning method involved scaling against a ratio of tuna and tuna-like species catches in global waters versus those in the Indian Ocean. Catch data were taken from the FAO Capture Production database's ISSCAAP group "tunas, bonitos and billfishes" for all oceans and for the Indian Ocean alone (FAO 2014). These figures, and the resulting ratios, are shown in Table 3 and Figure 1.

The third proportioning method involved constructing an index of longline effort. Although a number of gear types catch sharks, this index was chosen because it was assumed that longline gear both catches a large number of sharks and is easy to quantify on a global basis (e.g. unlike gill net effort). The number of longline hooks (in millions) fished annually was estimated for the Indian Ocean and provided by IOTC staff (IOTC 2014b), and were extracted from a database of raised longline effort for the WCPO (CES 2014). For the Eastern Pacific, longline effort was only available in nominal form for fleets from China, Japan, Korea, French Polynesia, Taiwan-China and the United States. Effort for other fleets, and for all fleets prior to 1984 has not been compiled (IATTC 2014). Longline effort in the Atlantic has been estimated under ICCAT's EFFDIS project through 2009 only (ICCAT 2015; ICCAT Secretariat, personal communication). In order to extend the series through 2011, nominal effort for 2005-2009 was extracted from the ICCAT Task II (Catch and Effort database, ICCAT 2014) by the ICCAT Secretariat and used to create a 5-year averaged conversion factor between nominal and EFFDIS effort (4.27). This conversion factor was used to construct annual effort values for 2010-2011 and thus complete the EFFDIS series in a rudimentary way[4]. These data, the total global longline effort figures and the ratio of Indian Ocean to global longline effort are shown in Table 4 and Figure 2.

The fourth proportioning method considers that the proportion of shark fins which are imported by Hong Kong and which also derive from shark catches in the Indian Ocean might best be represented by the proportion of Hong Kong's total shark fin imports which report as their "country of origin" countries around the Indian Ocean basin. One important drawback of this method is that it assumes that all sharks which are caught in the Indian Ocean and used in the shark fin trade are shipped to Hong Kong from Indian Ocean coastal States. This is probably not a valid assumption for the distant water fishing nations active in the Indian Ocean, in particular China, EU-France, Japan, Republic of Korea, EU-Portugal, EU-Spain and Taiwan-China. Given the possibility that a portion of Hong Kong imports recorded as originating in these seven locations may actually have been derived from Indian Ocean catches that were transported back and landed domestically, two methods (Methods 1 and 2) were tested. First, each country shown in the Hong Kong import database as importing unprocessed shark fins in dried or salted form from 1998-2011 was classified into one of

[4] It is noted that at the time of writing, a consultant engaged by ICCAT is updating the EFFDIS data series and a new series is expected to be available later in 2015.

three categories based on its propensity to be trading shark fins derived from Indian Ocean catches (Table 5). Under both methods, all imports from Indian Ocean coastal States fishing only in the Indian Ocean were tallied in full, and it was assumed that half of the imports from Australia, Indonesia, Malaysia, South Africa and Thailand were derived from the Indian Ocean (and half from other oceans). Under Method 1 only it was arbitrarily assumed that 20% of Hong Kong's imports from distant water fishing entities China, EU-France, Japan, the Republic of Korea, EU-Portugal, EU-Spain and Taiwan-China derived from the Indian Ocean. Method 2 assumes that none of the imports from these seven locations derives from the Indian Ocean (i.e. if any of them are producing shark fins from the Indian Ocean these fins are assumed to be shipped to Hong Kong via one of the other countries listed in Table 5). Tallies resulting from Methods 1 and 2 were expressed as ratios of the total amount of shark fins imported by Hong Kong in each year (Table 2). Under Method 1 the average ratio for 1998-2011 was 0.365 as compared to 0.304 for Method 2 (Table 6, Figure 3).

2.2 Model and Modelling Methods

The model was implemented with Markov chain Monte Carlo (MCMC) methods using the Gibbs sampler (Gelfand and Smith 1990) via OpenBUGS software version 3.2.3 rev 1012 (Imperial College London 2014). Since the original posterior distributions presented in Clarke et al. (2006a) require many hours of computing time to replicate, simplified representations of these complex distributions were approximated using triangular distributions (Step 1). Other uncertain parameters, such as Hong Kong's share of the global fin trade (Step 3), were specified as expert judgement-based ranges with uniformly distributed random variables. The annual quantity of Hong Kong imports (Step 2) and the proportioning indices (Step 4) were based on empirical data for each year, except for the geographic area which does not vary from year to year. Although there is uncertainty in these data it is not possible to quantify the variance and thus these parameters were specified using deterministic equations. The model was executed in four steps covering each of the four data sources given above (Annex 1):

Step 1

The probability distributions representing the range of estimates of the two shark species in the global trade by number and biomass (Table 1, the "anchor point" estimates) were approximated as triangular distributions using the reported lower limit of the 95% probability interval as the minimum, the upper limit of the 95% probability interval as the maximum, and the median as the mode. The model drew a random variable from each of the triangular distributions representing each species' number or biomass in 2000 in each iteration.

Step 2

Each random variable drawn in Step 1 was multiplied by the ratio of the standardized quantity of fins traded through Hong Kong in each year from 1980-1999 and 2001-2011 (Table 2) to the quantity of fins traded through Hong Kong in 2000 (i.e. 6,788 t). This step serves to scale the species-specific number or biomass estimates from 2000 to quantities representing trade levels in each of the other years. Due to a lack of quantitative data on trends in species composition this step assumes that the species composition in 2000, the only year for which the species composition is known, remains constant over the years 1980-2011. It is likely, however, that the relative proportion of blue sharks in trade has increased in recent years due to the relatively higher productivity of that species (Eriksson & Clarke 2015), and the relative proportion of oceanic whitetip sharks in trade has declined due to the severe downward trends in abundance observed for this species in some oceans (Clarke et al. 2013).

Step 3

Hong Kong's share in four alternative periods (S_a), i.e. 1980-1990, 1991-1995, 2001-2006 and 2007-2011, relative to its share in 1996-2000 (0.44-0.59, S) was specified as a series of uniformly distributed random variables using endpoints based on expert judgment (Section 2.1.3). The ratio of S and S_a was then computed and multiplied by the result from Step 2. The result of Step 3 is a species-specific number or biomass value representing sharks used in the global trade for each year from 1980-2011.

Step 4

The final step required proportioning the annual values from Step 3 to the Indian Ocean. Proportioning based on area used a constant of 0.216 for blue shark over all years in the time series; area proportioning was not applied to oceanic whitetip shark. The target species catch-based (Table 3 and Figure 1), longline effort-based (Table 4 and Figure 2) and country of origin-based (Table 6 and Figure 3) proportioning methods applied unique values for each year as deterministic calculations.

The model was run for 100,000 iterations, and medians and 95% probability interval endpoints were sampled from the final 10,000 iterations.

3 Results

The algorithm outlined above will, by definition, produce the same patterns of results for blue and oceanic sharks in number (Figures 4 and 5) and in biomass (Figures 6 and7). This is because the same scaling factors were applied to the four anchor point estimates (Table 1) thus only the absolute value of the starting point differs. In general the area-based proportioning method, which used constant annual values, produced the lowest estimates. The target species catch-based method produced the next higher estimates but these were very similar to (at most only 20% higher than) the area-based estimated quantities. The effort-based method and the two country of origin-based methods produced the highest estimates with values ranging from near the target species catch-based estimates to nearly double those amounts. The three effort- and country of origin-based methods' estimates were reasonably similar (medians are +/- 25% of each other despite large probability intervals) within the limited range of years which could be estimated for all three (1998-2011).

In addition to considering the absolute differences between the estimates in any given year, the trends in the estimates can also be interpreted with reference to which proportioning method was applied. For example, the relatively flat trend in the area-based series is expected given the constant (over time) geographical proportioning of the annual observed fluctuations in the Hong Kong trade quantities. All of the other proportioning methods superimpose an annually varying index over these Hong Kong trade fluctuations, but the fluctuations in the target species catch series are not materially different. Larger variations are observed in the effort- and country of origin-based methods when peaks or troughs in Hong Kong trade combine with peaks or troughs in the Indian Ocean proportioning indices. For example, the effort-based method produced local maxima in 2007 when both the quantity of shark fins imported by Hong Kong and the proportion of longline effort in the Indian Ocean were high relative to other years.

Focusing on the 1998-2011 period and accounting for the full width of the 95% probability intervals, Indian Ocean catch estimates for blue shark ranged from a minimum (area- and target species catch-based) of ~1-3 million sharks per year to a maximum (effort- and country of origin-based) of ~2-8 million sharks per year. In biomass, these Indian Ocean catches were estimated to be at least ~40,000-200,000 t (area-based) and at most ~75,000-350,000 t (effort- and country of origin-based) per year over the same period. For the oceanic whitetip sharks the estimates in number of sharks for 1998-2011 are ~50,000-400,000 sharks per year at the low end of the range (target species catch-based) and ~100,000-700,000 sharks per year at the upper end of the range (effort- and country of origin-based). In biomass the minimum estimates were ~2,000-15,000 t (target species catch-based) and the maximum estimates were ~3,500-25,000 t (effort- and country of origin-based). Median estimates for four of the proportioning were centred on 4 million blue sharks (150,000 t) and 250,000 oceanic whitetip sharks (8,000 t) per year in the most recent decade.

In order to explore the assumptions underlying the country of origin-based proportioning index, two variations were calculated. As expected, when Hong Kong imports from distant water fishing entities active in the Indian Ocean (China, EU-France, Japan, Republic of Korea, EU-Portugal, EU-Spain and Taiwan-China) were assumed to derive entirely from waters outside the Indian Ocean (Method 2)[5], and were thus excluded from the Indian Ocean-derived trade tally, the proportion of shark catches in the Indian Ocean declined. The alternative scenario (Method 1) assumed that 20% of Hong Kong imports from these locations derived from sharks caught in the Indian Ocean but were transported back to flag State before being shipped directly to Hong Kong. The choice of Method 2 over Method 1 reduced the country of origin-based proportioning index, and the resulting catch estimates by 10-20%. Method 2 produced an estimate that was intermediate to the higher estimates produced by the effort-based and country of origin-based (Method 1) estimates, and the lower estimates produced by the target species catch-based method.

[5] Note that this assumption allows that these seven entities may catch sharks whose fins enter the Hong Kong trade, however it assumes that this trade passes through one of the Indian Ocean coastal States shown in Table 5.

4 Discussion

Catch data for most shark species are insufficient to support stock assessment, yet concerns about the status of shark populations continue to grow. Under such circumstances, development of alternative historic shark catch time series and careful evaluation of whether these alternative series can fill some of the existing critical data gaps is a worthwhile exercise.

The estimates produced by this study were based on "anchor point" estimates derived from a shark fin trade data set compiled in Hong Kong in 2000 (Clarke et al. 2006a). To date these are the only quantitative, species-specific data on the shark fin trade and represent a snapshot of the centre of the global shark fin trade at that time. Using these data to estimate the number and biomass of shark catches in the Indian Ocean requires a number of assumptions, namely:

1. **The species composition of the sampled portion of the Hong Kong shark fin trade in Clarke et al. (2006a) is representative of global species composition.** As discussed in Clarke et al. (2006b), there is a lack of information to evaluate the strength of this assumption, but there are no other datasets that are considered more representative.
2. **The species composition of the fin trade observed in 2000, and the relationships between fin sizes/weights and whole shark weights observed at that time, are constant throughout the time series.** While some stock composition shifting would be expected over time, there are few existing data with which to explore alternative assumptions. It may be the case that the proportion of blue shark in the shark fin trade has increased as other, less productive species have been depleted (Eriksson & Clarke 2015). In such a case the estimates presented here would under-estimate the actual blue shark catch, and over-estimate the actual oceanic whitetip shark catch, in recent years.
3. **Each of the species assessed is equally likely to be found in the Indian Ocean as in any other ocean.** This appears to be a reasonable assumption given what is known regarding the distribution of these sharks.

Overlying these assumptions is the fact that estimating catches based on shark fin trade data will necessarily underestimate the true quantities of sharks caught. First, the original "anchor point" estimates are in themselves conservative because they are based only on those fins which could be confirmed to derive from the species of interest. More than half (54%) of the fins observed by Clarke et al. (2006a) could not be characterized by species and could have contained additional quantities of the species of interest (Clarke et al. 2006b). Second, only those sharks whose fins enter the international shark fin trade are enumerated. This is because there is no means in this study of accounting for mortality associated with sharks which are a) discarded dead with their fins attached; b) released with their fins attached but subsequently die due to injury or stress; or c) are retained but whose fins are either not used or used without being internationally traded. For these two reasons actual shark mortality is very likely to be greater than the estimates provided here.

