REVIEW OF THE STATISTICAL DATA AVAILABLE FOR BLUE SHARK (PRIONACE GLAUCA)

Prepared by IOTC Secretariat[1]

Purpose

To provide participants to the 21st Session of the IOTC Working Party on Ecosystems and Bycatch Data preparatory meeting (WPEB21DP) with a review of the status of the information available as of April 2025 for Blue shark (Prionace glauca), identified as bycatch species of the IOTC fisheries.

The IOTC Scientific Committee define "bycatch" as: "*All species, other than the 16 species listed in Annex B of the IOTC Agreement, caught or interacted with by fisheries for tuna and tuna-like species in the IOTC area of competence. A bycatch species includes those non-IOTC species which are (a) retained (byproduct), (b) incidentally taken in a fishery and returned to the sea (discarded); or (c) incidentally affected by interacting with fishing equipment in the fishery, but not taken.*"

IOTC Res. (18/02) specifies: *"In order to curb the level of unreported catches, each CPC shall ensure that its vessels catching blue shark in association with IOTC fisheries in the Agreement area record their catch in accordance with the requirements set out in the Resolution 15/01 on the recording of catch and effort data by fishing vessels in the IOTC area of competence or any Resolution superseding it"* as well *"CPCs shall implement data collection programmes that ensure improved reporting of accurate blue shark catch, effort, size and discard data to IOTC in full accordance with the Resolution 15/02 on the Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPCs), or any Resolution superseding it"*

Materials

The analysis in the paper relies on data submitted annually to the IOTC Secretariat by Contracting Parties and Cooperating Non-Contracting Parties (CPCs) in accordance with IOTC Conservation and Management Measures (CMMs). These data sets undergo revisions throughout the year, reflecting ongoing improvements in reporting accuracy and completeness. To enhance transparency and compliance with reporting standards, the IOTC Secretariat has increased the visibility of IOTC Reporting guidelines and IOTC forms on the IOTC website. While adherence to the IOTC Reporting Guidelines is not mandatory, the use of IOTC forms is strongly recommended for submitting data to the Secretariat. These guidelines and forms facilitate effective data curation and management, ensuring that the information used for analysis is robust and reliable for assessing the status and trends of Indian Ocean neritic tunas and seerfish fisheries.

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Retained catch data

The reporting of retained catches of species in the Indian Ocean, as mandated by IOTC Res. 15/02, requires that these catches be expressed in live weight equivalent and reported annually. This reporting encompasses several key aspects: the major fishing area within the Indian Ocean, the specific fleet involved, and the type of gear used. The preferred method for submission is using IOTC form 1RC.

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Two data sets of retained catches are made available by the Secretariat: (1) the raw estimates which include both the 16 IOTC species (prior to the breakdown of species and gear aggregates) and all other species considered as bycatch and (2) the best scientific estimates only available for the 16 IOTC species (e.g., IOTC 2022).

Changes in retained catches can occur due to several reasons:

I. **Updates**: Preliminary data for longline fisheries are initially submitted by June 30th each year, with updates received by December 30th of the same year;

II. **Revisions by CPCs**: Contracting Parties and Cooperating Non-Contracting Parties may revise historical data due to corrections of errors, inclusion of missing data, changes in data processing methodologies, etc.

III. **Estimation Process Changes**: The Secretariat may adjust catch estimations based on improved methods or assumptions, such as the selection of proxy fleets or updated morphometric relationships. These adjustments require endorsement by the IOTC Scientific Committee.

Discard data

The IOTC adheres to the FAO's definition of discards, as detailed in previous reports (Alverson et al. 1994, Kelleher 2005). This definition encompasses all non-retained catch, whether individuals are released alive or discarded dead. According to IOTC Resolution 15/02, estimates of total annual discard levels in terms of live weight or number must be reported to the Secretariat. These reports should specify the Indian Ocean major area, species, and type of fishery involved.

To facilitate this reporting, the IOTC has developed IOTC Form 1DI specifically for reporting discards. The data submitted via Form 1DI should be extrapolated at the source to provide comprehensive estimates of total discard levels for the year. This extrapolation should encompass details such as the type of gear used, the fleet involved, the specific Indian Ocean major area, and the species discarded. Notably, these reports should also include data on discards of non-fish species like turtles, cetaceans, and seabirds, ensuring a comprehensive overview of the impacts of fishing activities on marine biodiversity within the Indian Ocean region.

Geo-referenced catch and effort data

Catch and effort data within the IOTC framework are detailed and stratified across various parameters, as specified by IOTC Res. 15/02. Typically sourced from logbooks, these data are aggregated and reported annually, delineated by year, month, grid area, fleet, gear type, school type, and species targeted.

Geo-referenced catch information is particularly emphasized, either in live-weight equivalent or fish numbers, and is reported to the IOTC Secretariat. To streamline this reporting process, the recommended IOTC form 3-CE has been designed. This form facilitates the submission of geo-referenced catch and effort data, capturing details such as the activities of support vessels that assist large-scale purse seiners.

Furthermore, specific information related to the use of drifting floating objects and anchored fish aggregating devices is reported separately. This data is submitted using IOTC forms 3DA and 3AA respectively. These forms ensure that comprehensive information on fishing activities, including associated vessels and gear technologies, is available for effective management and conservation efforts within the Indian Ocean region.

Size-frequency data

The size composition of catches is derived from data sets that include individual body lengths or weights collected both at sea and during the unloading of fishing vessels. To standardize reporting and ensure comprehensive data collection, the IOTC has developed the IOTC Form 4SF. This form includes all necessary fields for complete reporting of size-frequency data, stratified by fleet, year, gear type, school type, month, grid area, and species, as stipulated by IOTC Res. 15/02.

While the majority of size data reported via Form 4SF pertain to retained catches, Contracting Parties and Cooperating Non-Contracting Parties (CPCs) also have the option to use the same form to report size data for discarded individuals. This flexibility allows for a more thorough understanding of the size distribution across different species and fishing activities.

Additionally, onboard observer programs under the ROS play a crucial role in collecting supplementary size data, including measurements of individuals discarded at sea. This data is reported to the IOTC Secretariat, contributing to broader insights into fisheries dynamics and supporting management strategies aimed at sustainable resource utilization in the Indian Ocean.

Regional Observer Scheme

Resolution 24/04 on a *Regional Observer Scheme* (ROS) makes provision for the development and implementation of national observer schemes among the IOTC CPCs starting from July 2010 with the overarching objective of collecting *"verified catch data and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC area of competence"*. The ROS aims to cover *"at least 5% of the number of operations/sets for each gear type by the fleet of each CPC while fishing in the IOTC Area of competence of 24 meters overall length and over, and under 24 meters if they fish outside their EEZs shall be covered by this observer scheme"*. Observer data collected as part of the ROS include:.

1. **Fishing Activities and Positions**: Detailed information on fishing operations and vessel locations.
2. **Catch Estimates and Composition**: Identification of catch composition, monitoring of discards, bycatch species, and size-frequency distribution.
3. **Gear Information**: Specifications such as gear type, mesh size, and any attachments used by the vessel.
4. **Logbook Cross-checking:** Verification of logbook entries, including species composition, quantities, live and processed weights, and fishing locations

Morphometric data

The current length-length and length-weight IOTC reference relationships for pelagic sharks mostly come from historical data collected in the Atlantic Ocean or Western-Central Pacific Ocean (Skomal and Natanson 2003; Francis and Duffy 2005). However, several morphometric data sets have been collected for sharks through different research and monitoring programs conducted in the Indian Ocean over the last decades, including measurements taken at sea and on land (Garcia-Cortés and Mejuto 2002; Ariz et al. 2007; Romanov and Romanova 2009; Espino et al. 2010; Filmalter et al. 2012). Hence, different statistical relationships have been established for several Indian Ocean pelagic sharks based on data that may cover different size ranges as well as different areas and time periods.

