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Preliminary Analysis and Data Development for Blue Shark (*Prionace glauca*) Catch Reconstruction.

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Executive Summary

This paper outlines the preliminary analysis and data developments for blue shark (*Prionace glauca)* catch reconstruction in the Indian Ocean. This project is oriented at developing new data sources and reconstructing the historical catch of blue shark in the Indian Ocean, it is currently underway with expected completion in late 2016.

1 Introduction

Blue shark (*Prionace glauca*) are a large pelagic species, broadly distributed throughout the Indian Ocean to a southern limit of ~50° S (Figure 1). Indian Ocean blue shark have been incidentally caught by many fisheries in the Indian ocean with records going back to the Japanese longline fleet in the early 1950s. The population was not heavily exploited before targeted fisheries (and/or bycatch rates increased) in the early 1990s. At this time the Taiwanese long line vessels began taking large numbers, initially in the SW region, followed by the other areas (Figure 1). The European longline fleet (predominantly Spain) started a targeted fishery in the 1990s, while only small numbers are reported in the driftnet fisheries, and purse seine catches are very rare. This project is oriented at developing new data sources and reconstructing the historical catch of blue shark in the Indian Ocean, it is currently underway with expected completion in late 2016.

2 Description of Data Sources

Caveats with respect to the data

The IOTC Secretariat (2015) discuss the many fleets catching blue shark in the Indian Ocean, note that the catchability, gear types, reporting and data quality vary greatly. The 2015 preliminary assessment used two catch series based on nominal catch and effort and the trade based estimates. There is enough uncertainty about the historical catch and reporting that the data is being reviewed for completeness and. Examples of the potential concerns identified with respect to the catch time series are

- Nominal catch estimates for some CPCs have been estimated using a simple species ratio (in the absence of better information, or more sophisticated approaches such as GLM).
- Catch-and-effort for BSH are highly incomplete: available for a (a.) limited number of years (i.e., from the late-1990s onwards) and (b.) an very limited number of fisheries (mostly Portugal and Taiwan LL, and Japan LL to a lesser extent).
- There appears to be many incidences of 'missing' catch. For example two fleets fishing in the same vicinity for the same species but only one reports any catch of (blue) sharks. This is likely a reporting issue.

Total catch

Catch estimates used in the 2015 assessment are shown in Figure 2. During the 2015 assessment it was it was assumed that the catch in mass figures provided by the IOTC members and cooperating non-contracting parties (CPC's) are the most reliable catch data available. While the total catch data are estimates, they are derived in large part from the industrial fleets in the Indian Ocean and are thought to be more reasonable for blue shark than for the other shark species. For the 2015 assessment an alternative catch series based on the trade based work was considered (Clarke 2015) however this was deemed less reliable due to changes in markets around 2012. This alternative catch series was calculated from trade based estimates using the proportion of tuna caught (IOTC–2015–WPEB11–24). This series extends from 1981-2011. To extend this catch series throughout the model domain a ratio (IOTC catch/ trade catch) from the 1980's was used to extend the model prior to 1980. The same method was used for extending the trade estimates to 2012-2014 based on the average ratio from the 2010's.Blue shark in the Indian ocean were initially assessed in 2015 (Rice and Sharma 2015) and one of the main issues was the lack of confidence in the catch data. Following the preliminary work undertaken in 2015 on an Indian Ocean blue shark (*Prionace glauca*) stock assessment ongoing work to develop a best confidence, catch series for blue shark in the Indian Ocean through the exploration of a number of sources of information, including,

- Nominal catch and catch-and-effort data reported by CPCs to the IOTC Secretariat
- At-sea-transhipment data (2009-present)
- In-port transhipment data (2005-present)
- Best available estimates of Indian Ocean blue shark catches and catch rates in the literature

Work with other nations has begun to identify additional data sources that can be incorporated into the assessment. To date two additional sources of catch, effort and/or size data for blue shark that have been developed are;

Australian Data:

- Landings (CDRs) since June 2006.
- Logbooks from April 2000 containing information on discards of BSH.
- Observer data since 2003

Indonesian Data

- RITF scientific observer program data
- Logbook data (still in request)
- National observer program data (still in request).

3 Approach to calculating catch

As mentioned above, the aim of this project is to improve upon the IOTC nominal catches (IOTC 2015) and the trade based estimates (Clarke 2015). Recent effort has focused on disaggregation of the IOTC data set, revising methods to develop the 'unreported' or 'missing' catch and developing new data sources.