Robust estimation requires use of a number of different algorithms to explore various assumptions and biases. However, this approach in combination with reporting of probability intervals rather than point estimates can lead to considerable uncertainty when drawing conclusions about the estimation results. It is thus important to discuss, qualitatively if necessary, the relative credibility of each of the five estimates (Figures 4-7, Annexes 2 and 3).

Of the four proportioning methods (area-, target species catch-, effort- and two country or origin-based methods), the most arbitrary is the area-based method. Although it is useful as a reference case, it is overly simplistic to assume that catches of blue sharks are directly proportional to the area of potential blue shark habitat in each ocean. For this reason the proportioning methods relating to fishing activity are more credible. The target species catch-proportioning method assumes that when tuna and billfish catches in the Indian Ocean are low relative to other oceans, shark catches in the Indian Ocean are also low relative to other oceans. This assumption may be erroneous, particularly if there have been shifts in targeting between tunas, billfishes and sharks to differing degrees in different oceans.

Another method for proportioning global to Indian Ocean totals using fishing activity was based on effort statistics, specifically longline effort in hooks. This method is considered to be more reliable that the area- or target species catch-based methods because its main assumption, i.e. that shark catch is proportional to longline effort, seems reasonable. The main source of bias associated with the effort-based method is the under- or non-reporting of longline effort particularly in small coastal longline fleets. There may also be bias associated with relying only on longline effort in oceans where large quantities of sharks are caught with other gear types. For example, although oceanic whitetip sharks are caught by purse seine gear in all oceans this is not expected to skew the effort-based proportioning method as all oceans would be affected. However, if large quantities of shark fins are produced by small-scale gear types (e.g. gill nets, hand lines) which comprise a larger portion of the fishery in the Indian Ocean (Murua et al. 2013), the actual Indian Ocean shark catch would be higher than estimated by the longline effort-based index. Similarly, it is known that longline effort is under-represented for the Eastern Pacific because of lack of effort data for many of the smaller fleets (IATTC 2014). This would tend to inflate the catch estimates in other oceans. Unless and until there is a common method for compiling effort statistics across all oceans, potential biases will exist due to different statistical procedures applied by each t-RFMO[6].

Due to the additional uncertainty associated with the effort-based method as it relates to the Indian Ocean fisheries, a fourth proportioning method involving country of origin statistics was applied. This method is the most likely to directly reflect the level of shark fin production in the region, but it is complicated by the potential for transhipment and other complex trading patterns particularly amongst the distant water fishing entities (Martin et al. 2013). Despite this inherent shortcoming, this method has an advantage over the effort- and target species catch-based proportioning methods: it may be easier to detect the importance of certain Indian Ocean developing States in

[6] Note that inconsistent statistical procedures also bias global catch statistics and thus the target species catch-based proportioning method.

shark trade statistics (i.e. Hong Kong imports) than in fishery statistics which for some of these fleets are unreliable.

Compared to an earlier version of this paper which used an older and incomplete series of longline effort data and applied a different country of origin-based proportioning method, the results presented here show higher effort-based estimates and lower trade-based estimates. Under this new methodology these two proportioning methods now show close agreement not only with overlapping probability intervals but also similar medians. The target species catch-based method provides a slightly lower but still plausible estimate (~30% lower than the effort- and country of origin (Method 1)-based methods, and ~15% lower than the alternative country of origin (Method 2)-based method).

There are few existing estimates of Indian Ocean shark catches which with to compare the results of this study. Murua et al. (2013) used ratios of shark catches to target species catches over the period 2000-2010 to produce a point estimate for each of 24 types of sharks (including "other sharks") and 16 fleet types (including "other"). The sum of the point estimates across the 16 fleet types was just over 50,000 t per year for blue sharks and slightly less than 17,000 t per year for oceanic whitetip sharks. The Murua et al. (2013) estimate for blue sharks (~50,000 t per year) is approximately half that estimated by the area- and target species catch-based estimates produced here (this study's median range ~100,000 t (2000) to 125,000 t (2011) per year). It is considerably lower than the more credible proportioning methods applied in the current study (this study's median ranges in the vicinity of 100,000 to 200,000 t per year). The Murua et al. (2013) estimate for oceanic whitetip sharks (~17,000 t per year), which is mainly determined by their estimates for the gill net fishery, is in contrast higher than the median estimates for any of the proportioning methods applied in this study. It is interesting to consider that the ratio of blue shark to oceanic whitetip shark catches based on Murua et al. (2013) is approximately 3:1 whereas the ratio of blue shark to oceanic whitetip shark fins in the Hong Kong trade is approximately 16:1 (Clarke et al. 2006a (see Table 1))[7]. It is also important to consider that the Hong Kong species ratio was calculated on the basis of data from 1999-2001 since which time it is expected that oceanic whitetip shark populations have severely declined (e.g. Clarke et al. 2013) and their representation in the shark fin trade, and in shark catches, has likely declined concomitantly.

This discussion highlights that while both catch estimation methods have merit, there are also some important uncertainties which cannot be resolved on the basis of existing data. Given the urgent need for improvement in historic catch data to support shark stock assessment, further study of these and other methods is strongly encouraged.

5 Acknowledgements

[7] The ratio of blue shark to oceanic whitetip shark catches in the IOTC catch and effort databases for 2000-2010 is on the order of 27:1 (calculated by the author based on data provided by M. Herrera and S. Martin on 9 October 2014).

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Table 1. Number and biomass of blue and oceanic whitetip sharks (median and 95% probability interval) used in the global shark fin trade in 2000 (Clarke *et al*. 2006a).

Species	Number (million)	Biomass ('000 t)
Blue shark	10.74 (4.64 – 15.76)	364 (204 – 619)
Oceanic whitetip shark	0.60 (0.22 – 1.21)	22 (9 – 47)

Table 2. Adjusted total imports of shark fin (t) to Hong Kong, 1980-2011 (see text for adjustment methods). The "anchor point" estimate is shown in bold (Source: HKSARG 2012)

Year	Quantity (t)	Year	Quantity (t)
1980	2,739	1996	4,513
1981	2,741	1997	4,868
1982	2,704	1998	5,196
1983	2,512	1999	5,824
1984	2,748	**2000**	**6,788**
1985	2,613	2001	6,435
1986	2,788	2002	6,513
1987	3,317	2003	6,960
1988	3,272	2004	6,142
1989	3,003	2005	5,887
1990	3,018	2006	5,337
1991	3,526	2007	5,798
1992	4,265	2008	5,536
1993	3,856	2009	5,559
1994	4,144	2010	5,759
1995	4,706	2011	6,175

Table 3. FAO-reported capture production of tunas, bonitos and billfishes globally and in the Indian Ocean, and their ratio, 1980-2011 (FAO 2014).

Year	**Global (million t)**	**Indian Ocean (million t)**	**Ratio (Indian Ocean : Global)**
1980	2.676	0.305	0.114
1981	2.700	0.326	0.121
1982	2.800	0.385	0.138
1983	2.961	0.400	0.135
1984	3.152	0.496	0.157
1985	3.239	0.598	0.185
1986	3.548	0.654	0.184
1987	3.678	0.719	0.195
1988	4.108	0.838	0.204
1989	4.105	0.796	0.194
1990	4.371	0.769	0.176
1991	4.508	0.782	0.173
1992	4.541	0.927	0.204
1993	4.653	1.106	0.238
1994	4.788	1.094	0.228
1995	4.944	1.212	0.245
1996	4.900	1.232	0.251
1997	5.165	1.269	0.246
1998	5.723	1.279	0.223
1999	5.936	1.405	0.237
2000	5.832	1.400	0.240
2001	5.762	1.334	0.232
2002	6.135	1.445	0.236
2003	6.291	1.557	0.248
2004	6.336	1.665	0.263
2005	6.517	1.644	0.252
2006	6.542	1.690	0.258
2007	6.617	1.479	0.224
2008	6.609	1.481	0.224
2009	6.732	1.462	0.217
2010	6.765	1.495	0.221
2011	6.825	1.526	0.224

Table 4. Estimates of longline fishing effort (in million hooks) compiled from t-RFMO databases, and the ratio of total effort in the Indian Ocean, 1980-2011 (see text for derivation details).

Year	Atlantic Ocean Longline Effort (ICCAT 2015)	Western and Central Pacific Ocean Longline Effort (CES 2014)	Eastern Pacific Longline Effort (IATTC 2014)	Indian Ocean Longline Effort (IOTC 2014b)	Total Longline Effort	Ratio (Indian Ocean : Total)
1980	247	695	na	268	na	na
1981	232	737	na	255	na	na
1982	265	667	na	303	na	na
1983	216	756	na	330	na	na
1984	221	724	135	302	1,382	0.219
1985	277	1,053	130	301	1,761	0.171
1986	286	742	196	333	1,557	0.214
1987	270	884	237	362	1,753	0.207
1988	278	838	235	419	1,770	0.237
1989	283	755	230	547	1,815	0.301
1990	332	767	238	688	2,025	0.340
1991	324	667	283	666	1,940	0.343
1992	321	800	270	669	2,060	0.325
1993	353	683	225	875	2,136	0.410
1994	381	586	223	842	2,032	0.414
1995	347	596	190	759	1,892	0.401
1996	399	567	152	941	2,059	0.457
1997	379	569	140	1,006	2,094	0.480
1998	397	639	175	1,239	2,450	0.506
1999	427	731	166	1,073	2,397	0.448
2000	475	787	140	961	2,363	0.407
2001	457	966	238	891	2,552	0.349
2002	350	1,009	315	888	2,562	0.347
2003	377	993	302	806	2,478	0.325
2004	373	1,100	213	931	2,617	0.356
2005	297	874	152	935	2,258	0.414
2006	293	856	107	877	2,133	0.411
2007	307	947	103	956	2,313	0.413
2008	300	952	89	742	2,083	0.356
2009	280	1,069	100	724	2,173	0.333
2010	271	950	154	665	2,040	0.326
2011	302	1,072	152	637	2,163	0.294

Table 5. Categorization of Hong Kong import records for estimating the amount of trade derived from sharks caught in the Indian Ocean.

		Proportion of Hong Kong imports recorded as originating in each country and assumed to derive from the Indian Ocean	
Category	**Countries**	**Method 1**	**Method 2**
Imports from coastal States which border the Indian Ocean (only), and which do not engage in distant water fishing	Bahrain, Bangladesh, Egypt, Ethiopia, India, Iran Islamic Republic, Kenya, Kuwait, Madagascar, Maldives, Mauritius, Mozambique, Myanmar, Oman, Pakistan, Qatar, Saudi Arabia, Seychelles, Singapore, Somalia, Sri Lanka, Sudan, Tanzania, United Arab Emirates, Yemen	1.0	1.0
Imports from coastal States which border both the Indian Ocean and another ocean, and which do not engage in distant water fishing	Australia, Indonesia, Malaysia, South Africa, Thailand	0.5	0.5
Distant water fishing nations fishing in the Indian Ocean	China, EU-France, Japan, Republic of Korea, EU-Portugal, EU-Spain, Taiwan-China	0.2	0

Table 6. Dried and 'salted' (frozen) shark fin imports by Hong Kong from Indian Ocean basin countries (plus major fishing entities not located around the Indian Ocean basin but having a major fishing presence in the Indian Ocean), 1998-2011. 'Salted' fins were normalized for water content by dividing reported weights by four and then summed with dried fins to produce the quantities shown here. The names of countries which were reported to import both dried and 'salted' fins are shown in capital letters. Each annual country value was then applied to the factors shown as Method 1 or Method 2 (see text) and summed to produce an annual Indian Ocean basin total. That total was then expressed as a ratio (Method 1 or 2) to the annual adjusted Hong Kong shark fin import totals shown in Table 2.