Methods

Data available for bycatch species

The present report is based on the compilation of information derived from the datasets of bycatch species referenced in the related resolutions that were reported to the Secretariat, i.e.:

- Retained catch data for shark and ray species, including those reported as species aggregates;
- Catch and effort data for shark and ray species, including those reported as species aggregates;
- Size-frequency data for shark and ray species;
- Information on discards for shark and ray species available from the ROS;
- Fishery interactions with marine turtles, cetaceans, and seabirds derived from the ROS.

Retained catch data for bycatch species should be considered with caution, due to several reasons that include the historically low reporting rates and a tendency to report catches for aggregated shark and ray species. Furthermore, catches of some shark and ray species that interact with coastal fisheries targeting other species than tuna and tuna-like ones may not be reported to the IOTC. In addition, catches that have been reported are thought to represent only those species that are retained onboard, without taking into account discarded individuals. Finally, in many cases, the reported catches refer to dressed weights while no information is provided on the type of processing undertaken, creating more uncertainty in the estimates of catches in live weight equivalents.

Information available on the estimates of total discards collated through IOTC form 1DI was not used in the present report as the data are currently very limited, often provided using heterogeneous formats (not fully compliant with IOTC standards) which do not include several metadata fields (e.g., reason for discard, fate) as well as the detailed information on sampling coverage and raising procedures adopted (if any).

Data processing

The preparation of the curated public-domain datasets for bycatch species follows three main data processing steps which are briefly summarized below.

First, standard controls and checks are performed to ensure that the metadata and data submitted to the Secretariat are consistent and include all mandatory fields (e.g., dimensions of the strata, etc.). The controls depend on each data set and may require the submission of revised data from CPCs if the original ones are found to be incomplete.

Second, when retained catches are not reported by a CPC, catch data from the previous year may be repeated or derived from a range of sources, e.g., the FAO FishStat database. In addition, for some specific fisheries characterized by well-known, outstanding issues in terms of data quality, a process of re-estimation of species and/or gear composition may be performed based on data available from other years or areas, or by using proxy fleets, i.e., fleets occurring in the same strata which are assumed to have a very similar catch composition (Moreno et al. 2012).

Finally, filtering and conversions are applied to the size data reported for the most common shark and ray species in order to harmonize their format and structure, and remove data which are non-compliant with IOTC standards, e.g., provided with size bins exceeding the maximum width considered meaningful for the species (IOTC 2020). All samples collected using types of measurement other than fork length (FL; straight distance from the tip of the upper snout to the fork of the tail) are converted into FL by using the IOTC equations and binned by constant intervals of 5 cm in size. If no IOTC-endorsed equations exist to convert from a given length measurement for a species to the standard FL measurement, the original size-frequency data are not disseminated although they are kept within the IOTC databases for future reference.

Results

Overall bycatch levels & trends of Blue shark

Overall levels and quality of reported catches of shark and ray species have increased over time due to the development and expansion of tuna and tuna-like fisheries across the Indian Ocean. Blue shark catches remain associated with considerably uncertainties due to estimates of blue shark catches from Indonesian artisanal fisheries. In recent years (2018–2022), the average annual catch of blue sharks in the Indian Ocean was around 24,000 tonnes, around 64% of which was taken by Indonesia (IOTC-2024-SC27-ES17_BSHE). However, the application of the re-estimation methodology to Indonesian catches, presented at WPDCS20 and endorsed by SC27, resulted in a 25% reduction in blue shark catches over the same period (**Fig. 1**). Despite the modifications to the data series, blue sharks still account for the majority of reported shark catches at the species level. However, it is important to emphasise that the aggregate species account for up to 70% of the total number of sharks caught. (**Fig. 1**).

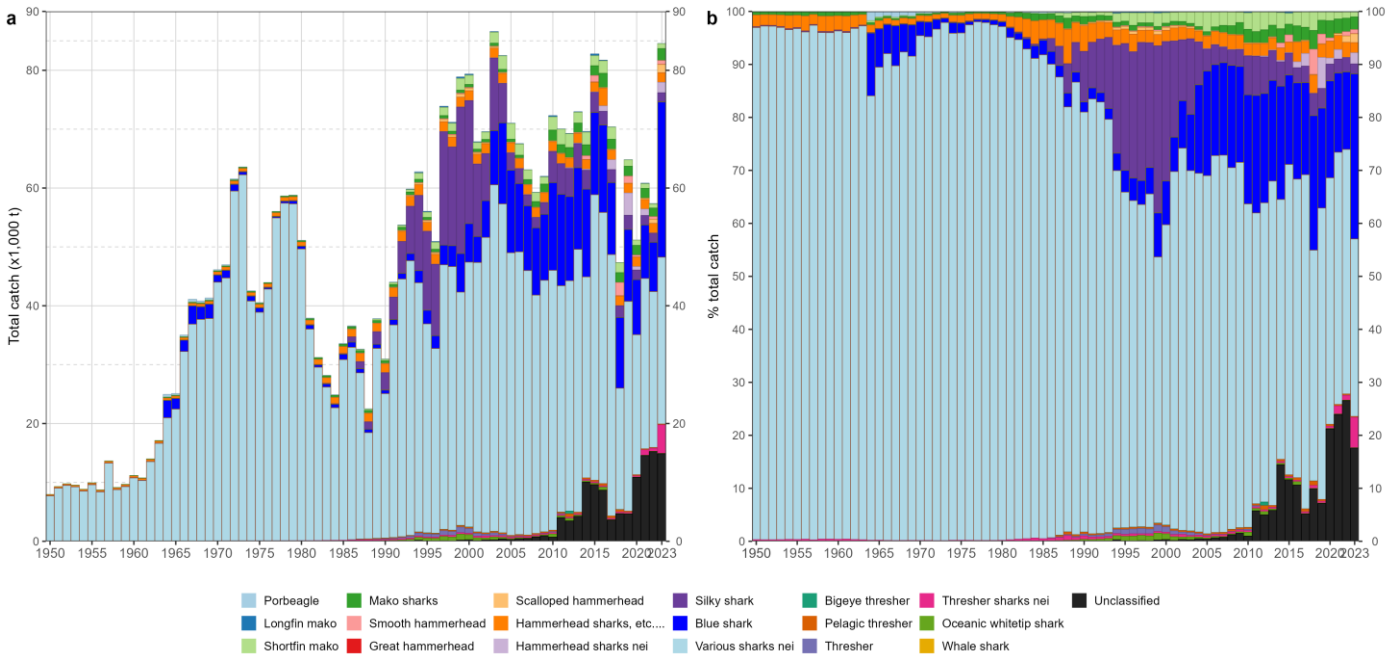

Figure 1: Annual cumulative absolute (a) and relative (b) time series of retained catches (metric tonnes; t) of shark species for the period 1950-2023

The change in the time series also implies a reordering of the contributions of blue shark catches by the three main fleets (Taiwan,China, EU,Spain, and Indonesia) until 2022. Reported catches of blue sharks by Indonesia in 2023 dominate once again, with similar values to previous reports, as the re-estimation methodology has not yet been applied to the latest data submission (**Fig. 2**).