Disaggregation

A preliminary disaggregation of the "shark-not identified" category (which are the bulk of the overall shark catches) to a most-likely species based on known proportions has been conducted (IOTC-2016-WPEB-XXX). This method uses control rules to assign the shark-not identified category to species level sharks based on reports from other fleets operating in the same time/space. The results of this exercise indicate that the majority of the Sharks-NEI catches is silky sharks (*Carcharhinus falciformis*) catches, with a significant proportion assigned to blue sharks. This because in the IOTC database, most of the Sharks-NEI catches is recorded under artisanal or semi-industrial gears, and silky shark is the predominant species caught with semi-industrial gears, whereas blue shark is mostly caught with artisanal and industrial gears. The overall reliability of this disaggregation depends heavily on the quality of the original, raw data. Nevertheless, this same approach has been adopted for the disaggregation of IOTC main species prior to each Working Party / Stock Assessment.

Preliminary Catch Modeling

In the past catch estimation for blue shark has been burdened by lack of data, to work around this lack of data we have modeled the catches based on total yearly catches, with ratios of on a year to year basis. Nominal catch (Figure 2) increases dramatically in the early 1990s, which to a certain extent is expected because the catch of tunas and swordfish does as well.

A more advanced method has been developed using the same data from the nominal catch database, BSH catch rates were calculated, defined as the ratio of total BSH catches to target species catches. Average ratios were calculated for each fine-scale gear and year combination. Fleets reporting zero catches of blue sharks were assumed to be false zeros and so were not used in calculating the average and unclassified gear types were removed. Where CPCs were reporting catches of target species but no blue shark catches, these catches of blue sharks were then estimated using the average BSH:target species catch ratio for that gear-year combination, i.e., those fleets reporting zero catches are allocated catches based on the catch rates of those fleets reporting non-zero catches. This work is ongoing and oriented at using statistical models can based on reliable data from fleets, and then used to model for others fleets with inconsistent reporting rates.

Additionally a compilation of alternative natural mortality, growth rates and recruitment relationships for blue shark has been developed (Table 1). This is because the different tuna-RFMOs use very different M estimates/assumptions in their stock assessments, but it is not clear that there is compelling evidence for real biological differences in different regions. In doing this we take into account the Range of values accepted in other RFMOs; as well as plausible growth rates based on recent results from the Indian Ocean and potential alternatives from the Pacific and Atlantic oceans.