	Method 1	Method 2	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AUSTRALIA	0.5	0.5	53461	45541	52963	30916	38248	30524	19420	32684	18905	52105	88903	56236	64751	50555
Bahrain	1	1			362	643	979	578	0	0	0	0	114	0	269	68
Bangladesh	1	1	7798	19481	42053	9824	13806	10295	13417	7296	4616	5697	16806	15705	6418	11271
CHINA			86370	86803	60629	57569	168199	407873	294788	95688	30945	1134	12528	10787	9123	9366
Egypt	1	1	2565	7297	5509	4175	3708	7070	8868	1944	2800	6822	5707	20414	16356	10131
Ethiopia	1	1		509				0	0	0	0	0	0	0	0	0
EU-FRANCE	0.2	0	592	1118	3467	363	143	1830	7297	6922	3638	631	320	0	1956	3685
INDIA	1	1	178294	384332	315591	281195	231009	241718	240119	128722	98992	83832	82365	161582	123337	103531
INDONESIA	0.5	0.5	376861	459781	597012	679694	768509	600538	453084	430909	356292	472061	388744	494359	467922	361384
Iran Islamic Republic	1	1						0	638	3204	0	24	300	0	767	0
JAPAN	0.2	0	425199	386502	254207	252288	205305	205192	215329	208767	202958	247754	149616	153145	155176	113251
Kenya	1	1	7110	12860	16049	15741	6901	10689	24840	16266	29911	23967	10984	9923	10922	15904
KOREA (REPUBLIC OF)	0.2	0	300	2258	16260	20992	19797	58170	70091	95885	32232	88053	85434	87264	86298	106204
Kuwait	1	1	1430			591	1394	200	0	0	311	602	1865	0	0	581
MADAGASCAR	1	1	8741	5206	19630	17481	20401	13106	29071	24524	30795	22460	28011	13868	21757	27906
MALAYSIA	0.5	0.5	3924	9023	11895	5260	6734	3544	3552	1703	1904	36200	12324	5088	28049	6212
Maldives	1	1	1162	1883	8631	1267	6536	7920	1297	2544	0	5844	7593	1720	1815	0
MAURITIUS	1	1	18027	11294	19488	2673	8542	33864	13187	25204	15803	24382	5161	29661	19628	13519
MOZAMBIQUE	1	1	2746	4410	2894	3962	5999	7749	652	2051	2456	4519	3860	7563	5528	1036
Myanmar	1	1	462			208	0	0	0	0	0	0	0	0	0	0
OMAN	1	1	98320	63791	149279	125299	29650	8060	20356	79708	69635	33921	37387	58877	12402	30515
Pakistan	1	1	50017	33449	55298	46633	36281	35507	53705	31400	39525	65827	39062	70634	52291	34954
EU-Portugal	0.2	0	3748	3530				0	172	0	0	0	0	0	0	0
Qatar	1	1		300	430	298	120	0	0	0	0	0	0	0	0	0
Saudi Arabia	1	1		9022			789	1371	202	3353	160	6370	5158	5060	3906	10042
Seychelles	1	1		1286	7643	9635	10048	1763	546	2013	336	2125	2594	7744	5224	3923
SINGAPORE	1	1	245407	328591	296720	222444	333262	397954	431955	426509	335862	303967	466911	337554	366435	726667
Somalia	1	1						0	4488	0	0	0	0	0	0	0
SOUTH AFRICA	0.5	0.5	62044	80448	138559	103380	127249	104786	87932	80600	77682	64510	113170	97445	106822	65140
EU-SPAIN	0.2	0	845741	744009	970412	863578	910607	979784	775826	858768	863037	925472	758406	715471	619159	859568
SRI LANKA	1	1	36986	55086	54535	50798	28552	53802	110777	62397	69661	42259	39448	81658	52518	69355
Sudan	1	1			100			0	0	0	0	1265	377	702	460	0
TAIWAN-CHINA	0.2	0	215096	459993	639869	784143	849216	876799	690495	509244	717163	667718	571704	557143	594500	545034
Tanzania	1	1	3222	2360	21751	2973	90	458	385	370	3102	4959	3024	3789	2221	1647
THAILAND	0.5	0.5	17539	7491	34235	30679	26336	37796	12935	23946	13773	8038	18085	22082	29362	88256
United Arab Emirates	1	1	464026	405244	498863	357789	538918	507263	405608	500333	406996	474422	492540	443323	420502	386534
Yemen	1	1	190535	232762	350052	225573	118095	105810	54810	82595	214957	269332	224738	216052	422498	332833
Total from above using Method 1			1889171	2217146	2671179	2199951	2309270	2339700	2114180	2040409	1930190	2085204	2100219	2128195	2186949	2393611
TOTAL from above using Method 2			1573762	1880304	2282210	1804164	1878617	1833770	1703381	1685355	1560195	1699052	1784618	1823433	1893707	2066190
Hong Kong Total (from Table 2)			5195777	5823683	6787929	6434813	6513007	6959699	6141969	5887061	5336705	5798486	5535517	5558389	5759196	6174597
Ratio of IO to Hong Kong Total - Method 1			0.364	0.381	0.394	0.342	0.355	0.336	0.344	0.347	0.362	0.360	0.379	0.383	0.380	0.388
Ratio of IO to Hong Kong Total - Method 2			0.303	0.323	0.336	0.280	0.288	0.263	0.277	0.286	0.292	0.293	0.322	0.328	0.329	0.335

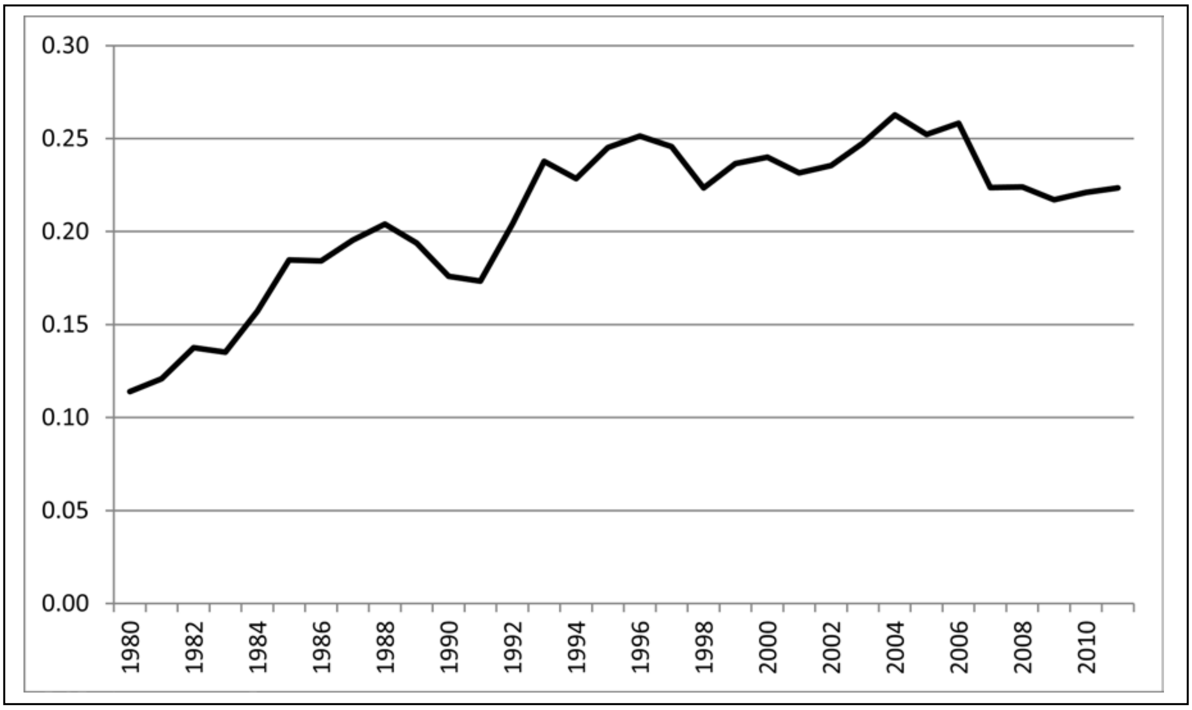

Figure 1. Annual ratios of FAO-reported capture production of tunas, bonitos and billfishes in the Indian Ocean to the global catch of these species, 1980-2011 (data given in Table 3).

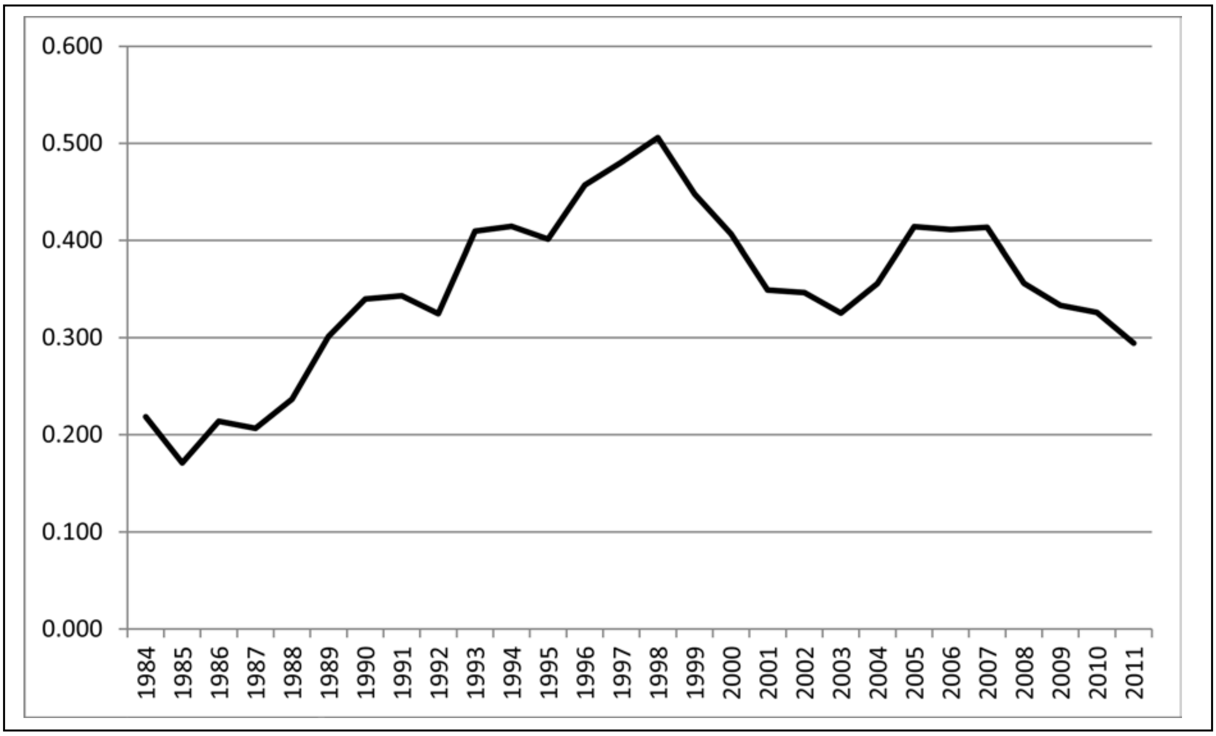

Figure 2. Annual ratios of longline effort in the Indian Ocean to global longline effort, 1984-2011 (data given in Table 4).

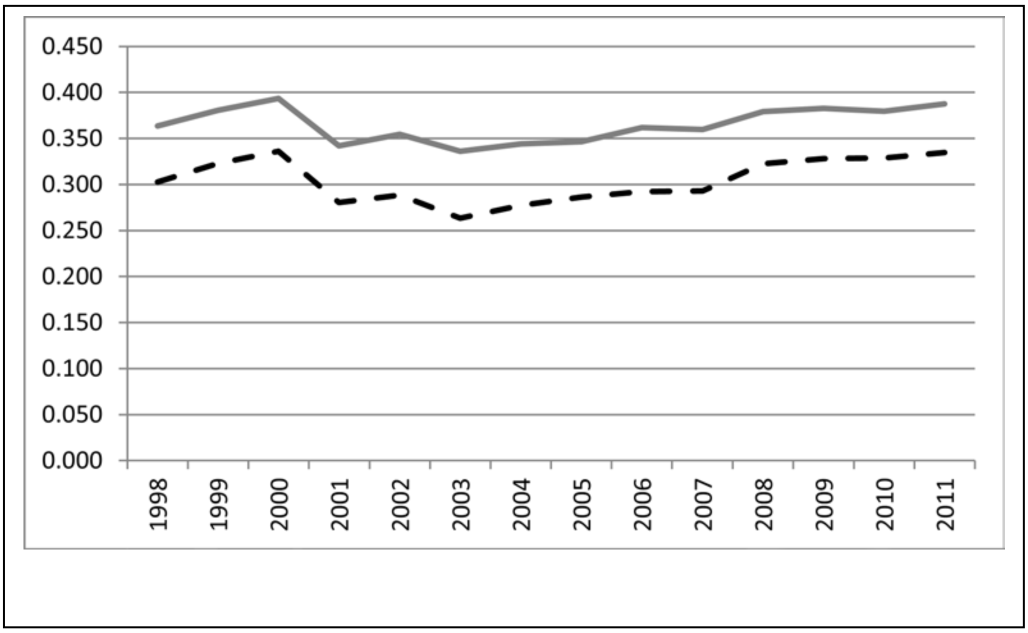

Figure 3. Annual proportion of Hong Kong shark fin imports estimated to be derived from the Indian Ocean using two methods (gray line=Method 1; dashed line=Method 2 (see text and Table 5 for methods and Table 6 for data), 1998-2011.

