SILKY SHARK (*CARCHARHINUS FALCIFORMIS*)

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Taxonomy

Silky shark (*Carcharhinus falciformis*) is a species in the Kingdom Animalia. The scientific name is derived from the Latin 'falciformis' meaning sickle-shaped in reference to the outline of the dorsal and pectoral fins. The common name refers to the fine texture of the skin of this species compared with other sharks, a result of its densely packed, tiny dermal denticles. Silky shark is a member of the genus Carcharhiniformes which is the largest order of sharks, comprising 26 species.

Table 1. Taxonomic hierarchy and nomenclature (source: ITIS)

Kingdom	Animalia
Subkingdom	Bilateria
Infrakingdom	Deuterostomia
Phylum	Chordata
Subphylum	Vertebrata
Infraphylum	Gnathostomata
Superclass	Chondrichthyes
Class	Chondrichthyes - cartilaginous fishes, rays, sharks
Subclass	Elasmobranchii - cartilaginous fishes, rays, sharks, skates, torpedoes
Superorder	Euselachii
Order	Carcharhiniformes
Family	Carcharhinidae
Genus	Carcharhinus
Species	Carcharhinus falciformis

Synonyms:

- *Aprionodon sitankaiensis* Herre, 1934
- *Carcharhinus atrodorsus* Deng, Xiong and Zhan, 1981
- *Carcharhinus floridanus* Bigelow, Schroeder and Springer, 1943
- *Carcharias falciformis* Müller and Henle, 1839
- *Eulamia malpeloensis* Fowler, 1944

Common names: Silky shark [English]; Requin soyeux [French]; Tiburón piloto [Spanish]; Jaquetón [Spanish]

Distribution & habitat

Geographic range

Silky shark (*Carcharhinus falciformis*) (Müller and Henle, 1839) is one of the most common semi-pelagic sharks inhabiting warm tropical and subtropical waters throughout the world (**Fig. 1**).

