BLUE SHARK

SUPPORTING INFORMATION

(Information collated from reports of the Working Party on Ecosystems and Bycatch and other sources as cited)

CONSERVATION AND MANAGEMENT MEASURES

Blue shark in the Indian Ocean are currently subject to a number of Conservation and Management Measures adopted by the Commission:

- Resolution 15/01 *On the recording of catch and effort data by fishing vessels in the IOTC area of competence* sets out the minimum logbook requirements for purse seine, longline, gillnet, pole and line, handline and trolling fishing vessels over 24 metres length overall and those under 24 metres if they fish outside the EEZs of their flag States within the IOTC area of competence. As per this Resolution, catch of all sharks must be recorded (retained and discarded).
- Resolution 15/02 *Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPCs)* indicated that the provisions, applicable to tuna and tuna-like species, are applicable to shark species.Resolution 11/04 *On a Regional Observer Scheme* requires data on blue shark interactions to be recorded by observers and reported to the IOTC within 150 days. The Regional Observer Scheme (ROS) started on 1st July 2010.
- Resolution 17/05 *On the conservation of sharks caught in association with fisheries managed by IOTC* includes minimum reporting requirements for sharks, calls for full utilisation of sharks and includes a ratio of fin-to-body weight for frozen shark fins retained onboard a vessel and a prohibition on the removal of fins for sharks landed fresh.
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Extracts from Resolutions 15/01,15/02, 11/04 and 05/05

RESOLUTION 15/01 ON THE RECORDING OF CATCH AND EFFORT DATA BY FISHING VESSELS IN THE IOTC AREA OF COMPETENCE

Para. 1. Each flag CPC shall ensure that all purse seine, longline, gillnet, pole and line, handline and trolling fishing vessels flying its flag and authorized to fish species managed by IOTC be subject to a data recording system.

Para. 10 (start). The Flag State shall provide all the data for any given year to the IOTC Secretariat by June 30th of the following year on an aggregated basis.

RESOLUTION 11/04 ON A REGIONAL OBSERVER SCHEME

Para. 10. Observers shall:

b) Observe and estimate catches as far as possible with a view to identifying catch composition and monitoring discards, by-catches and size frequency

Resolution 15/02 MANDATORY STATISTICAL REPORTING REQUIREMENTS FOR IOTC CONTRACTING PARTIES AND COOPERATING NON-CONTRACTING PARTIES (CPCS)

Para. 2. Estimates of the total catch by species and gear, if possible quarterly, that shall be submitted annually as referred in paragraph 7 (separated, whenever possible, by retained catches in live weight and by discards in live weight or numbers) for all species under the IOTC mandate as well as the most commonly caught elasmobranch species according to records of catches and incidents as established in Resolution 15/01 *on the recording of catch and effort data by fishing vessels in the IOTC area of competence* (or any subsequent superseding Resolution).

RESOLUTION 17/05 ON THE CONSERVATION OF SHARKS CAUGHT IN ASSOCIATION WITH FISHERIES MANAGED BY IOTC

Para. 2. CPCs shall take the necessary measures to require that their fishermen fully utilise their entire catches of sharks, with the exception of species prohibited by the IOTC. Full utilisation is defined as retention by the fishing vessel of all parts of the shark excepting head, guts and skins, to the point of first landing.

Para. 6. CPCs shall report data for catches of sharks no later than 30 June of the following year, in accordance with IOTC data reporting requirements and procedures in Resolution 15/02 *mandatory statistical requirements for IOTC Members and Cooperating Non-Contracting Parties (CPC's)* (or any subsequent superseding resolution), including all available historical data, estimates and life status of discards (dead or alive) and size frequencies.

FISHERIES INDICATORS

Blue shark: General

Blue shark (*Prionace glauca*) is the most common shark in pelagic oceanic waters throughout the tropical and temperate oceans worldwide (**Fig. 1**). It has one of the widest ranges of all the shark species and may also be found close inshore. Adult blue sharks have no known predators; however, subadults and juveniles may be preyed upon by

shortfin makos, great white sharks, and adult blue sharks. Fishing is a major contributor to adult mortality. **Table 1** outlines some of the key life history traits of blue shark in the Indian Ocean.