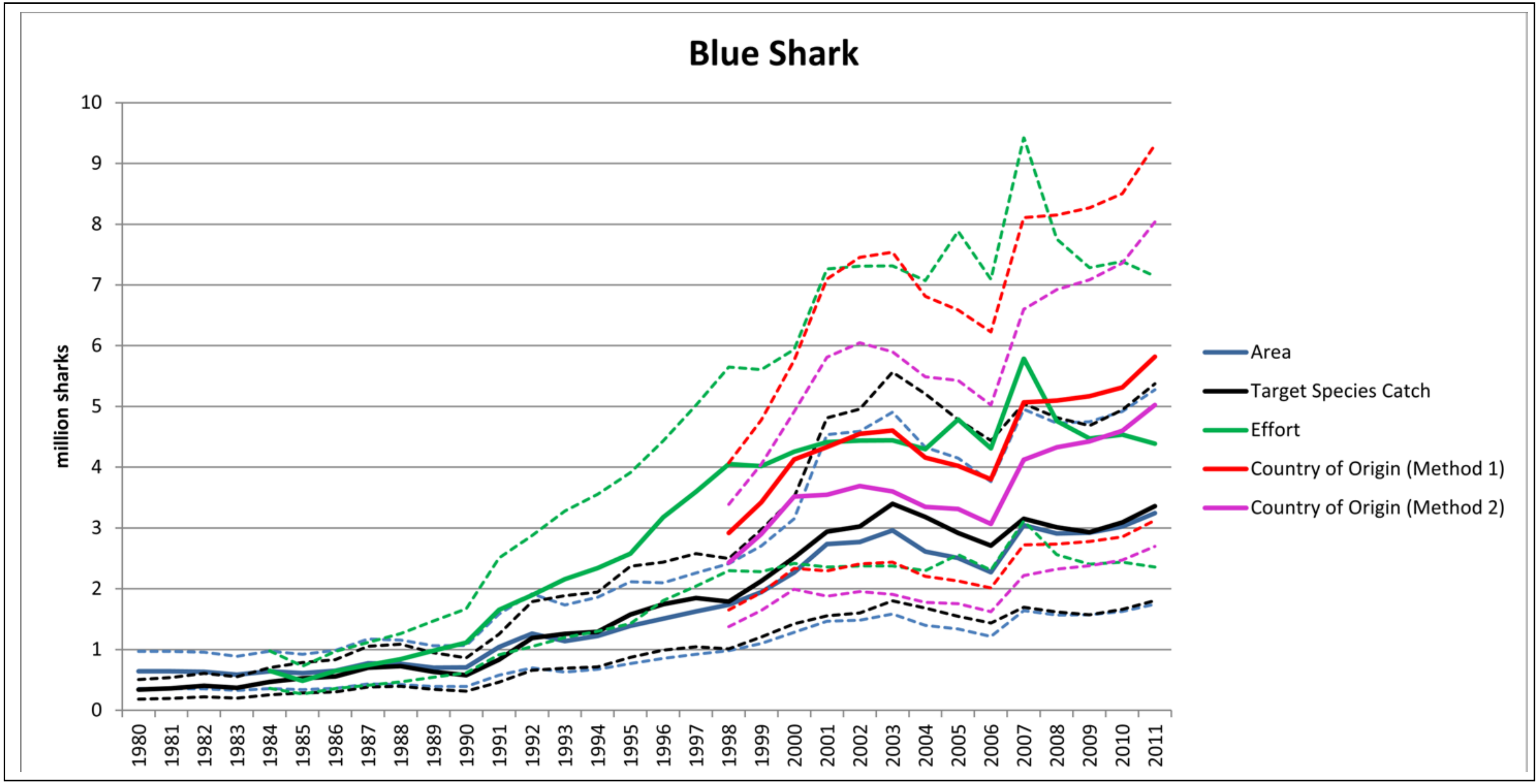

Figure 4. Annual median (solid line) and 95% confidence interval (dashed lines) estimates for blue shark (in million sharks), using area, target species catch, longline effort, and two types of country of origin proportioning methods to scale the number of sharks present in the global shark fin trade to those derived from the Indian Ocean, thus representing Indian Ocean shark catches.

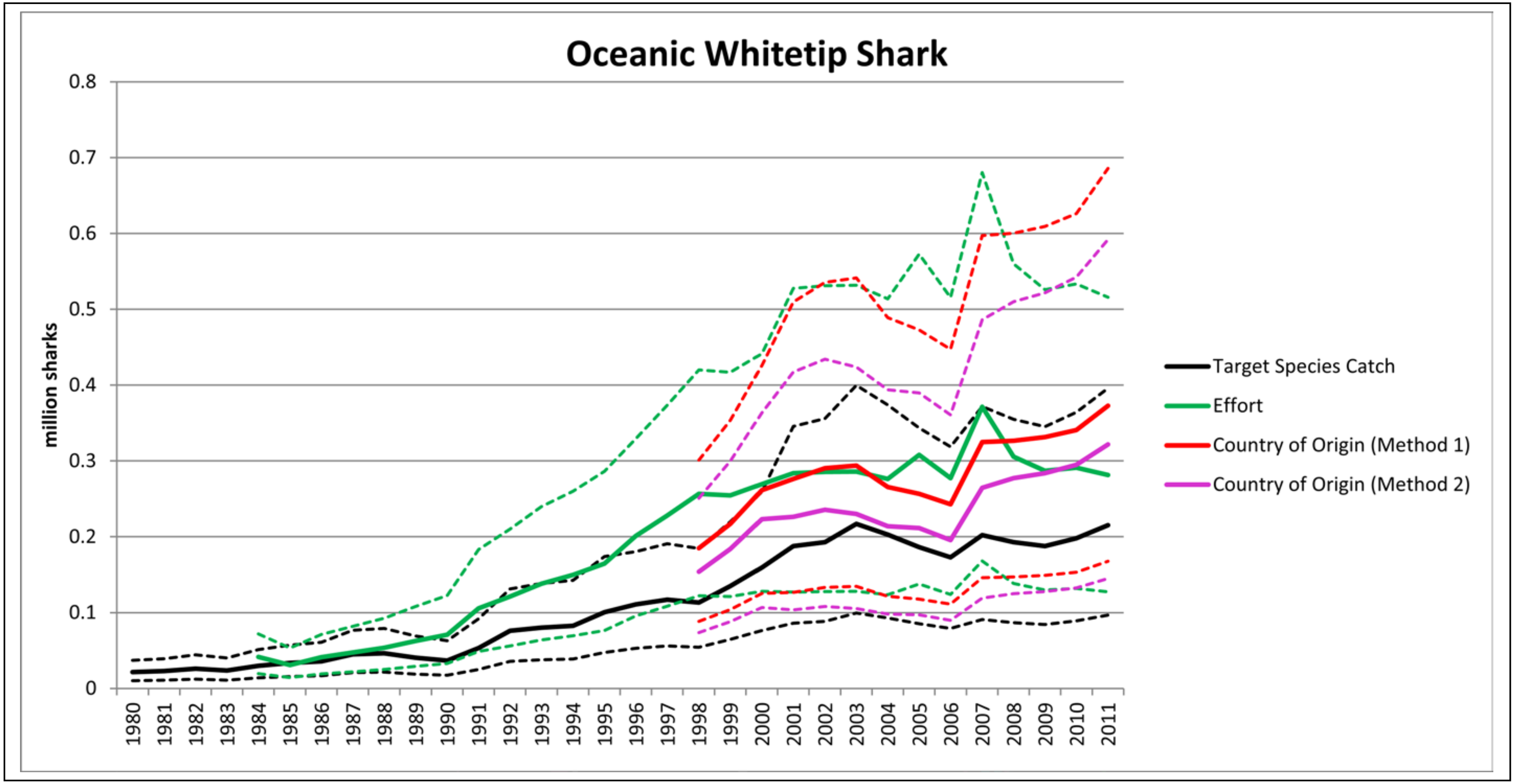

Figure 5. Annual median (solid line) and 95% confidence interval (dashed lines) estimates for oceanic whitetip shark (in million sharks), using target species catch, longline effort, and two types of country of origin proportioning methods to scale the number of sharks present in the global shark fin trade to those derived from the Indian Ocean, thus representing Indian Ocean shark catches.

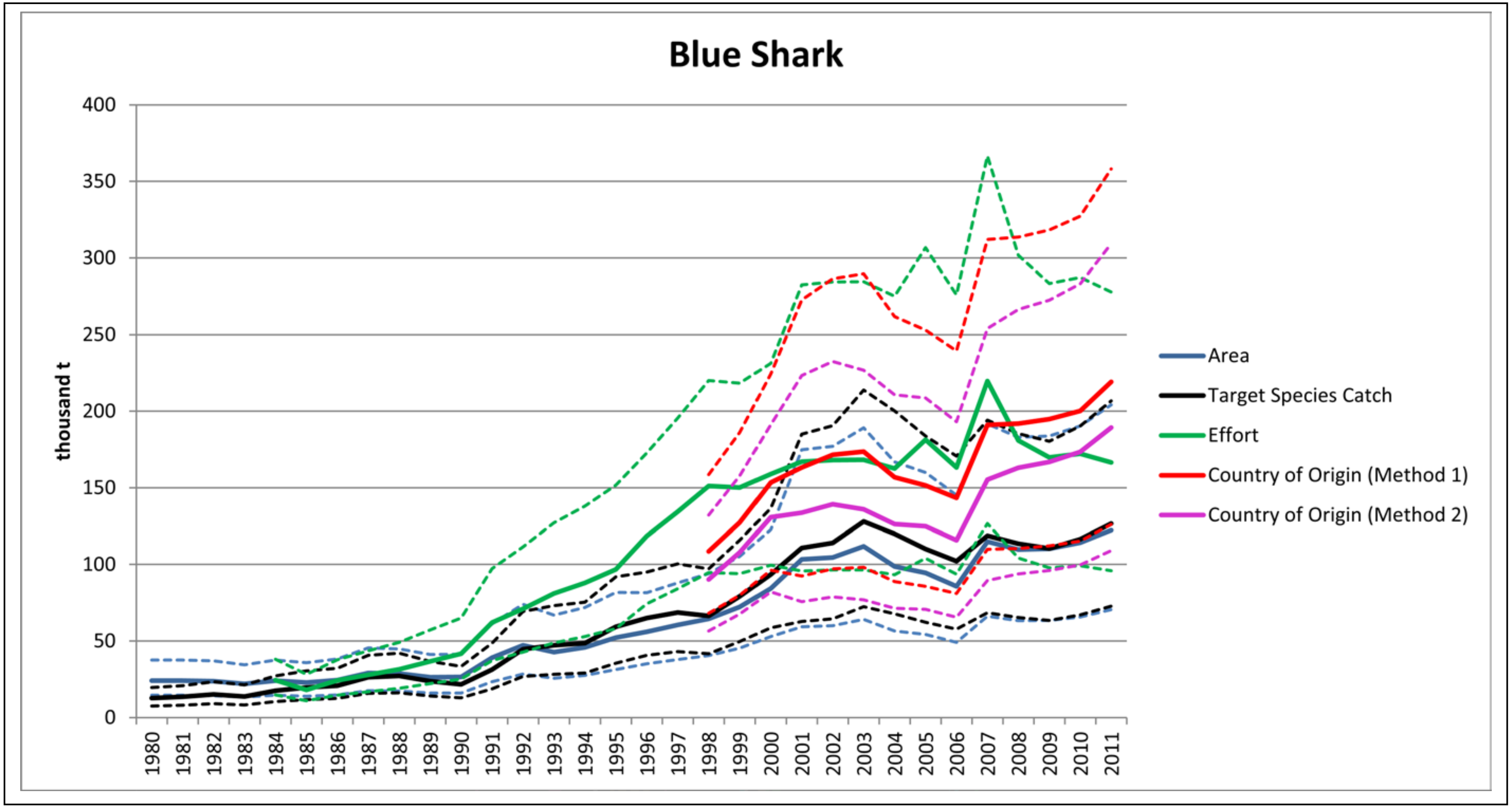

Figure 6. Annual median (solid line) and 95% confidence interval (dashed lines) estimates for blue shark (in thousand t), using area, target species catch, longline effort, and two types of country of origin proportioning methods to scale the number of sharks present in the global shark fin trade to those derived from the Indian Ocean, thus representing Indian Ocean shark catches.