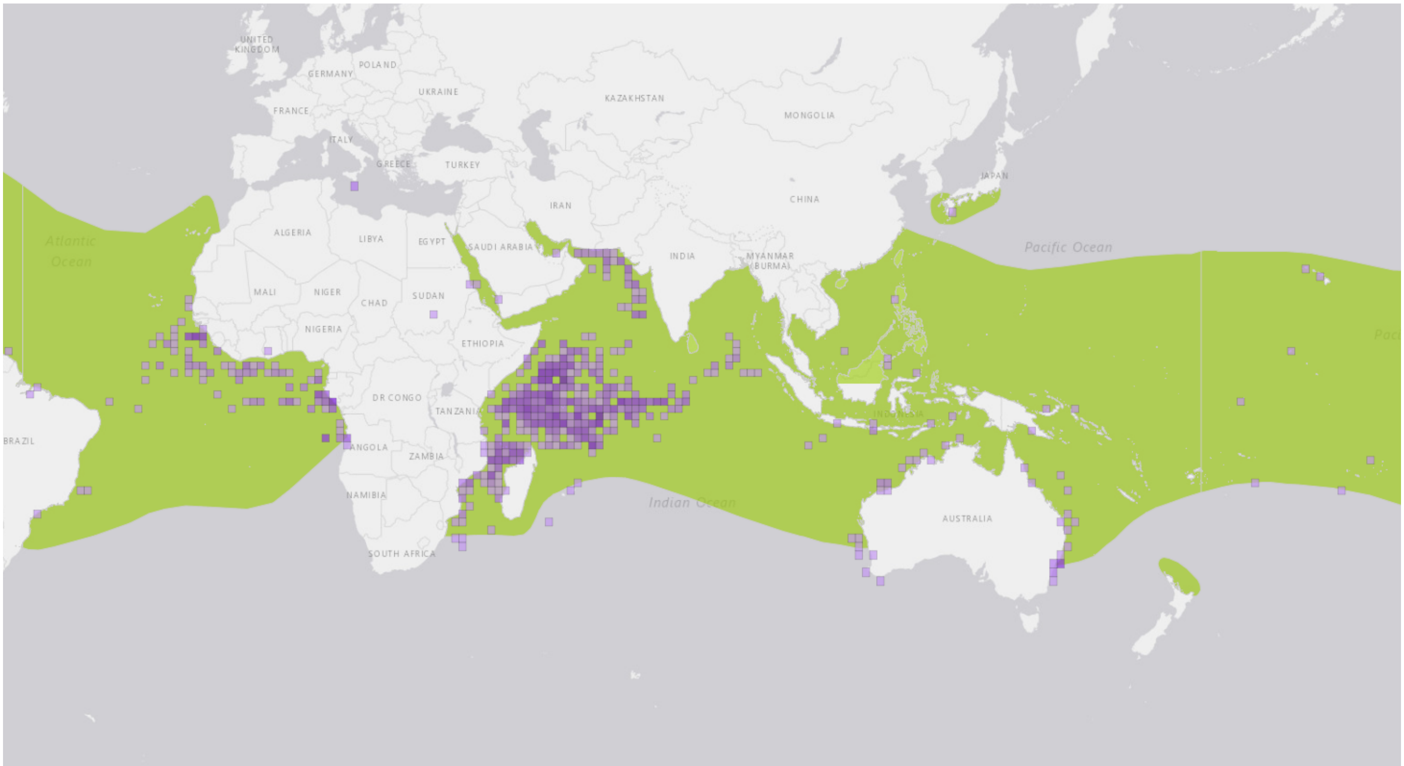

Fig. 1. Global distribution of silky shark according to IUCN expert range maps (green envelope) and observations recorded in the Global Biodiversity Information Facility (purple squares). Source: www.mol.org

Essentially pelagic, the silky shark is distributed from slopes to the open ocean. It also ranges to inshore areas and near the edges of continental shelves and over deep-water reefs, demonstrating strong fidelity to seamounts and natural or man-made objects (like Fish Aggregating Devices) floating at the sea surface. Silky sharks live down to 500 m: typically, smaller individuals are found in coastal waters but have also been regularly reported in open ocean environments (Filmalter et al. 2015). Small silky sharks are also commonly associated with schools of tuna, particularly under floating objects while large silky sharks associate with free-swimming tuna schools. Silky sharks often form mixed-sex schools containing similar sized individuals. The area of overlap with the IOTC management area is high (**Fig. 1**) and no information is available on stock structure.

Movements & migrations

A recent biotelemetry tagging study on silky sharks in the Chagos archipelago concluded that many silky sharks show a degree of site fidelity but can also undergo long distance migrations (one tagged individual moved more than 4,500 km track distance all the way to the coast of Kenya) (Curnick et al. 2020).

Acoustic telemetry experiments combined with satellite tags deployed on juvenile silky sharks (77-116 cm TL) in the Indian Ocean showed they could stay associated with drifting floating objects for periods varying between 3 and 30 days (Filmalter et al. 2015). These experiments showed that small silky sharks exhibit highly variable vertical behaviour during the night while vertical movements appear more restricted during the day, with the sharks being mainly located between 0 and 40 m deep most of the time (Dagorn et al. 2007, Filmalter et al. 2011, 2015, Forget et al. 2015).

Curnick et al. (2020) showed that larger silky sharks (148-169 cm TL) also undertake diel vertical migrations and oscillatory diving behaviour, diving to depths greater than 300 m (down to 1,112 m, the deepest ever recorded for this species) but spending the majority of their time (>99%) in the top 100 m of the water column. These movements overlap directly with typical deployment depths of purse seine and longline sets in the Indian Ocean. The diel variations are thought to be a result of night-time feeding excursions by the sharks (Filmalter et al. 2017).

Biology

Growth & morphometrics

The maximum age of silky shark has been estimated to be 20+ years for males and 22+ years for females (Branstetter 1987, Hall et al. 2012, Varghese et al. 2016), while in the Pacific area it was estimated to be around 25-28 years (Oshitani et al. 2003, Grant et al. 2018).