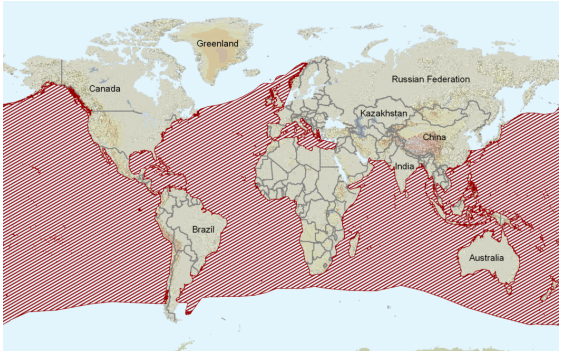

Fig. 1. Blue shark: The worldwide distribution of the blue shark (source: www.iucnredlist.org).

TABLE 1. Blue shark: Biology of Indian Ocean blue shark (*Prionace glauca*).

Parameter	Description
Range and stock structure	In the tropical Indian Ocean, the greatest abundance of blue sharks occurs at depths of 80 to 220 m, in temperatures ranging from 12 to 25°C. The distribution and movements of blue shark are strongly influenced by seasonal variations in water temperature, reproductive condition, and availability of prey. Long-distance movements have been observed for blue sharks, including transoceanic route from Australia to South Africa. The blue shark is often found in large single sex schools containing individuals of similar size. Subtropical waters south of 20°S and temperate waters appear to be nursery grounds where small blue sharks dominate, but where all range of sizes from 55 to 311 cm FL are recorded. In contrast mature fish (FL > 185cm) dominate in the off-shore equatorial waters. Area of overlap with IOTC management area = high. No information is available on stock structure.
Longevity	Bomb radiocarbon dating of Indian Ocean blue sharks showed that males of 270 cm FL may attain 25-27 years of age. Indian Ocean age and growth studies show that males may reach 25 and females 21 years old.
Maturity (50%)	Age: Sexual maturity is attained at about 4–7 years for males and 5–7 years for females. Size: Females mature at 194 cm TL and males at 201 cm TL. In the Atlantic 182–218 cm TL for males; 173–221 cm TL for females. In the South Pacific: 229–235 cm TL for males and 205–229 cm TL for females.
Reproduction	Blue shark is a viviparous species, with a yolk-sac placenta. Once the eggs have been fertilised there is a gestation period of between 9 and 12 months. Litter size is quite variable, ranging from four to 135 pups and may be dependent on the size of the female. The average litter size observed from the Indian Ocean is 38, very similar to the one reported in the Atlantic Ocean, 37. Generation time is about 8–10 years. In Indian Ocean, between latitude 2 ºN and 6 ºS, pregnant females are present for most of the year. • Fecundity: relatively high (25–55) • Generation time: 8–10 years • Gestation Period: 9–12 months • Annual reproductive cycle
Size (length and weight)	Maximum size is around 380 cm FL. New-born pups are around 40 to 51 cm TL. Length–weight relationship for both sexes combined in the Indian Ocean is $TW=0.159*10^{-4} * FL^{2.84554}$.

Sources: Gubanov & Gigor'yev 1975, Pratt 1979, Anderson & Ahmed 1993, ICES 1997, Scomal & Natansen 2003, Mejuto et al. 2005, Francis & Duffy 2005, Mejuto & Garcia-Cortes 2006, IOTC 2007, Matsunaga 2007, Nakano & Stevens 2008, Rabehagosoa et al. 2009, Romanov & Romanova 2009, Anon 2010, Romano & Campana 2011, Jolly et al. 013, Andrade et al. (2017); Coelho et al (2017).