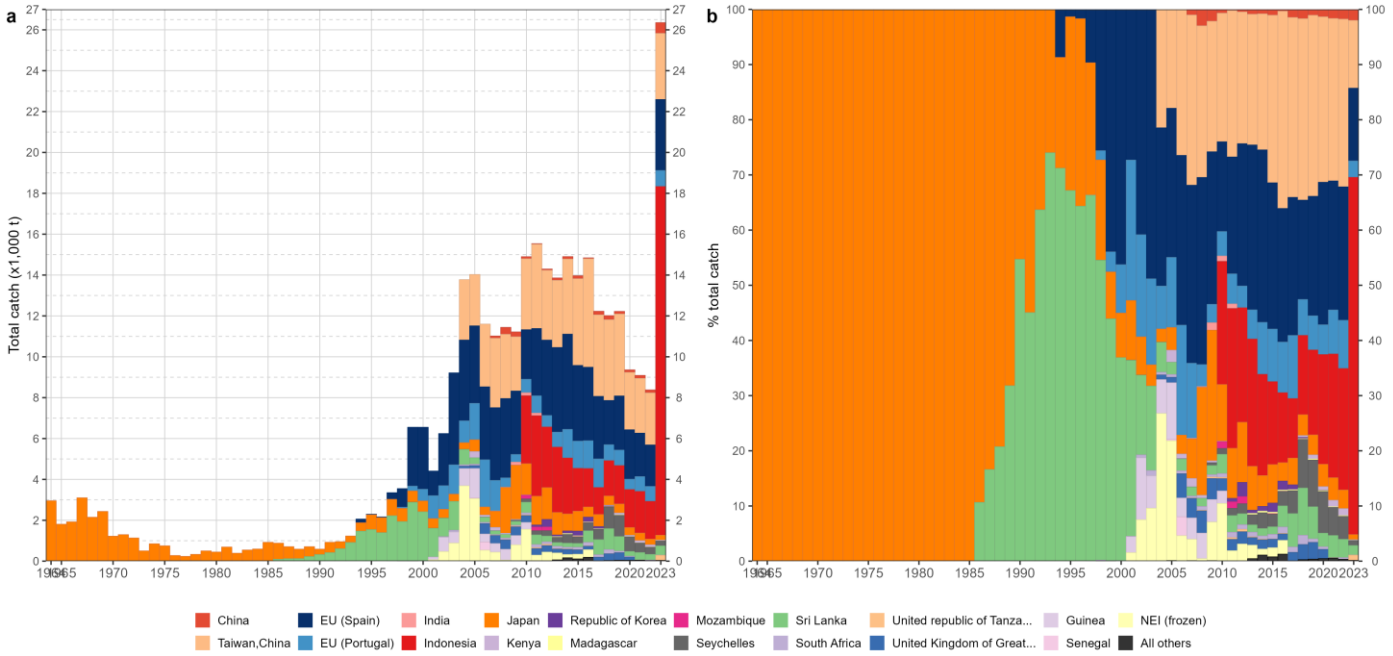

Figure 2: Annual cumulative absolute (a) and relative (b) time series of retained catches (metric tonnes; t) of blue shark by fleet for the period 1950-2023

Vulnerability to fisheries

Catches of blue shark have increased sharply from the mid-1990s, period in which longline and line fisheries accounted for more than 70% of total catches of these species (**Fig. 3**) and followed by a period of decrease since 2010.

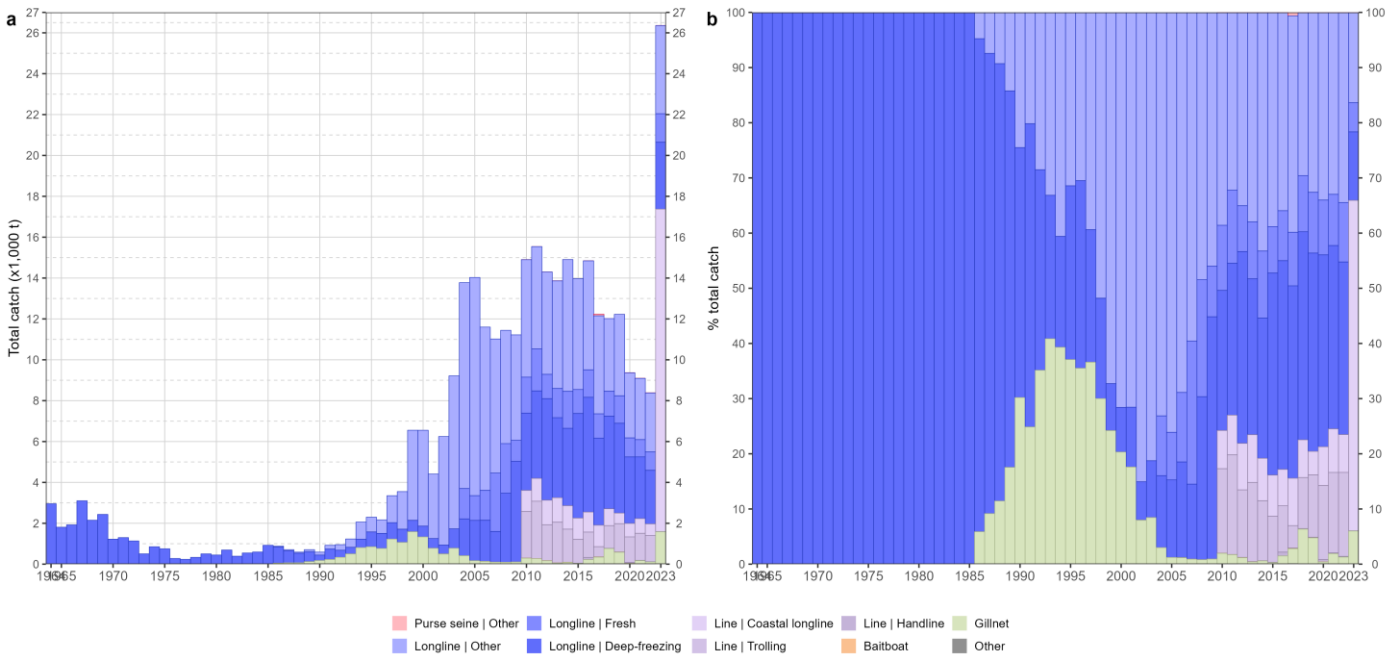

Figure 3: Annual absolute (a) and relative (b) time series of retained catches (metric tonnes; t) of blue shark by fishery for the period 1950-2023. 'Other' corresponds to all other fisheries combined

Table 1: Blue shark catches (metric tonnes; t) by year and fishery in the period 2014 to 2023.

Fishery	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Purse seine | Other	0	0	2	76	0	1	0	0	4	1
Longline | Other	6,447	5,421	5,334	4,799	3,555	3,987	3,185	2,998	2,885	4,312
Longline | Fresh	1,810	1,177	1,345	1,187	1,221	1,345	930	844	903	1,394
Longline | Deep-freezing	3,787	5,115	5,614	4,266	4,532	4,393	3,255	3,021	2,622	3,271
Line | Coastal longline	1,147	1,040	980	1,049	822	519	658	718	575	15,784
Line | Trolling	1,621	1,168	1,247	499	1,114	1,382	1,256	1,326	1,275	7
Line | Handline	3	7	102	13	9	14	41	12	11	3
Baitboat	1	0	0	2	0	1	1	0	0	0
Gillnet	80	31	217	332	761	579	30	170	103	1,582
Other	8	8	4	11	2	4	7	3	4	0
Total	14,904	13,968	14,845	12,231	12,017	12,224	9,362	9,092	8,382	26,354

Recent fishery features (2019-2023)

Until 2022, most longline fisheries reported a decline in blue shark catches. However, this trend was reversed in 2023 with blue shark catches increasing by 70% and 30% for the EU,Spain and Taiwan,China, respectively (**Fig. 4**). Although with small amounts, China, Mauritius, Sri Lanka, and Tanzania also reported considerable increases in blue shark catches.

The sharp increase in line and gillnet catches of blue sharks in 2023 is entirely dependent on Indonesia's reported catches and is subject to review (**Fig. 4**).