The maximum size the species can reach is 350 cm fork length (Compagno 1984). The size of new-born pups has been estimated at around 75–80 cm TL in the eastern Indian Ocean (Hall et al. 2012), 65-67 cm TL in the Arabian Sea (Varghese et al. 2016), 56–63 cm TL in the Maldives (Anderson & Ahmed 1993) and 78–87 cm TL in Aldabra Atoll (Fourmanoir 1961, Bonfil 1993).

Length (cm) – length (cm) and length (cm) - weight (kg) relationships have been developed for Indian Ocean silky shark from samples at sea onboard longliners during commercial and scientific cruises and from samples at unloading of purse seiners (**Table 2**).

Table 2. Morphometric relationships for Indian Ocean silky shark. Dressed weight (aka carcass weight) corresponds to headed and caudal peduncle-off weight (PD), i.e. the body without head, gills, guts, tail, and fins

Source measure	Target measure	Equation type	a	b	N	Source
Fork length FL	Total length TL	$TL = a \times FL + b$	1.2168	4.4049	192	Anderson et al. 2011
Fork length FL	Total length TL	$TL = a \times FL + b$	1.2	2.9	265	Filmalter et al. 2012
Fork length FL	Total length TL	$TL = a \times FL + b$	1.1436	10.1367	520	Ariz et al. 2007
Fork length FL	Round weight RW	$RW = a \times FL^b$	4.7255-6	3.1771	369	Ariz et al. 2007
Total length TL	Round weight RW	$RW = a \times TL^b$	6.507e-6	2.9876	390	Ariz et al. 2007
Fork length FL	Dressed weight PD	$PD = a \times FL^b$	1.3e-5	2.8323	94	Ariz et al. 2007
Total length TL	Dressed weight PD	$PD = a \times TL^b$	5.66e-6	2.8897	95	Ariz et al. 2007
Fork length FL	Round weight RW	$RW = a \times FL^b$	1.6e-5	2.91497	687	Romanov & Romanova 2009

Reproduction

The silky shark is a placental viviparous species with a gestation period of around 12 months (Branstetter 1987, Bonfil 1993). Females are thought to give birth around every two years (Branstetter 1981) but there is not thought to be one main season for giving birth in the Indian Ocean (Strasburg 1958, Bass 1973, Stevens 1984, Stevens & McLoughlin 1991). The number of pups per litter has been found to range from 2-14 in the Eastern Indian Ocean (Hall et al. 2012), 3-13 in the Pacific Ocean (Oshitani et al. 2003, Grant et al. 2018), and 4–15 in the Atlantic Ocean (Hazin et al. 2007).

- Biennial reproductive cycle
- Fecundity: medium (<20 pups)
- Generation time: 11–16 years
- Gestation period: 12 months
- Maturity (Hall et al. 2012, Varghese et al. 2016)
    - Females mature at about 215-230 cm TL and males at 200-223 cm TL
    - At around 15 years for females and about 11–13 years for males.

Trophic ecology

Silky sharks are opportunistic predators, ingesting a large variety of prey types including several teleost, cephalopod and crustacean species (Cabrera-Chávez-Costa et al. 2010, Duffy et al. 2015, Filmalter et al. 2017). Variations in their diet might be mainly driven by prey abundance rather than related to ontogenetic trends (Duffy et al. 2015). In the Indian Ocean, analysis of stomach contents of 66 silky sharks caught in the eastern Arabian Sea along the coasts of India showed a highly diverse diet dominated by tuna species (~40% of the total weight), the pelagic crab *Charybdis smithii* (13%), and squids to a lesser extent (Varghese et al. 2016). Stomachs of juveniles of silky shark associated with Fish Aggregating Devices (FADs) drifting in the Western Indian Ocean showed that part of the prey was coming from the FAD-associated assemblage but that predation of non-associative free-swimming prey such as pelagic crabs and flying fishes remained the primary foraging strategy of silky shark (Filmalter et al. 2017).