Blue shark: Fisheries

Blue sharks are often targeted by some semi-industrial and artisanal fisheries and are a bycatch of industrial fisheries (pelagic longline tuna and swordfish fisheries and anecdotally in the purse seine fishery). However, in recent years longliners are occasionally targeting this species, due to an increase in its commercial value worldwide. The blue shark appears to have a similar distribution to swordfish. Typically, the fisheries take blue sharks between 180–240 cm FL or 30 - 52 kg. Males are slightly smaller than the females. In other Oceans, angling clubs are known to organise shark fishing competitions where blue sharks and mako sharks are targeted. Sport fisheries for oceanic sharks are apparently not so common in the Indian Ocean.

There is little information on the fisheries prior to the early 1970s, and some countries continue not to collect shark data while others do collect information but do not report it to IOTC. It appears that substantial catches of sharks have gone unrecorded in several countries. Furthermore, many catch records probably under-represent the actual catches of sharks because they do not account for discards (i.e. do not record catches of sharks for which only the fins are kept or of sharks usually discarded because of their size or condition) or they reflect dressed weights instead of live weights.

FAO also compiles landings data on elasmobranchs, but the statistics are limited by the lack of species-specific data and data from the major fleets.

The practice of shark finning is considered to be regularly occurring and on the increase for this species (Clarke et al. 2006, Clarke 2008) and the bycatch/release injury rate is unknown but probably high.

Preliminary estimations of at-haulback mortality showed that 24.7% of the blue shark specimens captured in longline fisheries targeting swordfish are captured dead at time of haulback (**Table 2**). Specimen size seems to be a significant factor, with larger specimens having a higher survival at-haulback (Coelho et al. 2011).

TABLE 2. Blue shark: Estimated frequency of occurrence and bycatch mortality in the Indian Ocean pelagic fisheries.

Gears	PS	LL		BB/TROL/HAND	GILL	UNCL
		SWO	TUNA			
Frequency	rare	abundant		rare	unknown	unknown
At vessel mortality	unknown	13 to 51 %	0 to 31%	unknown	unknown	unknown
Post release	unknown	19% (Atlantic)		unknown	unknown	unknown

Sources: Boggs 1992, Romanov 2002, 2008, Diaz & Serafy 2005, Ariz et al. 2006, Peterson et al. 2008, Romanov et al. 2008, Campana et al. 2009, Poisson et al. 2010, Coelho et al. (2011), Coelho et al. (2013a).

Blue shark: Catch trends

The catches reported to IOTC for blue shark (**Fig. 2**) are highly uncertain as is their utility in terms of minimum catch estimates. Sixteen CPCs have reported nominal catch data on sharks for the main species listed in Resolution 15/01 (i.e. Australia, Belize, China, EU (France, Spain, Portugal and United Kingdom), India, Indonesia, and I.R. Iran, Japan, Rep. of Korea, Madagascar, Maldives, Mauritius, Philippines, Seychelles, South Africa and Sri Lanka). For CPCs targeting swordfish, blue sharks formed 68% of catches.

Note that the catches recorded for sharks are thought highly incomplete. The catches of sharks are usually not reported and when they are they might not represent the total catches of this species but simply those retained on board. It is also likely that the amounts recorded refer to weights of processed specimens, not to live weights. In 2017 (the year of data used for the last stock assessment) nineteen countries reported catches of blue sharks in the IOTC area of competence. Due to those large uncertainties, several catch reconstructions were conducted during the 2017 assessment (**Fig 3**).