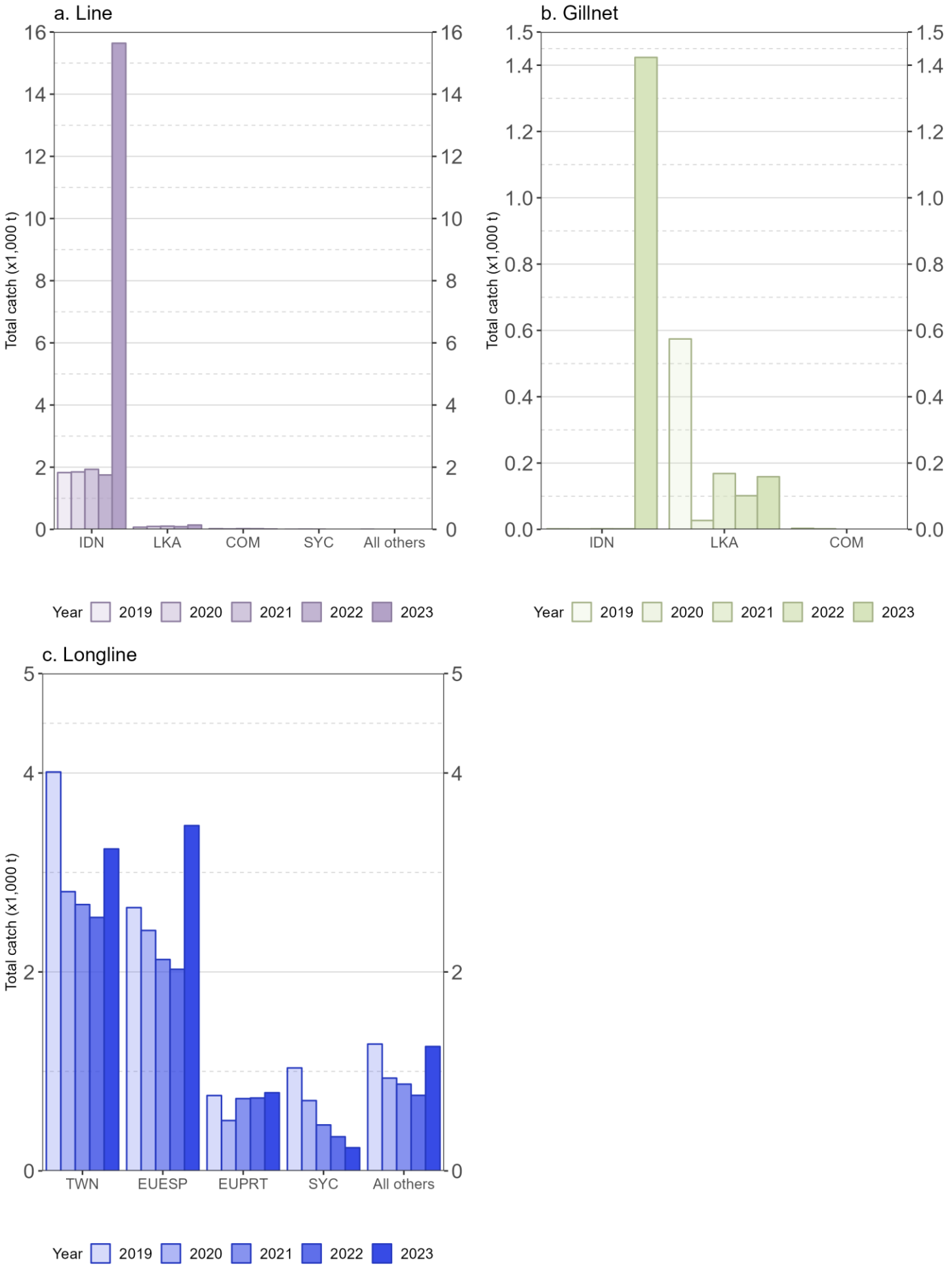

Figure 4: Annual catch trends (metric tonnes; t) of blue shark by fishery group between for the period 2019-2023

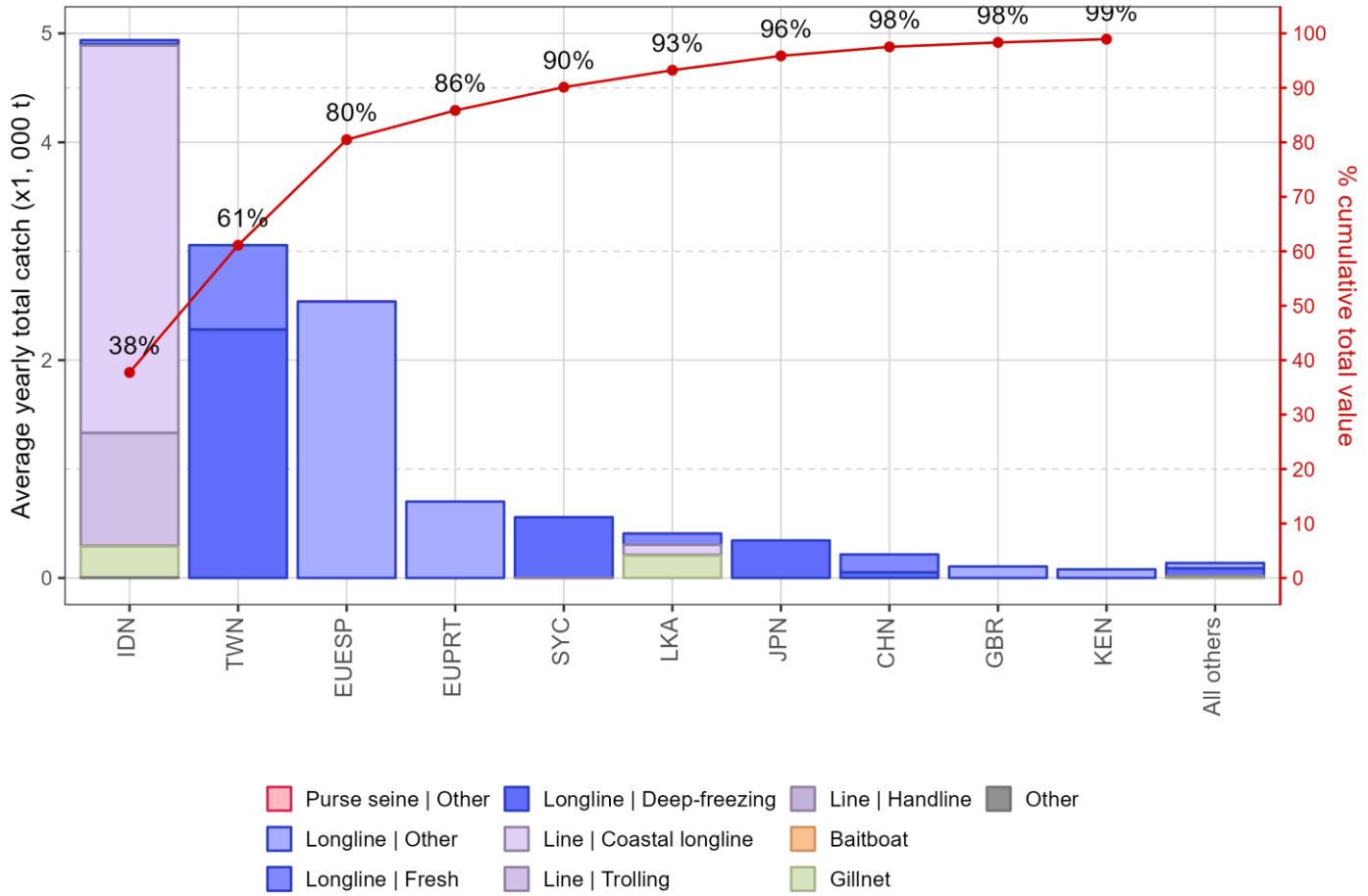

Figure 5: Average annual catch trends (metric tonnes; t) of blue shark by fleet and fishery for the period 2019-2023

Discarding practices

Longline fisheries

Data on total discards in most fisheries remain sparse and fragmented, therefore discards are inferred from observer data collected through the ROS program. The ROS data presented in this document are from EU,France, Japan, Seychelles, and Sri Lanka longline fisheries with varying years by fleet within the period 2007-2021 and which do not fully cover the longline fishing grounds. Acknowledging some differences between fleets, approximately 80% of recorded interactions with blue sharks result in discards, of which 80% of individuals are discarded alive (**Fig. 6**).