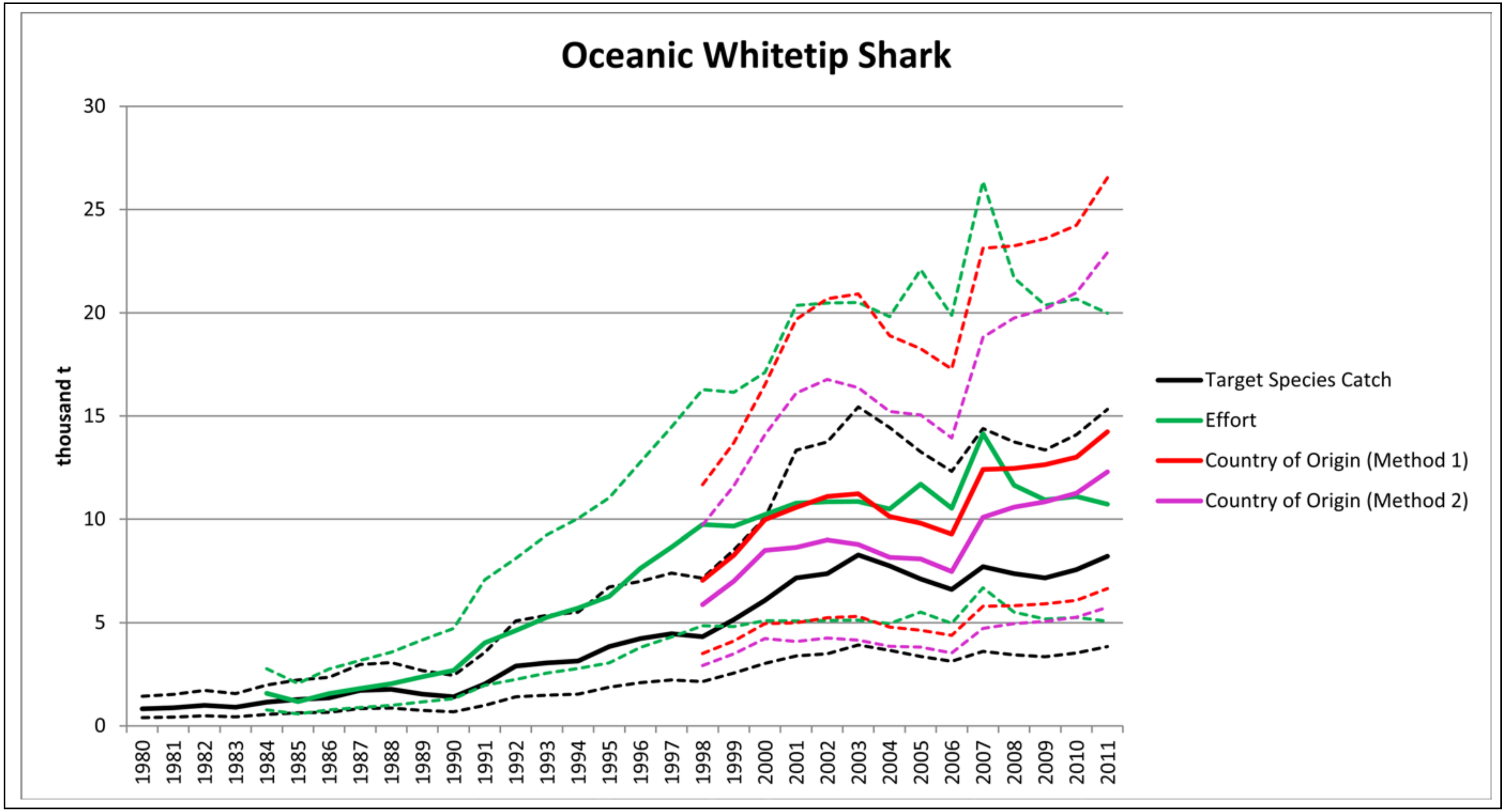

Figure 7. Annual median (solid line) and 95% confidence interval (dashed lines) estimates for oceanic whitetip shark (in thousand t), using target species catch, longline effort, and two types of country of origin proportioning methods to scale the number of sharks present in the global shark fin trade to those derived from the Indian Ocean, thus representing Indian Ocean shark catches.

Annex 1. WinBUGS code

```
model
{
        #these are HK's assumed share of the global totals in each period
        shar8090~dunif(0.65,0.80)
        shar9195~dunif(0.50, 0.65)
        shar9600~dunif(0.44,0.59)
        shar0006~dunif(0.30,0.50)
        shar0711~dunif(0.25,0.40)

for (z in 1:11){
        ratio[z] <- shar9600/shar8090
        }
for (z in 12:16){
        ratio[z] <- shar9600/shar9195
        }
for (z in 17:21){                                         #for 1996-2000 (this is the base period)
        ratio[z] <- 1
        }
for (z in 22:27){
        #2001-2006
        ratio[z] <- shar9600/shar0006
        }
for (z in 28:32){
        ratio[z] <- shar9600/shar0711
        }

for (g in 1:2) {            #this is a triangular distribution for the biomass of BSH and OCS in 2000
        rv[g]~dunif(0,1000)        #to run for all five species, change this loop to in 1:5; fix trimin, trimode, trimax
        x[g]<-rv[g]/1000

        gate[g]<-((trimode[g]-trimin[g]) / (trimax[g]-trimin[g]))
        A[g]<-min(x[g],gate[g])                  # find out whether x is higher or lower than criterion
        B[g]<-equals(x[g],A[g])        # if x IS lower then B will be 1, if x>calculation then B will be 0
        C[g]<-equals(B[g],0)# sets C to zero if B=1 or sets C to 1 if b=0; so B and C are binary and opposite

        draw[g]<-(B[g]*(trimin[g]+sqrt(x[g]*(trimode[g]-trimin[g])*(trimax[g]-trimin[g]))))
                +(C[g]*(trimax[g]-sqrt((1-x[g])*(trimax[g]-trimode[g])*(trimax[g]-trimin[g]))))

for (h in 1:32) {
                scaled[g,h] <- draw[g] * (HKimport[h]/HKimport[21]) #(imports in year X relative to 2000 i.e. Year 21)
                share[g,h] <- scaled[g,h] * ratio[h]        #scale by whether HK's share was more or less than in 2000
                areaprop[g,h] <- share[g,h] * GIS[g]        #area scalling
                tunaprop[g,h] <- share[g,h] * tunaIO[h]     #scale by total tuna catch (FISHSTAT)
                hookprop[g,h] <- share[g,h] * LLratio[h]    #scale by LL hook effort
                basinprop1[g,h] <- share[g,h] * basinratio1[h]          #country of origin scaling Method 1
                basinprop2[g,h] <- share[g,h] * basinratio2[h]          #country of origin Method 2
        }
    }
 }

#DATA
list(
#BIOMASS
trimin=c(204,9),            #species order is blue, oceanic whitetip
trimode=c(364,22),          # these are inputs for shark biomass from Ecology Letters (2006)
trimax=c( 619,47),          #all values in '000 t

#NUMBER OF SHARKS
#trimin=c(4.640,0.218),            #species order is blue, oceanic whitetip
#trimode=c(10.741,0.604),          # these are inputs for shark numbers
#trimax=c(15.762,1.209),                  #values in million sharks

HKimport=c(
2739,2741,2704,2512,2748,2613,2788,3317,3272,3003,3018,
3526,4265,3856, 4144,4706,
4513,4868,5196,5824,6788,
6435,6513,6960,6142,5887,5337,
5798,5536,5559,5759,6175),                   #HK adjusted imports of dried and salted unprocessed shark fins

GIS=c(0.216,0),                    #updated with Google Maps measure area function for BSH, area for OCS is N/A

tunaIO=c(0.114,0.121,0.138,0.135,0.157,0.185,0.184,0.195,0.204,0.194,0.176,
```

```
0.173,0.204,0.238,0.228,0.245,
0.251,0.246,0.223,0.237,0.240,
0.232,0.236,0.248,0.263,0.252,0.258,
0.224,0.224,0.217,0.221,0.224),           #FISHSTAT (not LL specific)

LLratio=c(0.200, 0.200,0.200,0.200,0.219,0.171,0.214,0.207,0.237,0.301,0.340,
0.343,0.325,0.410,0.414,0.401,
0.457,0.480,0.506,0.448,0.407,
0.349,0.347,0.325,0.356,0.414,0.411,
0.413,0.356,0.333,0.326,0.294), #ratio of LL hooks fished in IO versus the world, updated Aug 2015 (1980-1983 are dummies)

basinratio1=c(0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,
0,0,0.364,0.381,0.394,
0.342,0.355,0.336,0.344,0.347,0.362,
0.360,0.379,0.383,0.380,0.388),
#assumes 20% of DWFNs exports to Hong Kong (as recorded by HK) are from IO; no data before 1998

basinratio2=c(0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,
0,0,0.303,0.323,0.336,
0.280,0.288,0.263,0.277,0.286,0.292,
0.293,0.322,0.328,0.329,0.335))
#assumes none of DWFN exports to Hong Kong are from IO; 1998-2011 only
```

Annex 2. Blue shark results in numerical format (shown in Figures 4 and 6): in number (top) and in biomass (bottom).

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980	areaprop[1,1]	0.6473	0.1579	0.001525	0.3569	0.6406	0.9681
1981	areaprop[1,2]	0.6477	0.158	0.001526	0.3572	0.641	0.9688
1982	areaprop[1,3]	0.639	0.1559	0.001505	0.3523	0.6324	0.9557
1983	areaprop[1,4]	0.5936	0.1448	0.001398	0.3273	0.5875	0.8878
1984	areaprop[1,5]	0.6494	0.1584	0.00153	0.3581	0.6427	0.9713
1985	areaprop[1,6]	0.6175	0.1506	0.001455	0.3405	0.6111	0.9235
1986	areaprop[1,7]	0.6588	0.1607	0.001552	0.3633	0.652	0.9854
1987	areaprop[1,8]	0.7839	0.1912	0.001847	0.4322	0.7757	1.172
1988	areaprop[1,9]	0.7732	0.1886	0.001822	0.4264	0.7652	1.156
1989	areaprop[1,10]	0.7097	0.1731	0.001672	0.3913	0.7023	1.061
1990	areaprop[1,11]	0.7132	0.174	0.00168	0.3933	0.7058	1.067
1991	areaprop[1,12]	1.053	0.2597	0.002703	0.5768	1.042	1.585
1992	areaprop[1,13]	1.274	0.3142	0.00327	0.6976	1.261	1.917
1993	areaprop[1,14]	1.152	0.284	0.002956	0.6307	1.14	1.734
1994	areaprop[1,15]	1.238	0.3053	0.003177	0.6778	1.225	1.863
1995	areaprop[1,16]	1.405	0.3467	0.003608	0.7698	1.391	2.116
1996	areaprop[1,17]	1.496	0.3276	0.00322	0.8533	1.508	2.097
1997	areaprop[1,18]	1.614	0.3533	0.003473	0.9204	1.627	2.262
1998	areaprop[1,19]	1.723	0.3771	0.003707	0.9824	1.736	2.415
1999	areaprop[1,20]	1.931	0.4227	0.004155	1.101	1.946	2.706
2000	areaprop[1,21]	2.251	0.4927	0.004843	1.283	2.268	3.154
2001	areaprop[1,22]	2.809	0.786	0.008013	1.465	2.738	4.536
2002	areaprop[1,23]	2.843	0.7955	0.00811	1.483	2.771	4.591
2003	areaprop[1,24]	3.038	0.8501	0.008667	1.585	2.961	4.906
2004	areaprop[1,25]	2.681	0.7502	0.007648	1.399	2.613	4.329
2005	areaprop[1,26]	2.57	0.7191	0.00733	1.34	2.505	4.149
2006	areaprop[1,27]	2.33	0.6519	0.006646	1.215	2.271	3.762
2007	areaprop[1,28]	3.113	0.8516	0.008018	1.64	3.047	4.952
2008	areaprop[1,29]	2.972	0.8131	0.007655	1.566	2.909	4.729
2009	areaprop[1,30]	2.984	0.8165	0.007687	1.572	2.921	4.748
2010	areaprop[1,31]	3.092	0.8459	0.007964	1.629	3.026	4.919
2011	areaprop[1,32]	3.315	0.907	0.008539	1.747	3.245	5.274

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1998	basinprop1[1,19	2.894	0.6361	0.006761	1.652	2.918	4.074
1999	basinprop1[1,20	3.396	0.7463	0.007932	1.938	3.424	4.78
2000	basinprop1[1,21	4.093	0.8995	0.009561	2.335	4.127	5.761
2001	basinprop1[1,22	4.422	1.238	0.01241	2.295	4.332	7.096
2002	basinprop1[1,23	4.646	1.301	0.01304	2.411	4.551	7.455
2003	basinprop1[1,24	4.699	1.316	0.01319	2.438	4.603	7.54
2004	basinprop1[1,25	4.245	1.189	0.01192	2.203	4.159	6.812
2005	basinprop1[1,26	4.105	1.149	0.01152	2.13	4.021	6.586
2006	basinprop1[1,27	3.882	1.087	0.0109	2.014	3.803	6.229
2007	basinprop1[1,28	5.16	1.414	0.01607	2.723	5.069	8.109
2008	basinprop1[1,29	5.187	1.422	0.01616	2.737	5.096	8.151
2009	basinprop1[1,30	5.263	1.443	0.0164	2.778	5.171	8.272
2010	basinprop1[1,31	5.41	1.483	0.01685	2.855	5.315	8.502
2011	basinprop1[1,32	5.923	1.624	0.01845	3.126	5.819	9.308