A study on the isotopic niches of silky shark in the southwest Indian Ocean suggested that this species tends to forage in inshore more than offshore habitats and is a tertiary consumer (Rabehagasoa et al. 2012). These authors also suggested that FADs may act as an ecological trap for juvenile silky sharks leading to them occupying a lower trophic level than they would if not associated with a FAD as they predate more on FAD-associated prey (Duffy et al. 2015). This might not be as pronounced in the Western Indian Ocean where FAD-associated silky sharks have been shown to be able to move independently from FADs for some time and feed on pelagic prey not associated with the FADs (Filmalter et al. 2017, Bonnin et al. 2021).

Fisheries

Silky sharks are an important bycatch of pelagic longline fisheries targeting tunas and swordfish, as well as of purse seine fisheries due to their tendency to associate with tuna schools (Bonfil 2008, Watson et al. 2009, Gilman 2011). Little information is available on the survival of silky sharks released at sea in Indian Ocean longline fisheries (Coelho et al. 2011) but mortality has been estimated at around 15-20% in other fisheries (Musyl & Gilman 2018, Schaefer et al. 2021). Silky sharks, in particular juveniles, have a high propensity to associate with floating objects which makes them susceptible to FAD fishing, where they have been found to comprise as much as 95% of total elasmobranch bycatch (Ruiz et al. 2018, Clavareau et al. 2020). Rates of mortality for silky sharks caught as bycatch in purse seine fisheries are high, at around 85% in the Indian Ocean (Poisson et al. 2014a). Guidelines for good practices have been developed to tackle the issue of shark bycatch mortality in purse seine fisheries and some progress has been made over the last decade (Poisson et al. 2014b, Grande et al. 2019). FADs have also been shown to be a potentially important source of ghost mortality for silky sharks when they are entangled in the net webbing used in FAD sub-surface structure (Filmalter et al. 2013). Improved FAD design (e.g. “sausage” nets used for tails) and changes in components are considered to have substantially reduced this source of mortality in recent years (Grande et al. 2019) although the impact of these measures is difficult to assess. Besides, silky sharks have been the target of artisanal and semi-industrial fisheries, for both local meat markets and the international fin market (see section Markets).

Information on silky shark catches prior to the 1990s is scarce due to the lack of data collection and reporting. In addition, several shark species have been reported to the IOTC as species aggregates (e.g. *various sharks NEI*), preventing the compilation of historically accurate time series of catches (**Fig. 2**).