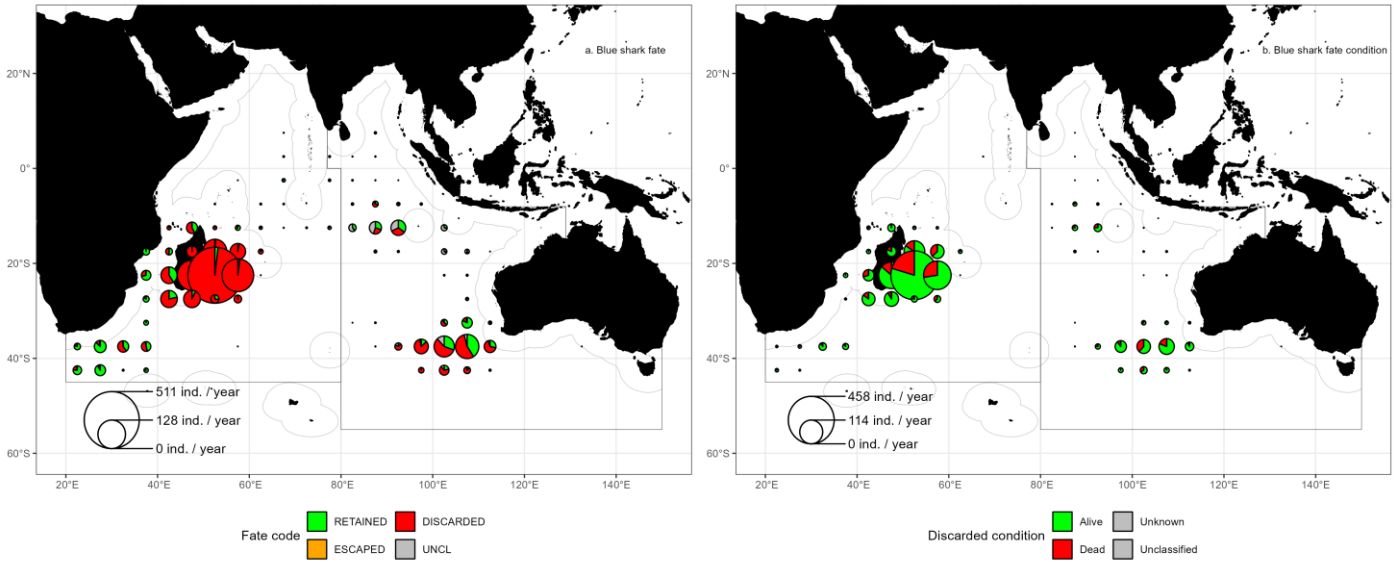

Figure 6: Mean annual number of blue shark interactions (numbers of individuals per year) with longline fisheries by fate (a) and discard condition (b) as reported to the Secretariat during the period 2009-2021

Size composition of the catch

There are two major reporting sources of size data for sharks and rays:

1) length/weight data by species, stratified by year, fleet, type of fishery, month, and 5x5 degrees grid, as per IOTC Res. 15/02 and to be reported according to the IOTC guidelines and through the recommended form 4SF, and

2) length/weight data collected through the Regional Observer Scheme programme (Res. 24/04).

Size data can be collected at sea by fishers or observers and at landing sites by staff from research institutions or the industry, and no size data derived from the analysis of pictures or videos collected through Electronic Monitoring systems has been yet reported as such to the IOTC Secretariat. Res. 15/02 states that *"size data for longline fleets may be provided as part of the Regional Observer Scheme where such fleets have at least 5% observer coverage of all fishing operations"*. Size data collected by observers could then have been reported twice to the Secretariat, although at different levels of spatio-temporal resolution, i.e., once per year, through regular submissions of fishery statistics stratified by fleet, gear, grid and month, and (when available) through the more detailed ROS data sets, which include information recorded by day / hour and exact location of capture.

The number of size samples for blue shark reported according to Res. 15/02 varies greatly between fleets and fisheries **(Table 2)**, accounting 318,933 size samples available for blue shark which around 80% are from logbooks **(Table 2).**

Table 2: Total number of fish size samples collected as per Res. 15/02 and reported at species level for blue shark covering the period 2005-2022 through IOTC forms 4SF or equivalent

		Year		Number of samples			
Fleet code	**Fishery group**	**From**	**To**	**Logbooks**	**Observers**	**Total**	**% Logbooks**
TWN	LL	2012	2023	214,185	11,584	225,769	94.87
EUPRT	LL	2011	2023	9,553	16,228	25,781	37.05
JPN	LL	2009	2020	2,389	18,897	21,286	11.22
SYC	LL	2007	2023	15,777	0	15,777	100.00
EUESP	LL	2009	2023	5,494	2,468	7,962	69.00
KOR	LL	2007	2018	3,593	3,898	7,491	47.96
ZAF	LL	2005	2023	3,004	865	3,869	77.64
LKA	GN	2005	2023	2,294	0	2,294	100.00
CHN	LL	2012	2023	993	578	1,571	63.21
GBR	LL	2017	2019	0	1,463	1,463	0.00
KEN	LL	2023	2023	0	1,414	1,414	0.00
LKA	LI	2018	2021	886	0	886	100.00
LKA	LL	2017	2023	763	0	763	100.00
MDG	LL	2018	2019	690	0	690	100.00
IDN	LL	2018	2022	287	395	682	42.08
EUREU	LL	2016	2023	0	542	542	0.00
IDN	LI	2019	2021	414	0	414	100.00
COM	LI	2019	2023	142	0	142	100.00
LKA	PS	2022	2022	39	0	39	100.00
MOZ	LI	2015	2015	34	0	34	100.00
MOZ	LL	2015	2015	34	0	34	100.00
MUS	LL	2018	2019	15	0	15	100.00
EUMYT	LL	2017	2017	0	13	13	0.00
EUREU	LI	2023	2023	1	0	1	100.00
IDN	GN	2020	2020	1	0	1	100.00

Blue shark size data from deep-freezing longliners appear to be consistent between observer and non-observer data indicating a median fork length of about 175 cm **(Figs. 7-8)**. Size data collected for blue shark by observers onboard longliners targeting swordfish show a distribution described by a median fork length of 182 cm, which is smaller than the median of the sizes collected by other enumerators (222 cm) **(Figs. 7-8)**. The fresh longliners also show differences

between the median fork length reported by observers on board (157 cm) and by enumerators (182 cm) **(Figs. 7-8)**. However, in all three cases, it is necessary to consider the sample design and size obtained by observers vs. enumerators, 55,148 vs. 216,156 for deep-freezing longliners, 3,023 vs. 16,314 for longliners targeting swordfish, and 172 vs. 23,869 for fresh longliners.