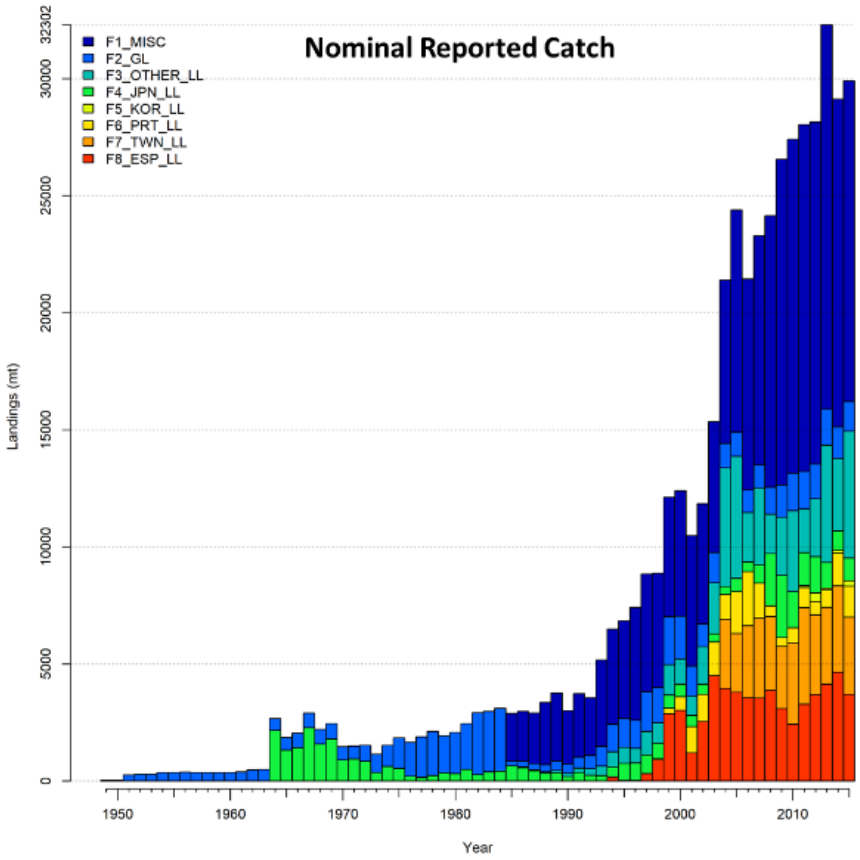

Fig 2. Blue shark: Total reported catch to IOTC, by fleet from 1970–2015 (MISC = other gears; GL = Gillnet; LL = Longline; JPN = Japan; KOR = Rep. of Korea; PRT = EU,Portugal; TWN = Taiwan,China; ESP = EU,Spain)