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1998		2.409	0.5295	0.005628	1.375	2.429	3.391
1999	basinprop	2.879	0.6327	0.006725	1.643	2.903	4.052
2000	basinprop	3.49	0.7671	0.008153	1.992	3.519	4.913
2001	basinprop	3.62	1.014	0.01016	1.879	3.547	5.809
2002	basinprop	3.769	1.055	0.01058	1.956	3.692	6.048
2003	basinprop	3.678	1.03	0.01033	1.909	3.603	5.902
2004	basinprop	3.418	0.9573	0.009597	1.774	3.349	5.486
2005	basinprop	3.383	0.9473	0.009498	1.756	3.314	5.429
2006	basinprop	3.131	0.8768	0.008791	1.625	3.068	5.025
2007	basinprop	4.199	1.151	0.01308	2.216	4.126	6.6
2008	basinprop	4.407	1.208	0.01373	2.326	4.329	6.925
2009	basinprop	4.507	1.236	0.01404	2.379	4.428	7.084
2010	basinprop	4.684	1.284	0.01459	2.472	4.601	7.361
2011	basinprop	5.114	1.402	0.01593	2.699	5.024	8.037

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1984	hookprop[1,5]	0.6563	0.1597	0.000494	0.3621	0.6525	0.9783
1985	hookprop[1,6]	0.4873	0.1186	0.000367	0.2688	0.4845	0.7263
1986	hookprop[1,7]	0.6506	0.1583	0.00049	0.3589	0.6469	0.9698
1987	hookprop[1,8]	0.7488	0.1822	0.000564	0.4131	0.7445	1.116
1988	hookprop[1,9]	0.8456	0.2058	0.000637	0.4665	0.8408	1.261
1989	hookprop[1,10]	0.9857	0.2399	0.000743	0.5438	0.9801	1.469
1990	hookprop[1,11]	1.119	0.2723	0.000843	0.6173	1.113	1.668
1991	hookprop[1,12]	1.665	0.4124	0.0013	0.9156	1.652	2.507
1992	hookprop[1,13]	1.909	0.4727	0.00149	1.049	1.893	2.874
1993	hookprop[1,14]	2.177	0.5391	0.001699	1.197	2.159	3.278
1994	hookprop[1,15]	2.362	0.585	0.001844	1.299	2.343	3.557
1995	hookprop[1,16]	2.598	0.6435	0.002028	1.429	2.578	3.912
1996	hookprop[1,17]	3.153	0.691	0.002192	1.804	3.177	4.433
1997	hookprop[1,18]	3.572	0.7829	0.002484	2.044	3.6	5.022
1998	hookprop[1,19]	4.019	0.8809	0.002795	2.3	4.051	5.651
1999	hookprop[1,20]	3.988	0.8742	0.002774	2.282	4.02	5.608
2000	hookprop[1,21]	4.223	0.9256	0.002937	2.417	4.256	5.938
2001	hookprop[1,22]	4.519	1.264	0.004195	2.36	4.413	7.263
2002	hookprop[1,23]	4.548	1.272	0.004222	2.375	4.441	7.309
2003	hookprop[1,24]	4.552	1.273	0.004225	2.377	4.445	7.316
2004	hookprop[1,25]	4.4	1.231	0.004085	2.298	4.297	7.072
2005	hookprop[1,26]	4.904	1.372	0.004553	2.561	4.789	7.883
2006	hookprop[1,27]	4.414	1.235	0.004098	2.305	4.31	7.094
2007	hookprop[1,28]	5.907	1.621	0.005185	3.112	5.786	9.422
2008	hookprop[1,29]	4.861	1.334	0.004268	2.561	4.762	7.754
2009	hookprop[1,30]	4.566	1.253	0.004008	2.406	4.473	7.283
2010	hookprop[1,31]	4.631	1.271	0.004065	2.44	4.537	7.387
2011	hookprop[1,32]	4.478	1.229	0.003931	2.36	4.387	7.143

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980	aprop[1,1]	0.3406	0.08305	0.000937	0.1849	0.3395	0.5078
1981	tunaprop[1,2]	0.3617	0.08821	0.000996	0.1964	0.3606	0.5394
1982	tunaprop[1,3]	0.407	0.09924	0.00112	0.2209	0.4057	0.6069
1983	tunaprop[1,4]	0.3699	0.09019	0.001018	0.2008	0.3687	0.5515
1984	tunaprop[1,5]	0.4706	0.1147	0.001295	0.2555	0.4691	0.7017
1985	tunaprop[1,6]	0.5272	0.1286	0.001451	0.2862	0.5256	0.7862
1986	tunaprop[1,7]	0.5595	0.1364	0.00154	0.3038	0.5578	0.8343
1987	tunaprop[1,8]	0.7055	0.172	0.001942	0.383	0.7033	1.052
1988	tunaprop[1,9]	0.728	0.1775	0.002004	0.3952	0.7258	1.086
1989	tunaprop[1,10]	0.6354	0.1549	0.001749	0.345	0.6335	0.9475
1990	tunaprop[1,11]	0.5793	0.1413	0.001595	0.3145	0.5775	0.8639
1991	tunaprop[1,12]	0.8407	0.2073	0.002134	0.4617	0.8348	1.255
1992	tunaprop[1,13]	1.199	0.2957	0.003044	0.6585	1.191	1.79
1993	tunaprop[1,14]	1.265	0.3119	0.003211	0.6946	1.256	1.888
1994	tunaprop[1,15]	1.302	0.3211	0.003306	0.7151	1.293	1.944
1995	tunaprop[1,16]	1.589	0.3919	0.004034	0.8726	1.578	2.372
1996	tunaprop[1,17]	1.734	0.381	0.004049	0.9891	1.748	2.44
1997	tunaprop[1,18]	1.833	0.4028	0.004281	1.046	1.848	2.58
1998	tunaprop[1,19]	1.773	0.3897	0.004142	1.012	1.788	2.496
1999	tunaprop[1,20]	2.112	0.4642	0.004934	1.205	2.13	2.973
2000	tunaprop[1,21]	2.493	0.5479	0.005824	1.423	2.514	3.509
2001	tunaprop[1,22]	3	0.84	0.008422	1.557	2.939	4.814
2002	tunaprop[1,23]	3.088	0.8648	0.008671	1.603	3.026	4.956
2003	tunaprop[1,24]	3.468	0.9712	0.009737	1.8	3.398	5.565
2004	tunaprop[1,25]	3.246	0.9089	0.009112	1.684	3.18	5.208
2005	tunaprop[1,26]	2.981	0.8347	0.008369	1.547	2.92	4.783
2006	tunaprop[1,27]	2.767	0.7747	0.007767	1.436	2.711	4.44
2007	tunaprop[1,28]	3.211	0.8801	0.01	1.695	3.154	5.046
2008	tunaprop[1,29]	3.065	0.8403	0.00955	1.618	3.012	4.818
2009	tunaprop[1,30]	2.982	0.8174	0.00929	1.574	2.93	4.687
2010	tunaprop[1,31]	3.146	0.8625	0.009801	1.661	3.091	4.945
2011	tunaprop[1,32]	3.419	0.9373	0.01065	1.805	3.359	5.374

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980	areaprop[1,1]	24.67	5.963	0.05703	14.54	24.04	37.52
1981	areaprop[1,2]	24.69	5.968	0.05707	14.55	24.06	37.55
1982	areaprop[1,3]	24.36	5.887	0.0563	14.35	23.73	37.04
1983	areaprop[1,4]	22.63	5.469	0.05231	13.33	22.05	34.41
1984	areaprop[1,5]	24.75	5.983	0.05722	14.59	24.12	37.65
1985	areaprop[1,6]	23.54	5.689	0.05441	13.87	22.93	35.8
1986	areaprop[1,7]	25.11	6.07	0.05805	14.8	24.47	38.19
1987	areaprop[1,8]	29.88	7.222	0.06907	17.61	29.11	45.44
1988	areaprop[1,9]	29.47	7.124	0.06813	17.37	28.72	44.83
1989	areaprop[1,10]	27.05	6.538	0.06253	15.94	26.36	41.14
1990	areaprop[1,11]	27.19	6.571	0.06284	16.02	26.49	41.35
1991	areaprop[1,12]	40.14	9.808	0.101	23.49	39.1	61.24
1992	areaprop[1,13]	48.55	11.86	0.1221	28.42	47.29	74.08
1993	areaprop[1,14]	43.9	10.73	0.1104	25.69	42.75	66.97
1994	areaprop[1,15]	47.17	11.53	0.1187	27.61	45.95	71.98
1995	areaprop[1,16]	53.57	13.09	0.1348	31.36	52.18	81.74
1996	areaprop[1,17]	57.03	12.33	0.1214	35.14	56.07	81.6
1997	areaprop[1,18]	61.52	13.3	0.131	37.91	60.48	88.02
1998	areaprop[1,19]	65.66	14.2	0.1398	40.46	64.55	93.95
1999	areaprop[1,20]	73.6	15.92	0.1567	45.35	72.35	105.3
2000	areaprop[1,21]	85.78	18.55	0.1826	52.86	84.33	122.7
2001	areaprop[1,22]	107.1	29.75	0.3049	59.32	103.4	174.9
2002	areaprop[1,23]	108.4	30.11	0.3086	60.04	104.6	177
2003	areaprop[1,24]	115.8	32.17	0.3298	64.16	111.8	189.2
2004	areaprop[1,25]	102.2	28.39	0.291	56.62	98.68	166.9
2005	areaprop[1,26]	97.95	27.21	0.2789	54.27	94.58	160
2006	areaprop[1,27]	88.8	24.67	0.2529	49.2	85.75	145.1
2007	areaprop[1,28]	118.7	32.23	0.3044	66.21	114.9	191.7
2008	areaprop[1,29]	113.3	30.77	0.2906	63.22	109.7	183
2009	areaprop[1,30]	113.8	30.9	0.2918	63.48	110.2	183.8
2010	areaprop[1,31]	117.9	32.01	0.3023	65.77	114.2	190.4
2011	areaprop[1,32]	126.4	34.33	0.3241	70.52	122.4	204.2

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1998	basinprop1[1,19]	110.3	23.9	0.255	68.06	108.5	158.6
1999	basinprop1[1,20]	129.4	28.04	0.2992	79.85	127.3	186.1
2000	basinprop1[1,21]	156	33.79	0.3606	96.24	153.4	224.3
2001	basinprop1[1,22]	168.5	46.77	0.4678	92.46	163.3	272.7
2002	basinprop1[1,23]	177.1	49.13	0.4915	97.14	171.6	286.5
2003	basinprop1[1,24]	179.1	49.69	0.4971	98.25	173.6	289.8
2004	basinprop1[1,25]	161.8	44.9	0.4491	88.77	156.8	261.8
2005	basinprop1[1,26]	156.5	43.41	0.4342	85.82	151.6	253.1
2006	basinprop1[1,27]	148	41.05	0.4107	81.17	143.4	239.4
2007	basinprop1[1,28]	196.7	53.39	0.6098	109.9	191	312.1
2008	basinprop1[1,29]	197.7	53.66	0.613	110.5	192	313.7
2009	basinprop1[1,30]	200.6	54.46	0.622	112.1	194.8	318.3
2010	basinprop1[1,31]	206.2	55.97	0.6394	115.3	200.2	327.2
2011	basinprop1[1,32]	225.8	61.28	0.7	126.2	219.2	358.2

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1998	basinprop2[1,19]	91.84	1.99E+01	2.12E-01	5.67E+01	9.03E+01	1.32E+02
1999	basinprop2[1,20]	1.10E+02	2.38E+01	2.54E-01	6.77E+01	1.08E+02	1.58E+02
2000	basinprop2[1,21]	1.33E+02	2.88E+01	3.08E-01	8.21E+01	1.31E+02	1.91E+02
2001	basinprop2[1,22]	1.38E+02	3.83E+01	3.83E-01	7.57E+01	1.34E+02	2.23E+02
2002	basinprop2[1,23]	1.44E+02	3.99E+01	3.99E-01	7.88E+01	1.39E+02	2.32E+02
2003	basinprop2[1,24]	1.40E+02	3.89E+01	3.89E-01	7.69E+01	1.36E+02	2.27E+02
2004	basinprop2[1,25]	1.30E+02	3.62E+01	3.62E-01	7.15E+01	1.26E+02	2.11E+02
2005	basinprop2[1,26]	1.29E+02	3.58E+01	3.58E-01	7.07E+01	1.25E+02	2.09E+02
2006	basinprop2[1,27]	1.19E+02	3.31E+01	3.31E-01	6.55E+01	1.16E+02	1.93E+02
2007	basinprop2[1,28]	1.60E+02	4.35E+01	4.96E-01	8.95E+01	1.55E+02	2.54E+02
2008	basinprop2[1,29]	1.68E+02	4.56E+01	5.21E-01	9.39E+01	1.63E+02	2.67E+02
2009	basinprop2[1,30]	1.72E+02	4.66E+01	5.33E-01	9.60E+01	1.67E+02	2.73E+02
2010	basinprop2[1,31]	1.79E+02	4.85E+01	5.54E-01	9.98E+01	1.73E+02	2.83E+02
2011	basinprop2[1,32]	1.95E+02	5.29E+01	6.04E-01	1.09E+02	1.89E+02	3.09E+02