4 References

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5 **Tables**

Table 1. Life history parameters for blue shark

Parameter	**Value**	**Citation**	**Notes**
Length at birth	40	Joung, Hsu, Liu and Wu 2011	North Pacific
	34-48	Strasburg 1958	
	36 PCL	Nakano 1994	North Pacific
	35-60	Nakano & Seti 2002	North Pacific
	40-50	Wallace et al. 2006	Global
	45 cm	Pratt (1979)	North Atlantic
Length at 50% maturity	M: 185 cm TL	Joung, Hsu, Liu and Wu 2011	North Pacific
	F: 193 cm TL	Joung, Hsu, Liu and Wu 2011	North Pacific
	M: 150-155 cm PCL	Nakano et al. 1985	North Pacific
	F: 159 cm PCL	Nakano et al. 1985	North Pacific
	220 cm TL	Pratt (1979)	North Atlantic
	M: 140 to 160 cm PCL (186 to 212 cm TL) F: 140 to 160 cm PCL (186 to 212 cm TL)	Nakano 1994	North Pacific
Maximum length	M: 320 cm, 396 cm TL	Bigelow & Schroeder 1948	North Atlantic
	380 cm TL	Hart 1988	North Pacific
	F: 287 cm	Skomal & Natanson 2003	North Atlantic
Age at 50% maturity	M: 4-6 years	Nakano 1994	North Pacific
	F: 5-7 years	Nakano 1994	North Pacific
	M: 4-5	Skomal & Natanson 2003	North Atlantic
	F: 5 years	Skomal & Natanson 2003	North Atlantic
	6-7 years	Cailliet & Bedford 1983	North Pacific
Longevity	M: 16 years	Skomal & Natanson 2003	North Atlantic
	F: 15 years	Skomal & Natanson 2003	North Atlantic
	M: 16 years	Blanco-Parra et al. 2008	North Pacific
	F: 12	Blanco-Parra et al. 2008	North Pacific
Length conversions	FL=0.8313*TL+1.39	Kohler et al. 1995	North Atlantic
	PCL=0.9075*FL-0.3956	Kohler et al. 1995	North Atlantic
	PCL=0.762*TL-2.505	Nakano et al. 1985	North Pacific
	FL=0.829*TL-1.122	NOAA SWFSC	North Pacific
	FL=2.746*AL+11.803	NOAA SWFSC	North Pacific
	TL=0.286*AL-2.474	NOAA SWFSC	North Pacific
Reproduction	Placental viviparity		
Litter size	2-52 (mean=25.2)	Joung, Hsu, Liu and Wu 2011	North Pacific
	41	Bigelow & Schroeder 1948	North Atlantic
	25-50	Wallace et al. 2006	Global
	25-30 average (range 1-54)	Suda 1953, Nakano et al. 1985	North Pacific
Gestation	9-12 months	Cailliet & Bedford 1983, Pratt 1979	North Pacific & Atlantic
Breeding frequency	2 years	Joung, Hsu, Liu and Wu 2011	North Pacific
	1-2 years		
Sex ratio @ birth	1 to 1	Nakano et al. 1985, Nakano 1994, Nakano & Seki 2002	North Pacific
Length-weight	All: $Wt(kg)=2.57 \times 10^{-5}\ TL^{3.05}$	Harvey 1989	North Pacific
	M: $Wt(kg)=3.838 \times 10^{-6}\ TL^{3.174}$	Nakano et al. 1985	North Pacific
	F: $Wt(kg)=2.328 \times 10^{-6}\ PL^{3.294}$	Nakano et al. 1985	North Pacific
	M: $Wt(kg)=3.293 \times 10^{-6}\ PL^{3.225}$	Nakano 1994	North Pacific
	F: $Wt(kg)=5.388 \times 10^{-6}\ PL^{3.102}$	Nakano 1994	North Pacific
	All: $Wt(kg)=5.009 \times 10^{-6}\ FL^{3.054}$	NOAA SWFSC Juvy Survey	North Pacific
	All: $Wt(kg)=1 \times 10^{-6}\ FL^{3.23}$	Joung, Hsu, Liu and Wu 2011	North Pacific
Growth models (VB)	VB model: $L_t= L_\infty[1-e^{-K(t-to)}]$		
	M: $TL_t= 295.3[1-e^{-0.175(t+1.113)}]$	Cailliet & Bedford 1983	North Pacific
	F: $TL_t= 241.9[1-e^{-0.251(t+0.795)}]$	Cailliet & Bedford 1983	North Pacific
	M: $PCL_t= 308.2[1-e^{-0.094(t+0.993)}]$	Tanaka 1984	North Pacific
	F: $PCL_t= 256.1[1-e^{-0.116(t+0.1.306)}]$	Tanaka 1984	North Pacific
	M: $PCL_t= 289.7[1-e^{-0.129(t+0.756)}]$	Nakano 1994	North Pacific
	F: $PCL_t= 243.3[1-e^{-0.144(t+0.849)}]$	Nakano 1994	North Pacific
	All: $FL_t =285.4[1-e^{-0.17(t+1.41)}]$	Skomal & Natanson 2003	North Atlantic
	M: $FL_t= 282.3[1-e^{-0.18(t+1.35)}]$	Skomal & Natanson 2003	North Atlantic
	F: $FL_t= 286.8[1-e^{-0.16(t+1.56)}]$	Skomal & Natanson 2003	North Atlantic
	M: $TL_t= 375.8[1-e^{-0.121(t+1.554)}]$	Hua, Joung, Liu and Hung 2011	North Pacific
	F: $TL_t= 317.4[1-e^{-0.172(t+1.123)}]$	Hua, Joung, Liu and Hung 2011	North Pacific
	M: $TL_t=299.8[1-e^{-0.10(t+2.44)}]$	Blanco-Parra et al. 2008	NEPO (Mexico)
	F: $TL_t=237.5[1-e^{-0.15(t+2.15)}]$	Blanco-Parra et al. 2008	NEPO (Mexico)
	CS: $TL_t=303.4[1^{-e-0.10(t+2.68)}]$	Blanco-Parra et al. 2008	NEPO (Mexico)