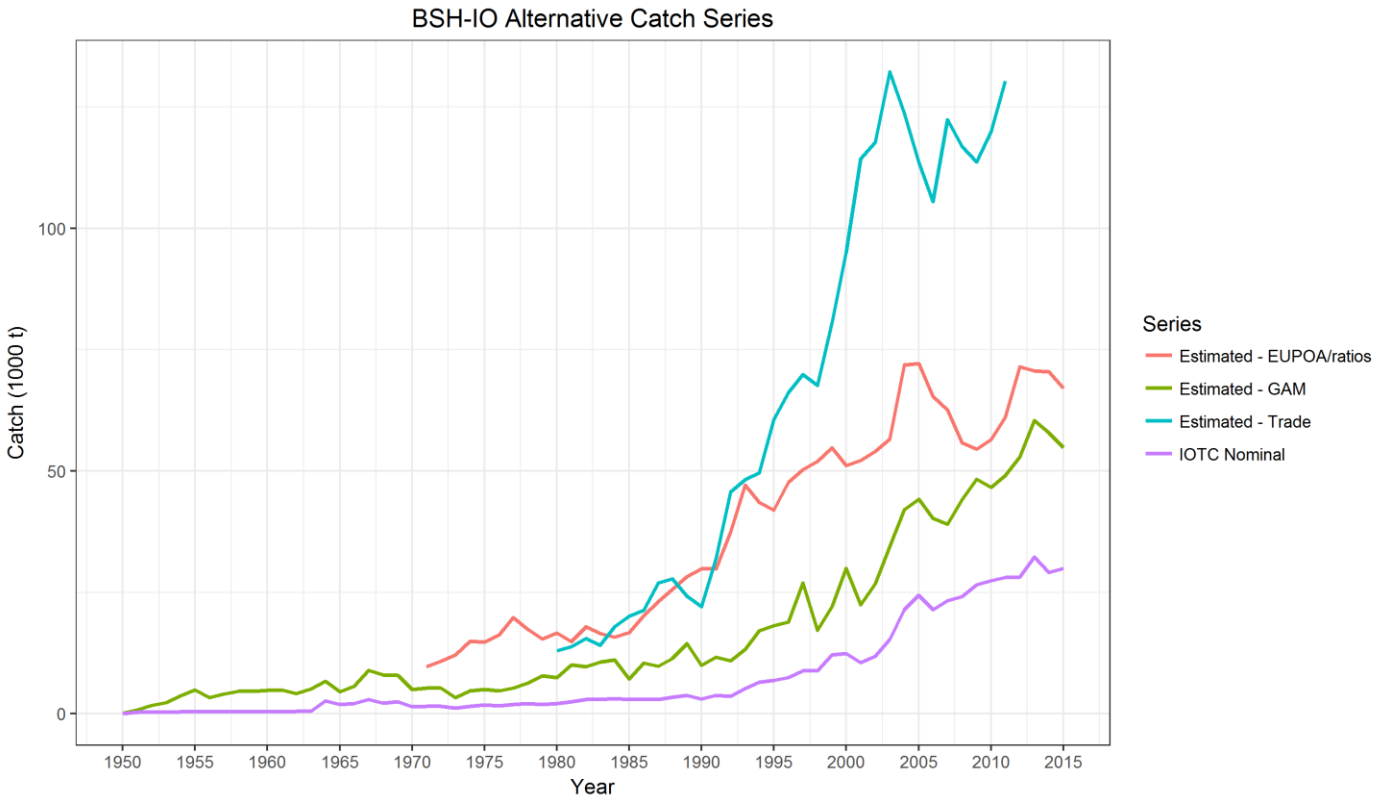

Fig. 3. Blue shark: Total reported and estimated catches. IOTC nominal refers to catches reported to IOTC. Methods for the various estimations are described in: GAM (IOTC-2017-WPEB13-23), EUPOA/ratios (IOTC-2017-WPEB13-22), Trade (IOTC-2015-WPEB11-24).

Blue shark: Nominal and standardised CPUE Trends

Standardised CPUE trends from EU,Portugal, EU,France and Japan, were used in the final base case stock assessment model in 2017. Additionally, standardised CPUE trends from EU.Spain Taiwan,China and Indonesia were used in the sensitivity analysis:

- EU,Spain (2001–2015) from document IOTC–2017–WPEB13–25.
- EU,Portugal (2000–2016) from document IOTC–2017–WPEB13–24.
- EU,France (2007-2016) from document IOTC–2017–WPEB13–27.
- Indonesia (2005-2016) from document IOTC–2017–WPEB13–26.
- Japan (early 1975–1993; late 1992–2016) from documents IOTC–2015–WPEB11–30 Rev_1 and IOTC–2017–WPEB13–29.
- Taiwan,China (2004–2016) from document IOTC–2017–WPEB13–INF08.

Differing trends were apparent in some of the standardised CPUE series, even in cases of fleets operating within the same areas (**Fig. 4**). However, the series used in the final base case assessment were all positively correlated.