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1984	hookprop[1,5]	25.1	6.066	0.05801	14.79	24.45	38.17
1985	hookprop[1,6]	18.63	4.504	0.04307	10.98	18.16	28.34
1986	hookprop[1,7]	24.88	6.014	0.05752	14.66	24.24	37.84
1987	hookprop[1,8]	28.63	6.921	0.06619	16.87	27.9	43.55
1988	hookprop[1,9]	32.34	7.816	0.07475	19.06	31.51	49.18
1989	hookprop[1,10]	37.7	9.111	0.08714	22.21	36.73	57.33
1990	hookprop[1,11]	42.79	10.34	0.09892	25.22	41.7	65.08
1991	hookprop[1,12]	63.74	15.58	0.1603	37.31	62.08	97.25
1992	hookprop[1,13]	73.05	17.85	0.1838	42.76	71.15	111.5
1993	hookprop[1,14]	83.32	20.36	0.2096	48.77	81.15	127.1
1994	hookprop[1,15]	90.42	22.09	0.2275	52.92	88.07	138
1995	hookprop[1,16]	99.46	24.3	0.2502	58.21	96.87	151.7
1996	hookprop[1,17]	120.7	26.1	0.2569	74.36	118.6	172.7
1997	hookprop[1,18]	136.7	29.57	0.291	84.24	134.4	195.6
1998	hookprop[1,19]	153.8	33.27	0.3275	94.79	151.2	220.1
1999	hookprop[1,20]	152.7	33.01	0.325	94.07	150.1	218.4
2000	hookprop[1,21]	161.6	34.96	0.3441	99.6	158.9	231.3
2001	hookprop[1,22]	173	48.06	0.4926	95.84	167	282.6
2002	hookprop[1,23]	174.1	48.37	0.4957	96.45	168.1	284.4
2003	hookprop[1,24]	174.2	48.41	0.4962	96.53	168.3	284.6
2004	hookprop[1,25]	168.4	46.8	0.4796	93.31	162.6	275.1
2005	hookprop[1,26]	187.7	52.16	0.5346	104	181.3	306.7
2006	hookprop[1,27]	169	46.94	0.4812	93.61	163.2	276
2007	hookprop[1,28]	226.9	61.62	0.5819	126.6	219.7	366.6
2008	hookprop[1,29]	186.7	50.72	0.4789	104.2	180.9	301.7
2009	hookprop[1,30]	175.4	47.64	0.4499	97.87	169.9	283.4
2010	hookprop[1,31]	177.9	48.32	0.4563	99.26	172.3	287.4
2011	hookprop[1,32]	172	46.72	0.4412	95.98	166.6	277.9

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980	tunaprop[1,1]	12.98	3.128	3.54E-02	7.602	12.73	19.65
1981	tunaprop[1,2]	13.79	3.323	3.76E-02	8.075	13.52	20.88
1982	tunaprop[1,3]	15.51	3.739	0.04231	9.085	15.21	23.49
1983	tunaprop[1,4]	14.1	3.398	0.03845	8.256	13.83	21.35
1984	tunaprop[1,5]	17.94	4.323	0.04892	10.5	17.59	27.16
1985	tunaprop[1,6]	20.1	4.843	0.05481	11.77	19.71	30.43
1986	tunaprop[1,7]	21.33	5.14	0.05816	12.49	20.92	32.29
1987	tunaprop[1,8]	26.89	6.48	0.07333	15.75	26.37	40.71
1988	tunaprop[1,9]	27.75	6.688	0.07568	16.25	27.22	42.02
1989	tunaprop[1,10	24.22	5.837	0.06605	14.18	23.75	36.67
1990	tunaprop[1,11	22.08	5.322	0.06022	12.93	21.66	33.44
1991	tunaprop[1,12	32.04	7.809	0.0805	18.79	31.37	48.66
1992	tunaprop[1,13	45.71	11.14	0.1148	26.8	44.74	69.4
1993	tunaprop[1,14	48.21	11.75	0.1211	28.27	47.19	73.21
1994	tunaprop[1,15	49.63	12.1	0.1247	29.11	48.58	75.37
1995	tunaprop[1,16	60.57	14.76	0.1522	35.52	59.29	91.97
1996	tunaprop[1,17	66.08	14.31	0.1527	40.76	64.97	95.01
1997	tunaprop[1,18	69.86	15.13	0.1615	43.09	68.69	100.4
1998	tunaprop[1,19	67.59	14.64	0.1562	41.7	66.46	97.19
1999	tunaprop[1,20	80.52	17.44	0.1861	49.67	79.17	115.8
2000	tunaprop[1,21	95.03	20.59	0.2197	58.62	93.44	136.6
2001	tunaprop[1,22	114.3	31.72	0.3174	62.72	110.8	185
2002	tunaprop[1,23	117.7	32.66	0.3267	64.58	114.1	190.5
2003	tunaprop[1,24	132.2	36.68	0.3669	72.52	128.1	213.9
2004	tunaprop[1,25	123.7	34.33	0.3434	67.86	119.9	200.2
2005	tunaprop[1,26	113.6	31.52	0.3154	62.33	110.1	183.8
2006	tunaprop[1,27	105.5	29.26	0.2927	57.85	102.2	170.6
2007	tunaprop[1,28	122.4	33.22	0.3794	68.41	118.8	194.2
2008	tunaprop[1,29	116.8	31.72	0.3623	65.32	113.5	185.4
2009	tunaprop[1,30	113.7	30.85	0.3524	63.54	110.4	180.4
2010	tunaprop[1,31	119.9	32.55	0.3718	67.04	116.4	190.3
2011	tunaprop[1,32	130.3	35.38	0.4041	72.86	126.6	206.8

Annex 3. Oceanic whitetip shark results in numerical format (shown in Figures 5 and 7): in number (top) and in biomass (bottom).

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980							
1981							
1982							
1983							
1984							
1985							
1986							
1987							
1988							
1989							
1990							
1991							
1992							
1993							
1994							
1995							
1996							
1997							
1998	basinprop1[2,19]	0.1887	0.05633	5.21E-04	0.08853	0.1851	0.3013
1999	basinprop1[2,20]	0.2214	0.06609	6.11E-04	0.1039	0.2171	0.3535
2000	basinprop1[2,21]	0.2668	0.07966	7.36E-04	0.1252	0.2617	0.4261
2001	basinprop1[2,22]	0.2883	0.1004	9.47E-04	0.1268	0.2765	0.5096
2002	basinprop1[2,23]	0.3029	0.1055	9.95E-04	0.1332	0.2905	0.5354
2003	basinprop1[2,24]	0.3063	0.1067	0.001006	0.1347	0.2939	0.5415
2004	basinprop1[2,25]	0.2768	0.09638	9.09E-04	0.1217	0.2655	0.4892
2005	basinprop1[2,26]	0.2676	0.09319	8.79E-04	0.1177	0.2567	0.473
2006	basinprop1[2,27]	0.2531	0.08813	8.32E-04	0.1113	0.2428	0.4473
2007	basinprop1[2,28]	0.3364	0.1155	0.001145	0.1462	0.325	0.5974
2008	basinprop1[2,29]	0.3382	0.1161	0.001151	0.147	0.3266	0.6005
2009	basinprop1[2,30]	0.3432	0.1178	0.001168	0.1491	0.3315	0.6094
2010	basinprop1[2,31]	0.3527	0.1211	0.001201	0.1533	0.3407	0.6263
2011	basinprop1[2,32]	0.3862	0.1326	0.001315	0.1678	0.373	0.6857

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980							
1981							
1982							
1983							
1984							
1985							
1986							
1987							
1988							
1989							
1990							
1991							
1992							
1993							
1994							
1995							
1996							
1997							
1998	basinprop2[2,19]	0.1571	4.69E-02	4.33E-04	7.37E-02	1.54E-01	2.51E-01
1999	basinprop2[2,20]	1.88E-01	5.60E-02	5.18E-04	8.81E-02	1.84E-01	3.00E-01
2000	basinprop2[2,21]	2.28E-01	6.79E-02	6.28E-04	1.07E-01	2.23E-01	3.63E-01
2001	basinprop2[2,22]	2.36E-01	8.22E-02	7.75E-04	1.04E-01	2.26E-01	4.17E-01
2002	basinprop2[2,23]	2.46E-01	8.56E-02	8.07E-04	1.08E-01	2.36E-01	4.34E-01
2003	basinprop2[2,24]	2.40E-01	8.35E-02	7.88E-04	1.06E-01	2.30E-01	4.24E-01
2004	basinprop2[2,25]	2.23E-01	7.76E-02	7.32E-04	9.80E-02	2.14E-01	3.94E-01
2005	basinprop2[2,26]	2.21E-01	7.68E-02	7.25E-04	9.70E-02	2.12E-01	3.90E-01
2006	basinprop2[2,27]	2.04E-01	7.11E-02	6.71E-04	8.98E-02	1.96E-01	3.61E-01
2007	basinprop2[2,28]	2.74E-01	9.40E-02	9.32E-04	1.19E-01	2.65E-01	4.86E-01
2008	basinprop2[2,29]	2.87E-01	9.87E-02	9.78E-04	1.25E-01	2.78E-01	5.10E-01
2009	basinprop2[2,30]	2.94E-01	1.01E-01	1.00E-03	1.28E-01	2.84E-01	5.22E-01
2010	basinprop2[2,31]	3.05E-01	1.05E-01	1.04E-03	1.33E-01	2.95E-01	5.42E-01
2011	basinprop2[2,32]	3.33E-01	1.15E-01	1.14E-03	1.45E-01	3.22E-01	5.92E-01

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980							
1981							
1982							
1983							
1984	hookprop[2,5]	0.04287	0.01375	4.44E-05	0.0194	0.04169	0.0719
1985	hookprop[2,6]	0.03183	0.01021	3.29E-05	0.0144	0.03095	0.05338
1986	hookprop[2,7]	0.0425	0.01363	4.40E-05	0.01923	0.04133	0.07128
1987	hookprop[2,8]	0.04891	0.01568	5.06E-05	0.02213	0.04756	0.08203
1988	hookprop[2,9]	0.05524	0.01771	5.72E-05	0.02499	0.05371	0.09264
1989	hookprop[2,10]	0.06439	0.02065	6.66E-05	0.02913	0.06261	0.108
1990	hookprop[2,11]	0.0731	0.02344	7.56E-05	0.03307	0.07108	0.1226
1991	hookprop[2,12]	0.1088	0.03523	1.13E-04	0.04897	0.1056	0.1834
1992	hookprop[2,13]	0.1247	0.04038	1.30E-04	0.05613	0.1211	0.2102
1993	hookprop[2,14]	0.1422	0.04606	1.48E-04	0.06402	0.1381	0.2398
1994	hookprop[2,15]	0.1543	0.04998	1.60E-04	0.06947	0.1498	0.2602
1995	hookprop[2,16]	0.1697	0.05497	1.76E-04	0.07641	0.1648	0.2862
1996	hookprop[2,17]	0.2059	0.06207	2.05E-04	0.09581	0.2013	0.3296
1997	hookprop[2,18]	0.2333	0.07032	2.32E-04	0.1085	0.2281	0.3734
1998	hookprop[2,19]	0.2625	0.07912	2.61E-04	0.1221	0.2566	0.4202
1999	hookprop[2,20]	0.2605	0.07852	2.59E-04	0.1212	0.2547	0.417
2000	hookprop[2,21]	0.2758	0.08314	2.74E-04	0.1283	0.2696	0.4415
2001	hookprop[2,22]	0.2953	0.1037	3.40E-04	0.127	0.284	0.5278
2002	hookprop[2,23]	0.2972	0.1044	3.42E-04	0.1278	0.2858	0.5312
2003	hookprop[2,24]	0.2974	0.1045	3.42E-04	0.128	0.286	0.5316
2004	hookprop[2,25]	0.2875	0.101	3.31E-04	0.1237	0.2765	0.5139
2005	hookprop[2,26]	0.3205	0.1126	0.000369	0.1379	0.3082	0.5728
2006	hookprop[2,27]	0.2884	0.1013	3.32E-04	0.1241	0.2773	0.5155
2007	hookprop[2,28]	0.3858	0.1333	0.00042	0.1682	0.3714	0.6805
2008	hookprop[2,29]	0.3175	0.1097	0.000346	0.1384	0.3057	0.56
2009	hookprop[2,30]	0.2983	0.103	3.25E-04	0.13	0.2871	0.526
2010	hookprop[2,31]	0.3025	0.1045	3.30E-04	0.1318	0.2912	0.5335
2011	hookprop[2,32]	0.2925	0.101	3.19E-04	0.1275	0.2816	0.5159