For the remaining fisheries without observer length data, the average reported fork lengths are 187 cm for gillnet fisheries, 162 cm for handline fisheries and 130 cm for coastal longlines, with small sample sizes for some fleets **(Table 1; Fig. 9).**

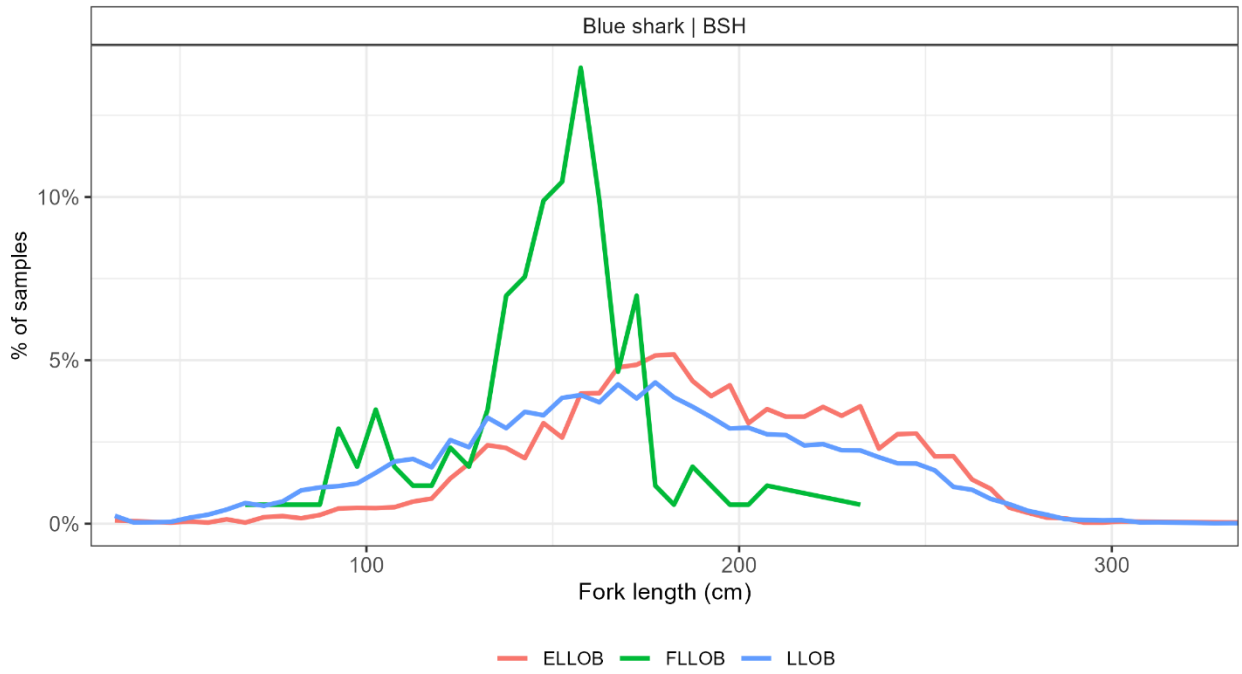

Figure 7: Relative distribution of fork lengths (cm) by 5 cm classes for blue shark sampled by observers in longline fisheries

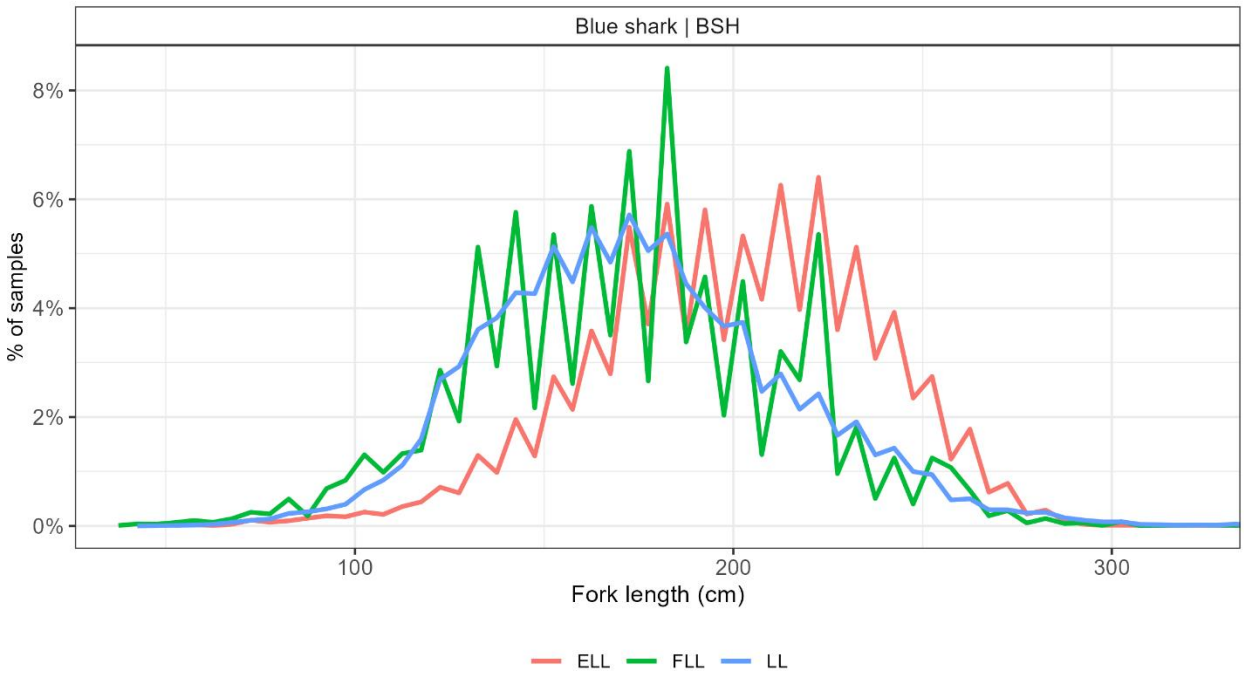

Figure 8: Relative distribution of fork lengths (cm) by 5 cm classes for blue shark sampled by enumerators in longline fisheries

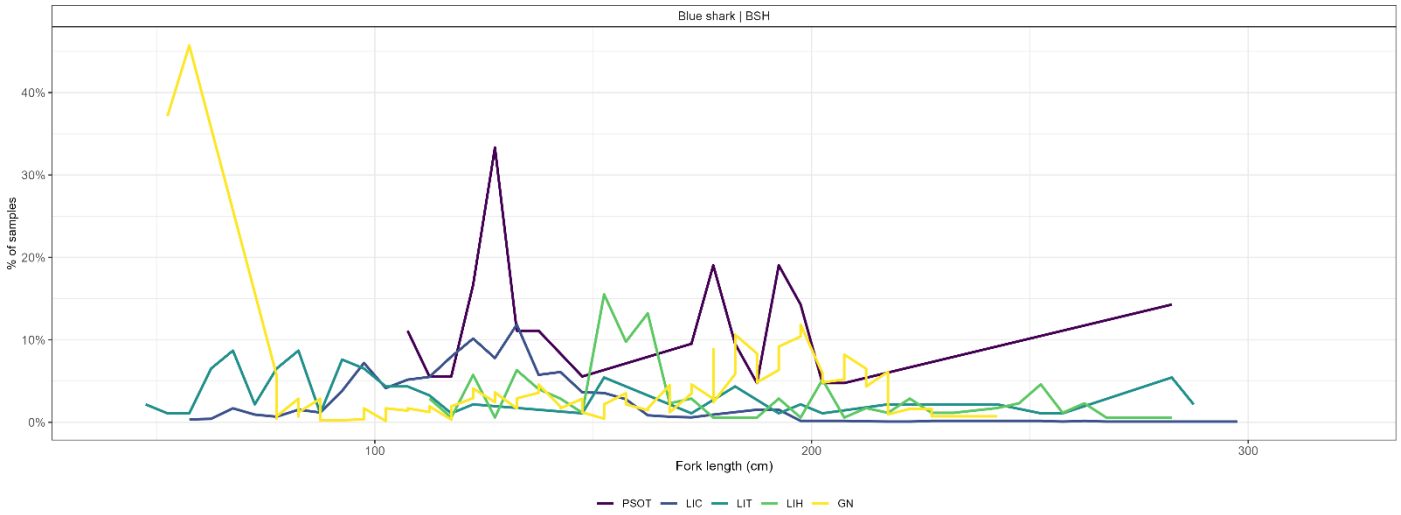

Figure 9: Relative distribution of fork lengths (cm) by 5 cm classes for blue shark sampled by enumerators in other fisheries

There are some major outstanding issues in the reporting of size data:

- **Gillnet fisheries of I.R. Iran and Pakistan**: to date, I.R. Iran and Pakistan have not reported size-frequency data of sharks species caught by their gillnet fisheries;
- **Longline fisheries of India, Malaysia, and Oman**: to date, these countries have seldom or not at all reported size-frequency data of shark species caught by their longline fisheries.
- **Coastal fisheries of India, Indonesia, Madagascar, and Yemen**: to date, these countries have seldom or not at all reported size-frequency data for their coastal fisheries. Madagascar reported size-frequency data for blue shark, silky shark, and smooth hammerhead shark for 2018-2020, and Indonesia for blue shark and silky shark for 2019-2020.