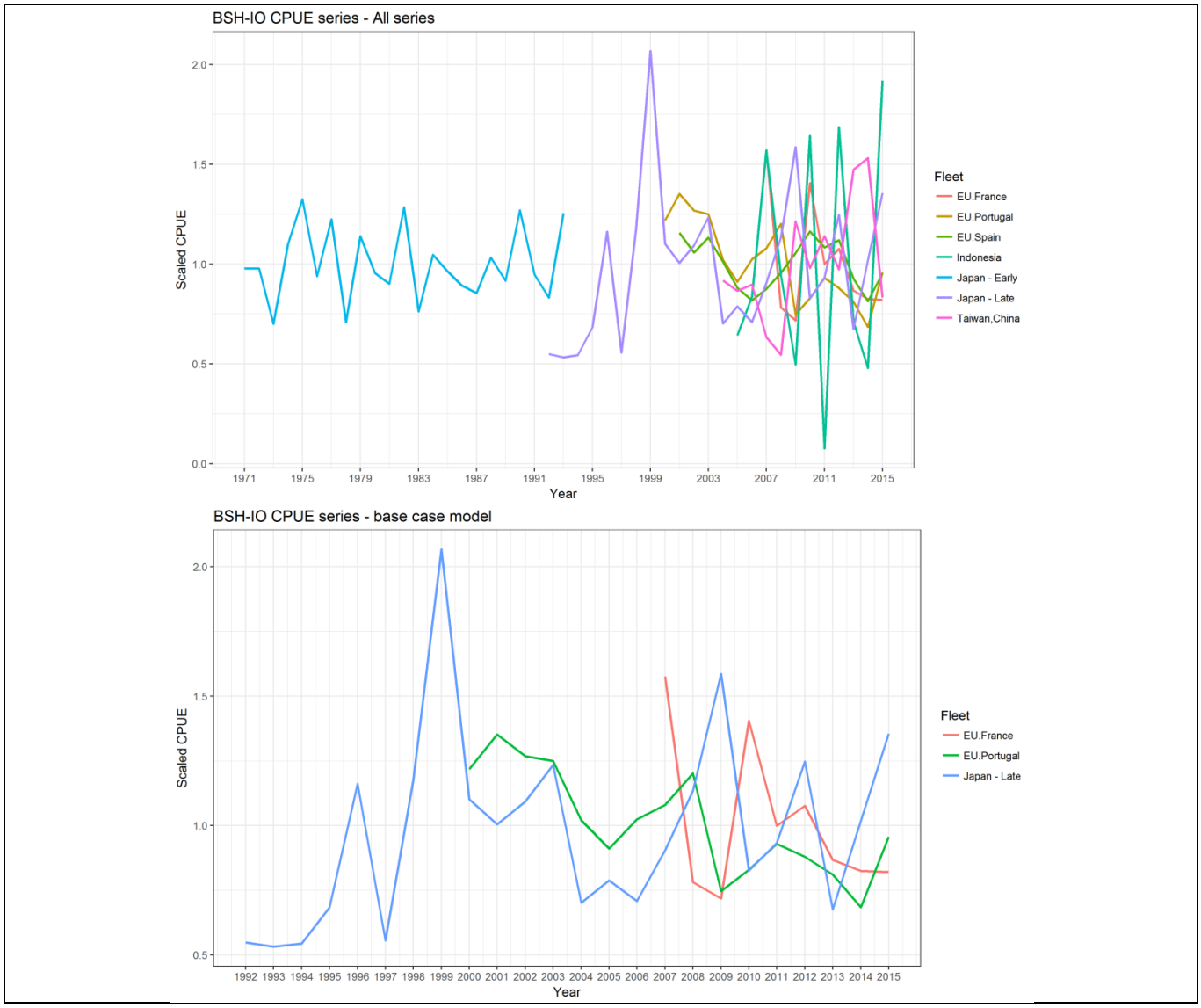

Fig. 4. Blue shark: Comparison of the blue shark standardised CPUE series for the longline fleets. Top plot represents all series used in the assessment including sensitivity runs and the bottom plot represents the series used in the final base case model. Series available were Japan (early, 1975–1993), Japan (late, 1992–2016), EU,Portugal (2000–2016), EU,Spain (2001–2015), EU,France (2007-2016), Taiwan,China (2004–2016) and Indonesia (2005-2016).

Blue shark: Average length of blue shark catches by fleet

Fig. 5 shows the aggregated fork length frequency distribution for the longline fleets reporting size information on blue sharks for all areas between 2005 and 2015. The data reported for vessels flagged for China, Japan, Rep. of Korea and EU,Portugal include data reported for longline fleets with observers onboard. The results highlight the difference

in the selectivity of fleets for different sized specimens, with the EU fleets, on average, selecting larger blue sharks than the other fleets.