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980	tunaprop[2,1]	0.02219	0.007029	6.59E-05	1.02E-02	0.0217	0.037
1981	tunaprop[2,2]	0.02357	0.007466	7.00E-05	0.01081	0.02305	0.0393
1982	tunaprop[2,3]	0.02652	0.0084	7.87E-05	0.01216	0.02593	0.04422
1983	tunaprop[2,4]	0.0241	0.007634	7.15E-05	0.01105	0.02357	0.04019
1984	tunaprop[2,5]	0.03066	0.009712	9.10E-05	0.01406	0.02998	0.05113
1985	tunaprop[2,6]	0.03435	0.01088	1.02E-04	0.01576	0.03359	0.05729
1986	tunaprop[2,7]	0.03646	0.01155	1.08E-04	0.01672	0.03565	0.06079
1987	tunaprop[2,8]	0.04597	0.01456	1.37E-04	0.02108	0.04495	0.07665
1988	tunaprop[2,9]	0.04744	0.01503	1.41E-04	0.02176	0.04638	0.0791
1989	tunaprop[2,10]	0.0414	0.01311	1.23E-04	0.01899	0.04048	0.06904
1990	tunaprop[2,11]	0.03775	0.01196	1.12E-04	0.01731	0.03691	0.06295
1991	tunaprop[2,12]	0.05482	0.01764	1.63E-04	0.02508	0.05326	0.09201
1992	tunaprop[2,13]	0.0782	0.02516	2.32E-04	0.03577	0.07597	0.1312
1993	tunaprop[2,14]	0.08248	0.02654	2.45E-04	0.03773	0.08013	0.1384
1994	tunaprop[2,15]	0.08492	0.02732	2.52E-04	0.03884	0.0825	0.1425
1995	tunaprop[2,16]	0.1036	0.03334	3.07E-04	0.0474	0.1007	0.1739
1996	tunaprop[2,17]	0.113	0.03374	3.12E-04	0.05302	0.1108	0.1805
1997	tunaprop[2,18]	0.1195	0.03567	3.30E-04	0.05605	0.1172	0.1908
1998	tunaprop[2,19]	0.1156	0.03451	3.19E-04	0.05424	0.1134	0.1846
1999	tunaprop[2,20]	0.1377	0.04111	3.80E-04	0.06461	0.1351	0.2199
2000	tunaprop[2,21]	0.1625	0.04852	4.48E-04	0.07626	0.1594	0.2596
2001	tunaprop[2,22]	0.1956	0.0681	6.43E-04	0.08602	0.1876	0.3457
2002	tunaprop[2,23]	0.2014	0.07012	6.62E-04	0.08856	0.1931	0.3559
2003	tunaprop[2,24]	0.2261	0.07874	7.43E-04	0.09945	0.2169	0.3997
2004	tunaprop[2,25]	0.2116	0.07369	6.95E-04	0.09307	0.203	0.374
2005	tunaprop[2,26]	0.1943	0.06767	6.39E-04	0.08548	0.1864	0.3435
2006	tunaprop[2,27]	0.1804	0.06281	5.93E-04	0.07934	0.173	0.3188
2007	tunaprop[2,28]	0.2093	0.07189	7.13E-04	0.09098	0.2022	0.3717
2008	tunaprop[2,29]	0.1999	0.06864	6.81E-04	0.08687	0.1931	0.3549
2009	tunaprop[2,30]	0.1944	0.06677	6.62E-04	0.0845	0.1878	0.3453
2010	tunaprop[2,31]	0.2051	0.07045	6.98E-04	0.08916	0.1981	0.3643
2011	tunaprop[2,32]	0.2229	0.07656	7.59E-04	0.0969	0.2153	0.3959

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980							
1981							
1982							
1983							
1984							
1985							
1986							
1987							
1988							
1989							
1990							
1991							
1992							
1993							
1994							
1995							
1996							
1997							
1998	basinprop1[2,19]	7.246	2.177	0.02015	3.506	7.053	11.68
1999	basinprop1[2,20]	8.501	2.554	0.02364	4.114	8.275	13.71
2000	basinprop1[2,21]	10.25	3.079	0.02849	4.958	9.974	16.52
2001	basinprop1[2,22]	11.07	3.875	0.03655	4.991	10.57	19.69
2002	basinprop1[2,23]	11.63	4.071	0.0384	5.244	11.1	20.68
2003	basinprop1[2,24]	11.77	4.117	0.03884	5.304	11.23	20.92
2004	basinprop1[2,25]	10.63	3.72	0.03509	4.792	10.14	18.9
2005	basinprop1[2,26]	10.28	3.596	0.03392	4.633	9.808	18.27
2006	basinprop1[2,27]	9.72	3.401	0.03208	4.382	9.276	17.28
2007	basinprop1[2,28]	12.92	4.46	0.04417	5.795	12.41	23.12
2008	basinprop1[2,29]	12.99	4.483	0.0444	5.825	12.47	23.24
2009	basinprop1[2,30]	13.18	4.549	0.04505	5.911	12.65	23.58
2010	basinprop1[2,31]	13.55	4.676	0.04631	6.075	13.01	24.24
2011	basinprop1[2,32]	14.83	5.119	0.0507	6.651	14.24	26.54

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980							
1981							
1982							
1983							
1984							
1985							
1986							
1987							
1988							
1989							
1990							
1991							
1992							
1993							
1994							
1995							
1996							
1997							
1998	basinprop2[2,19]	6.032	1.812	0.01677	2.919	5.871	9.724
1999	basinprop2[2,20]	7.207	2.166	0.02004	3.487	7.015	11.62
2000	basinprop2[2,21]	8.738	2.626	0.02429	4.228	8.506	14.09
2001	basinprop2[2,22]	9.065	3.172	0.02992	4.086	8.651	16.12
2002	basinprop2[2,23]	9.437	3.302	0.03115	4.254	9.006	16.78
2003	basinprop2[2,24]	9.209	3.223	0.0304	4.151	8.788	16.37
2004	basinprop2[2,25]	8.559	2.995	0.02825	3.859	8.168	15.22
2005	basinprop2[2,26]	8.47	2.964	0.02796	3.819	8.084	15.06
2006	basinprop2[2,27]	7.84	2.744	0.02588	3.534	7.482	13.94
2007	basinprop2[2,28]	10.52	3.63	0.03595	4.716	10.1	18.82
2008	basinprop2[2,29]	11.03	3.809	0.03772	4.949	10.59	19.75
2009	basinprop2[2,30]	11.29	3.896	0.03858	5.062	10.84	20.2
2010	basinprop2[2,31]	11.73	4.048	0.04009	5.26	11.26	20.99
2011	basinprop2[2,32]	12.81	4.42	0.04377	5.743	12.29	22.91

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980							
1981							
1982							
1983							
1984	hookprop[2,5]	1.64	0.528	0.004788	0.7749	1.58	2.773
1985	hookprop[2,6]	1.218	0.392	0.003555	0.5753	1.173	2.059
1986	hookprop[2,7]	1.626	0.5235	0.004747	0.7682	1.567	2.749
1987	hookprop[2,8]	1.872	0.6024	0.005463	0.8841	1.803	3.163
1988	hookprop[2,9]	2.114	0.6804	0.00617	0.9985	2.036	3.573
1989	hookprop[2,10]	2.464	0.7931	0.007192	1.164	2.374	4.165
1990	hookprop[2,11]	2.797	0.9003	0.008164	1.321	2.695	4.728
1991	hookprop[2,12]	4.166	1.351	0.01213	1.959	4.025	7.076
1992	hookprop[2,13]	4.775	1.549	0.01391	2.245	4.613	8.109
1993	hookprop[2,14]	5.446	1.767	0.01586	2.56	5.262	9.249
1994	hookprop[2,15]	5.91	1.917	0.01721	2.778	5.71	10.04
1995	hookprop[2,16]	6.5	2.109	0.01893	3.056	6.281	11.04
1996	hookprop[2,17]	7.887	2.39	0.02217	3.803	7.64	12.77
1997	hookprop[2,18]	8.936	2.708	0.02512	4.309	8.656	14.47
1998	hookprop[2,19]	10.05	3.047	0.02826	4.849	9.74	16.28
1999	hookprop[2,20]	9.978	3.024	0.02805	4.812	9.665	16.16
2000	hookprop[2,21]	10.57	3.202	0.0297	5.095	10.23	17.11
2001	hookprop[2,22]	11.31	3.985	0.03509	5.084	10.78	20.36
2002	hookprop[2,23]	11.38	4.01	0.03531	5.116	10.85	20.48
2003	hookprop[2,24]	11.39	4.013	0.03534	5.121	10.86	20.5
2004	hookprop[2,25]	11.01	3.879	0.03416	4.95	10.5	19.82
2005	hookprop[2,26]	12.27	4.324	0.03808	5.517	11.7	22.09
2006	hookprop[2,27]	11.05	3.892	0.03427	4.965	10.53	19.88
2007	hookprop[2,28]	14.84	5.181	0.04737	6.695	14.15	26.36
2008	hookprop[2,29]	12.22	4.264	0.03899	5.51	11.65	21.7
2009	hookprop[2,30]	11.47	4.005	0.03662	5.176	10.94	20.38
2010	hookprop[2,31]	11.64	4.062	0.03714	5.249	11.1	20.67
2011	hookprop[2,32]	11.25	3.928	0.03592	5.076	10.73	19.99

	node	mean	sd	MC_error	val2.5pc	median	val97.5pc
1980	tunaprop[2,1]	0.8522	0.2715	0.002543	0.4034	0.8271	1.434
1981	tunaprop[2,2]	0.9052	0.2884	0.002702	0.4285	0.8785	1.523
1982	tunaprop[2,3]	1.018	0.3244	0.00304	0.4821	0.9884	1.713
1983	tunaprop[2,4]	0.9256	0.2949	0.002762	0.4381	0.8983	1.557
1984	tunaprop[2,5]	1.178	0.3751	0.003514	0.5574	1.143	1.981
1985	tunaprop[2,6]	1.319	0.4203	0.003938	0.6245	1.28	2.22
1986	tunaprop[2,7]	1.4	0.446	0.004179	0.6628	1.359	2.356
1987	tunaprop[2,8]	1.765	0.5624	0.005269	0.8357	1.713	2.97
1988	tunaprop[2,9]	1.822	0.5804	0.005437	0.8624	1.768	3.065
1989	tunaprop[2,10]	1.59	0.5065	0.004745	0.7527	1.543	2.675
1990	tunaprop[2,11]	1.45	0.4618	0.004327	0.6862	1.407	2.439
1991	tunaprop[2,12]	2.105	0.6813	0.006271	0.9891	2.031	3.562
1992	tunaprop[2,13]	3.003	0.9718	0.008944	1.411	2.897	5.08
1993	tunaprop[2,14]	3.168	1.025	0.009434	1.488	3.055	5.359
1994	tunaprop[2,15]	3.261	1.055	0.009712	1.532	3.145	5.517
1995	tunaprop[2,16]	3.98	1.288	0.01185	1.869	3.838	6.732
1996	tunaprop[2,17]	4.34	1.304	0.01207	2.1	4.224	6.996
1997	tunaprop[2,18]	4.588	1.379	0.01276	2.22	4.466	7.397
1998	tunaprop[2,19]	4.439	1.334	0.01234	2.148	4.321	7.157
1999	tunaprop[2,20]	5.288	1.589	0.0147	2.559	5.147	8.525
2000	tunaprop[2,21]	6.241	1.875	0.01735	3.02	6.075	10.06
2001	tunaprop[2,22]	7.511	2.628	0.02479	3.386	7.168	13.35
2002	tunaprop[2,23]	7.733	2.706	0.02553	3.486	7.38	13.75
2003	tunaprop[2,24]	8.684	3.039	0.02866	3.915	8.287	15.44
2004	tunaprop[2,25]	8.127	2.844	0.02683	3.664	7.756	14.45
2005	tunaprop[2,26]	7.464	2.612	0.02464	3.365	7.123	13.27
2006	tunaprop[2,27]	6.927	2.424	0.02287	3.123	6.611	12.32
2007	tunaprop[2,28]	8.039	2.775	0.02748	3.606	7.719	14.39
2008	tunaprop[2,29]	7.676	2.65	0.02624	3.443	7.37	13.74
2009	tunaprop[2,30]	7.467	2.577	0.02553	3.349	7.17	13.36
2010	tunaprop[2,31]	7.878	2.719	0.02693	3.533	7.565	14.1
2011	tunaprop[2,32]	8.562	2.955	0.02927	3.84	8.221	15.32