On the other hand, Eu,Portugal returned to reporting size data after 4 years, due to the restrictions on the deployment of on-board observers as a consequence of the Covid19, and Kenya reported blue shark size data for the first time, also from observers.

Spatial information on sharks and rays' catches

Geo-referenced catches of sharks and rays are reported both in number of fish and total weight and generally represent only a subset of the annual retained catches reported by fleet and gear for each species. Due to the general lack of information on the size composition of the catch, these cannot be converted into a common unit and therefore spatial distribution maps of catches are provided both in numbers and in weight. Overall, the distribution of the catches of sharks and rays shows the increasing improvements of data reporting over time, with data becoming available for more shark and ray species from an increasing number of CPCs and fisheries over the last four decades.

Spatial information available on retained catches of blue shark in numbers starting on the 2000s and is mostly reported from longliners of China, Japan, Seychelles and Taiwan,China (**Fig. 10**). Most of the fleets capturing blue shark increased the reporting of georeferenced catches in weight along the decades **(Fig. 11).** Nevertheless, although Eu,Spain is one of the main longline fleets retaining blue shark, the georeferenced catches are poorly reported, with data provided only in 2020 (**Figs. 12, 13**).

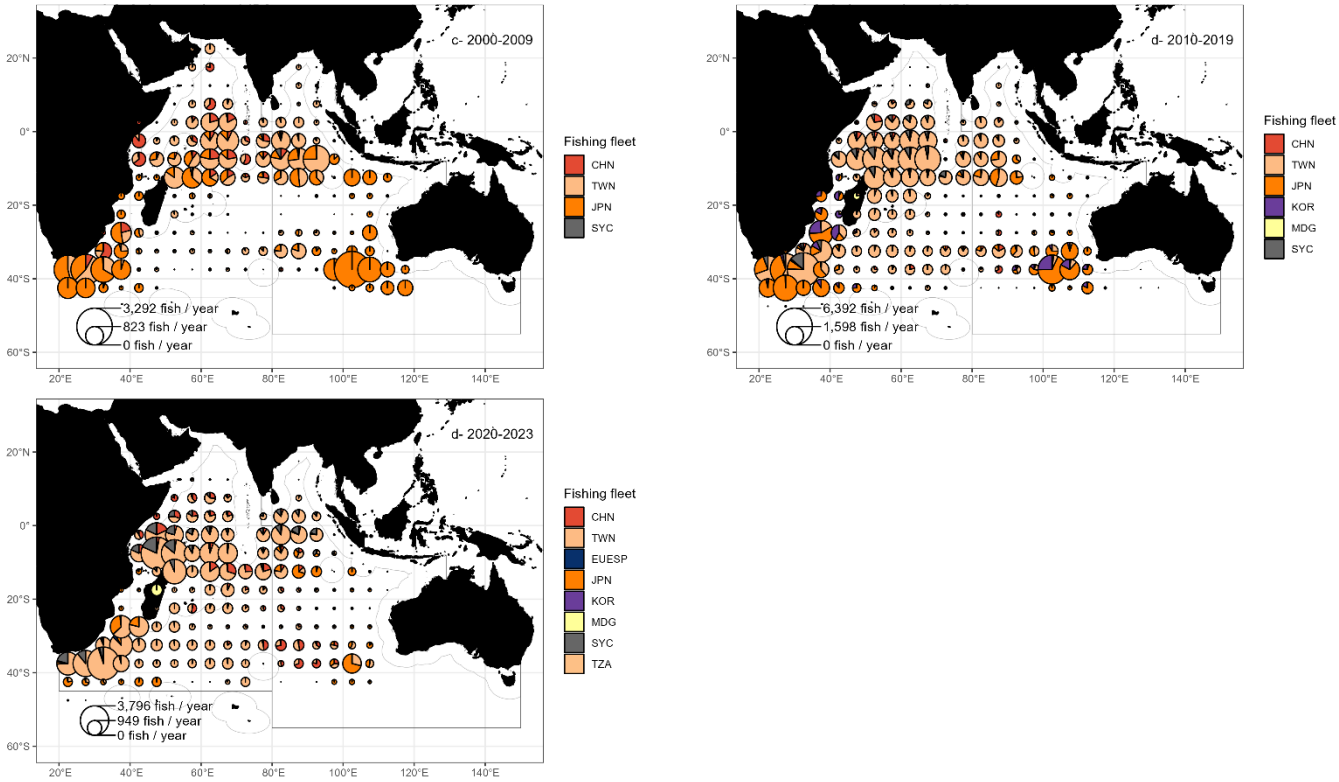

Figure 10: Mean annual geo-referenced catches by number of blue sharks by fishing fleet and decade reported to the Secretariat.

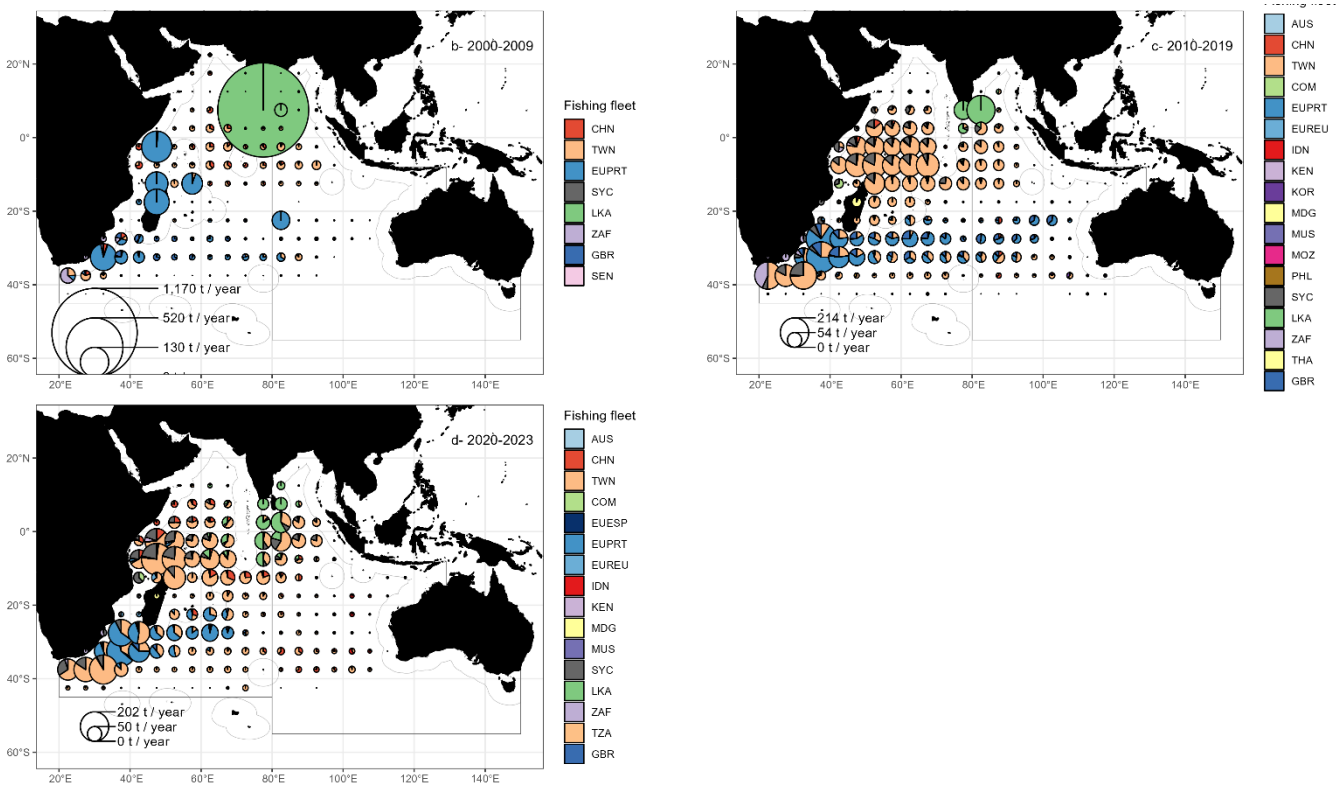

Figure 11: Mean annual geo-referenced catches by weight (metric tonnes; t) of blue sharks by fishing fleet and decade reported to the Secretariat.