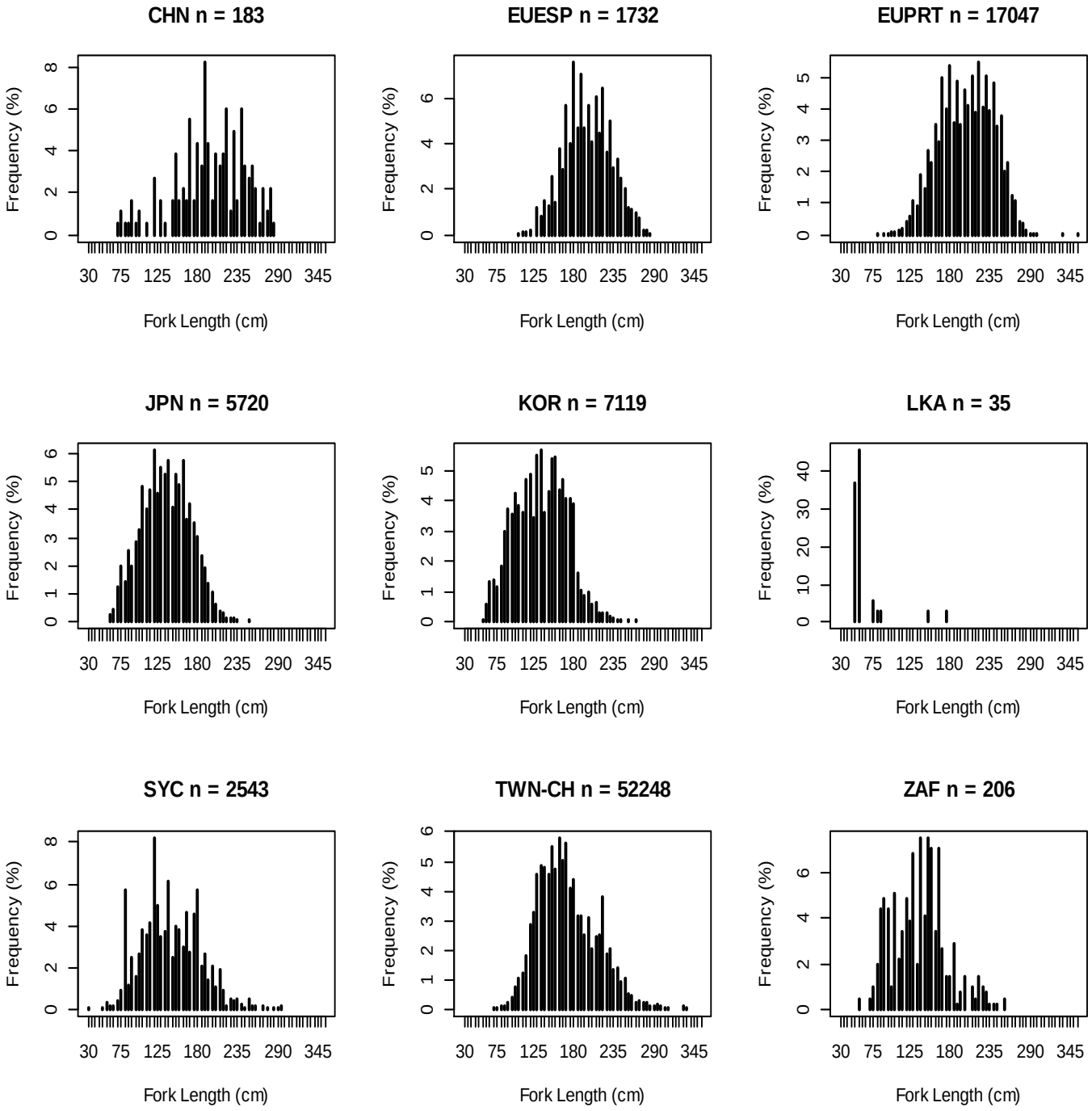

Fig. 5. Fork length frequency distributions (%) of blue shark derived from the samples reported for the longline fleets of China (CHN LL), EU,Spain (EUESP ELL), EU,Portugal (EUPRT ELL), Japan (JPN LL), Korea (KOR LL), Sri Lanka LKA (G/L), Seychelles (SYC LL), Taiwan,China (TWN FLL/LL) and South Africa (ZAF ELL) between 2005 and 2015 in 5 cm length classes.

Blue shark: Number of squares fished

Data not available.