Figures

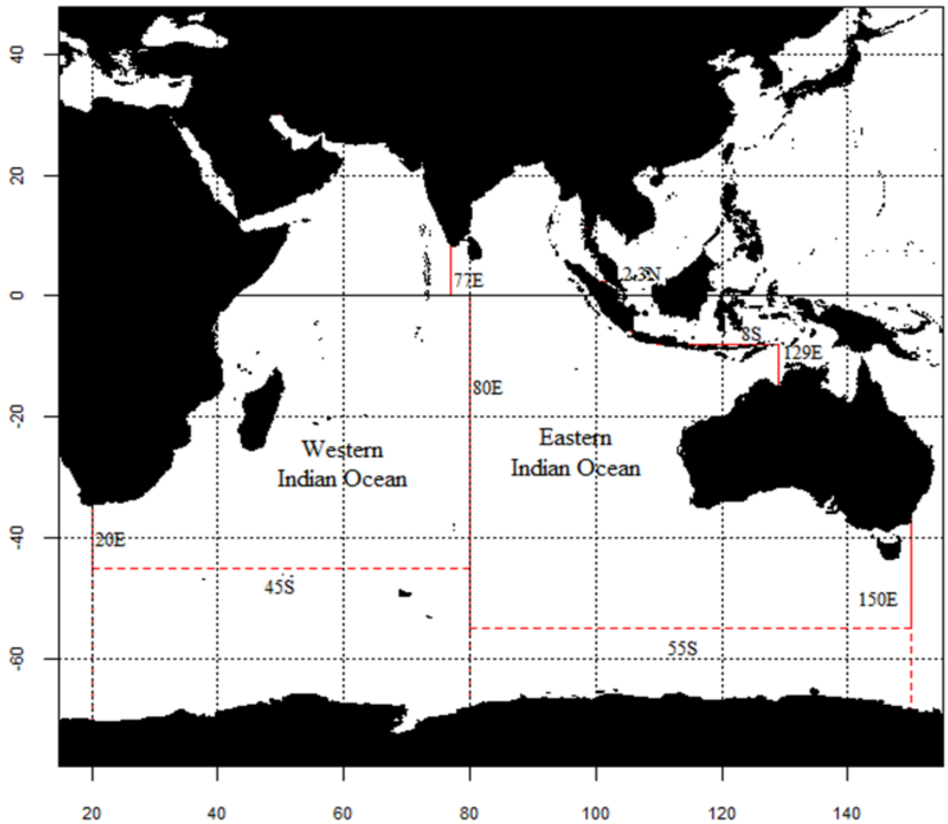

Figure 1. The IOTC area.

IOTC TRADE

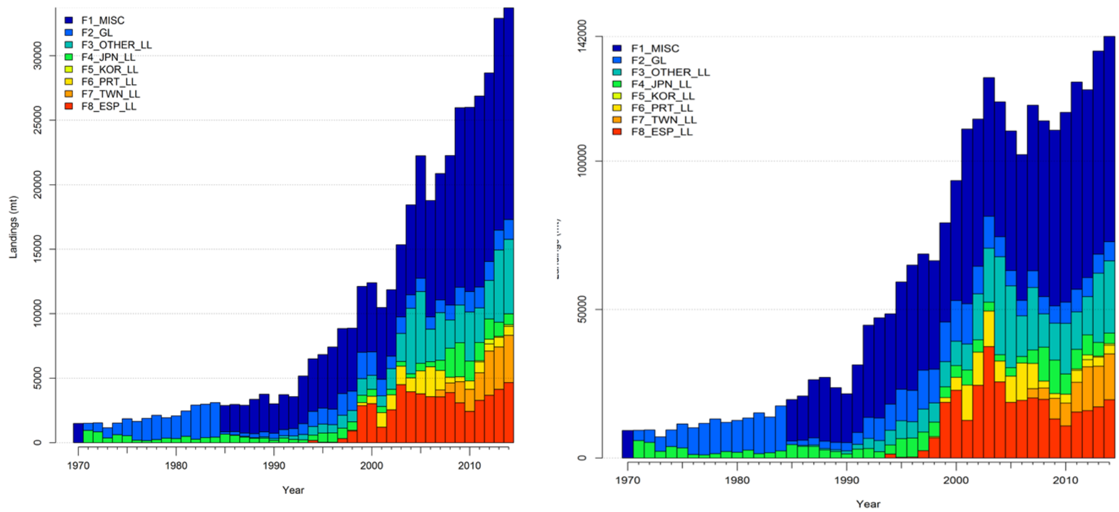

Figure 2 Catch series used in the 2015 blue shark assessment, the left panel is the IOTC nominal catch while the right panel is based on the trade based estimates from Clarke 2015.