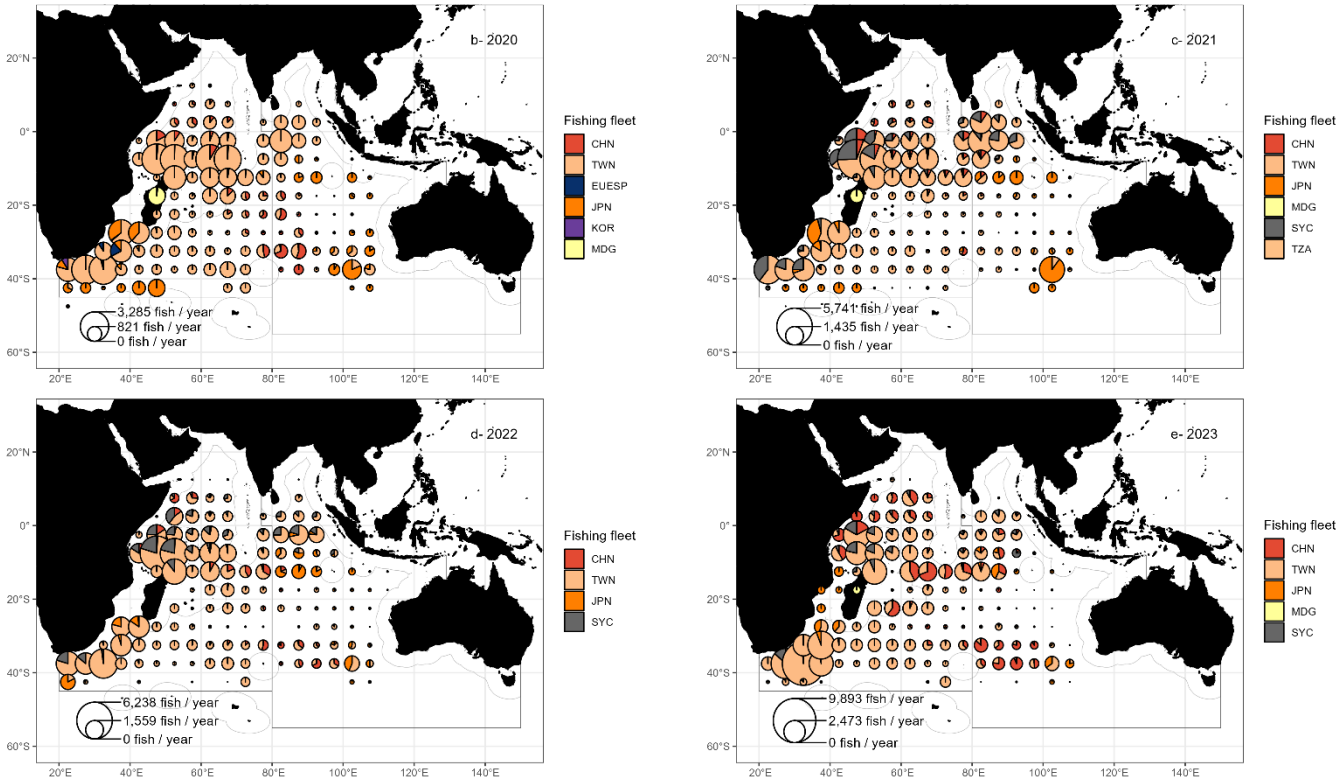

Figure 12: Mean annual georeferenced catches by number of blue sharks by fishing fleet and year reported to the Secretariat from 2020 to 2023.

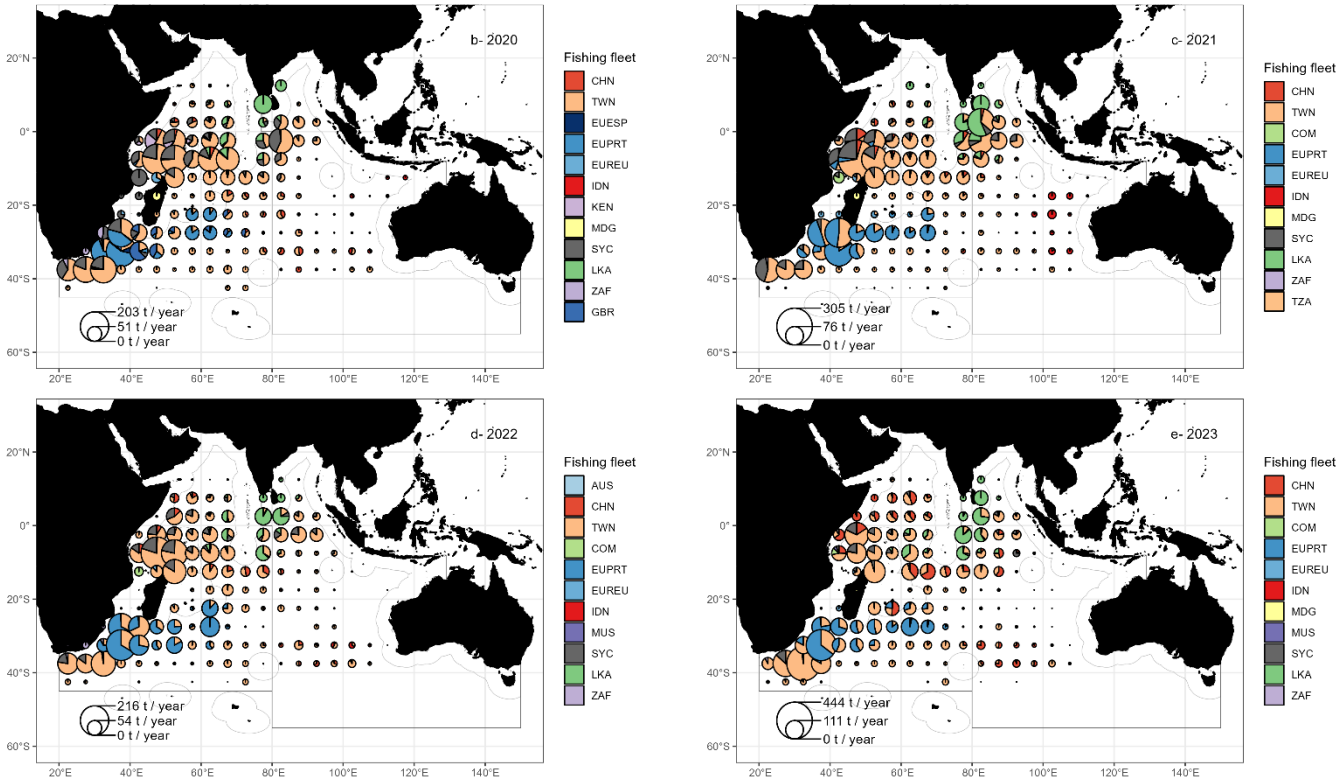

Figure 13: Mean annual georeferenced catches by weight (metric tonnes; t) of blue shark by fishing fleet and year reported to the Secretariat from 2020 to 2023.

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