STOCK ASSESSMENT

The first stock assessment of blue shark in the Indian Ocean was carried out in 2015. In 2017, a new stock assessment was conducted using four stock assessment models, specifically a data-limited catch only model (SRA), two Bayesian biomass dynamic models (JABBA with process error and a Pella-Tomlinson production model without process error)

and an integrated age-structured model (SS3). The base case models were run using estimated catch series (IOTC-2017-WPEB13-23). Results from each model are show in **Table 3**.

The SRA was considered to be interesting as an exploratory tool, particularly as a method for directly comparing the effect of the different catch histories. The production models (JABBA and PTSPM) had the advantage of incorporating CPUE information and while these are not considered perfect indices relative abundance, they provide more information than the catch history which is useful to incorporate. Finally, the SS model allowed for the incorporation of more detailed biological information, including the size data available and so it was agreed that this was the preferred model. The final advice for management was therefore based on an SS3 base case model using the GAM-based catch history estimates and CPUE series from Portugal, EU-France (Reunion) and Japan (late). The major axes of uncertainties identified in the selected model were catches and CPUE indices of abundance. Model results were explored with respect to their sensitivity to the major axes of uncertainty identified. If the alternative CPUE groupings were used then the stock status was somewhat more positive ($B>>B_{MSY}$ and $F<<F_{MSY}$), while if the alternative catch series (trade and EUPOA) were used then the estimated stock status resulted in $F>F_{MSY}$.

TABLE 3. Blue shark: Indian Ocean-wide summary of key management quantities from the assessments undertaken in 2017 (note that the PPTM uses a different base case; IOTC nominal catches).

Management quantity	SS3 (Doc #33 Rev_1)	SRA (Doc #30)	JABBA (Doc #31)	PPTM (Doc #32 Rev_1)
Most recent catch estimate (t) (2015) (GAM based estimates or nominal catches for PPTM)	54,735	54,735	54,735	29,916
Mean catch over last 5 years (t) (2011–2015) (GAM based estimates or nominal catches for PPTM)	54,994	54,994	54,994	29,507
h (steepness)	0.79	n.a.	n.a.	n.a.
MSY (1,000 t) (80% CI)	33.1 (29.5 – 36.7)	39.5 (32.1 – 48.4)	47.3 (32.3 – 83.7)	34.9 (22.8-57.9)
Data period (catch)	1950 – 2015	1950 - 2015	1950 – 2015	1980 - 2015
CPUE series	EU-PRT, EU-REU, JPN_L	n.a.	JPN_L, EU-PRT, EU-REU	JPN_L, EU-ESP, TWN-CHN, EU-PRT, IDN
CPUE period	JPN_L (1992 – 2015) EU-PRT (2000 – 2015) EU-REU (2007 – 2015)	n.a.	JPN_L (1992 – 2015) EU-PRT (2000 – 2015) EU-REU (2007 – 2015)	JPN_L (1992 – 2015) EU-ESP (2001 – 2015) TWN-CHN (2004 – 2015) EU-PRT (2000 – 2015) IDN (2005– 2015)
F_{MSY}	0.31 (0.30 – 0.31)	0.13 (0.12 – 0.15)	0.14 (0.12 – 0.16)	0.14
SB_{MSY} or $*B_{MSY}$ (1,000 t)	38.8 (34.2 – 43.6)	295.70 (241.64 –	349.24 (238.30 – 616.82)	258.62
F_{2015}/F_{MSY} (80% CI)	0.904 (0.678 – 1.13)	1.37 (0.88 – 2.43)	0.87 (0.40 – 1.74)	0.55

B_{2015}/B_{MSY} (80% CI)	n.a.	1.01 (0.7 – 1.29)	1.33 (0.92 – 1.72)	1.62
SB_{2015}/SB_{MSY} (80% CI)	1.50 (1.33 – 1.63)	n.a.	n.a.	n.a.
B_{2015}/B_{1950} (80% CI)	n.a.	0.5 (0.35 – 0.65)	0.81 (0.51 – 1.26)	n.a.
SB_{2015}/SB_{1950} (80% CI)	0.52 (0.46 – 0.56)	n.a.	n.a.	n.a.
$SB_{2015}/SB_{1950, F=0}$	1.02	n.a.	n.a.	n.a.

n.a. = not available

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