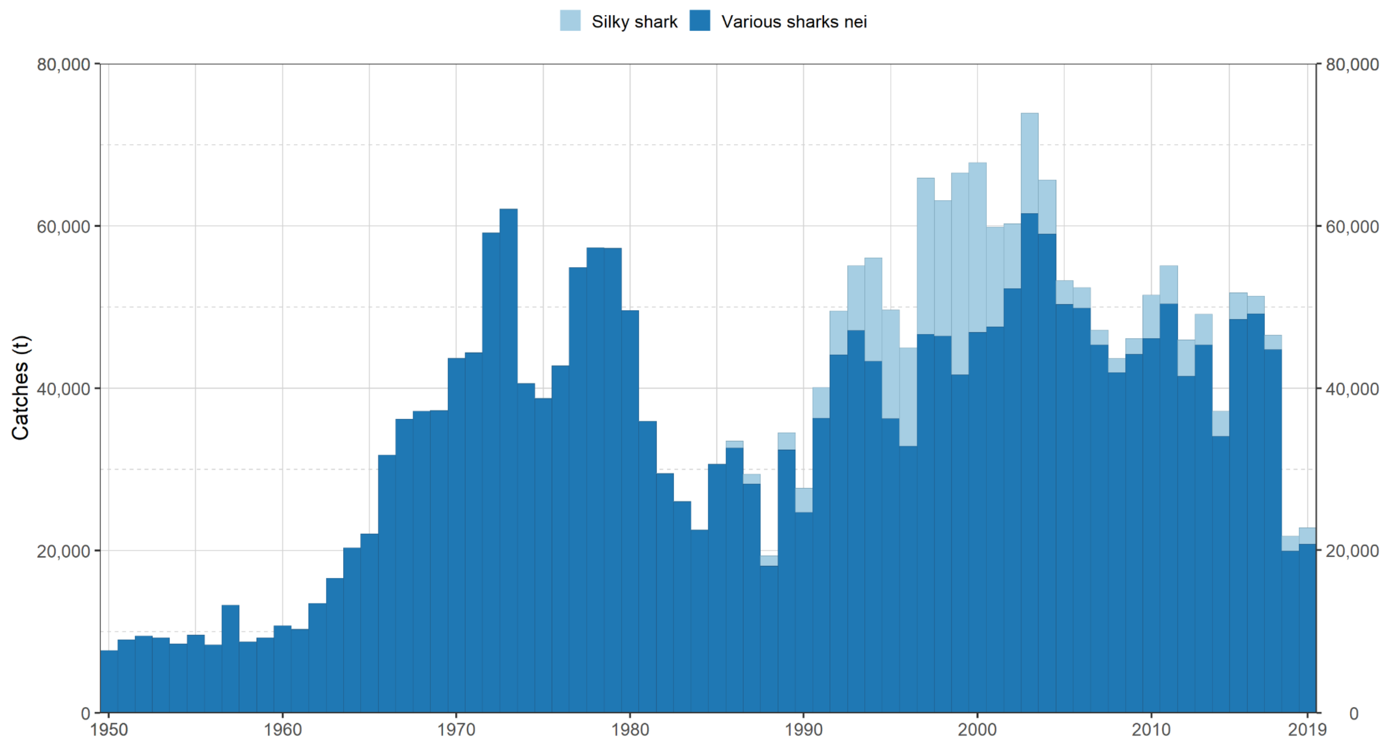

Fig. 2. Annual nominal catches reported for silky shark and unidentified shark species possibly including silky shark in IOTC fisheries during 1950-2019

It is likely that many catch records under-represent the actual catches of silky sharks because most CPCs do not monitor and/or report 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 record dressed weights instead of live weights. Therefore, the nominal catches for silky sharks reported to the IOTC Secretariat are thought to be incomplete and highly uncertain, as is their utility in terms of minimum catch estimates.

In the past, possible silky shark catches for fleets/countries have been estimated based on the ratio of shark catch over target species by *métier* (Murua et al. 2013). This estimation was based on nominal catches of target species from the IOTC database under the assumption that target catches are correctly declared. The study highlighted that the catch data on silky sharks in the IOTC database may be considerably underestimated, i.e., total estimated catches were approximately 10 times higher than those declared in the IOTC database (Murua et al. 2013).

The practice of shark finning is still considered to be regularly occurring for this species (Fields et al. 2018, Cardeñosa et al. 2020).

Catch trends & distribution

The trend in nominal catches of silky sharks available to the IOTC is mostly driven by Sri Lankan fisheries (**Fig. 3a**). From the early 1980s, Sri Lanka progressively developed an offshore tuna fishery composed of gillnetters and longliners that started to preferentially target sharks from the 1990s with the advent of the lucrative shark fin export trade (Joseph 1999). This explains the major increase in catches of silky sharks observed from the mid 1980s, reaching a maximum of about 25,000 t in 1999 (**Fig. 3a**). Following the adoption of the 1999 FAO International Plan of Action-Sharks, the Fisheries Act of Sri Lanka was modified so that fisher had to land the fins attached to the carcasses of all shark and skate species (Herath 2012). This explains the notable reduction in Sri Lankan catches of silky shark observed in the early 2000s, the 5% fin-to-carcass ratio being imposed in the whole Indian Ocean in 2005 (IOTC Res. 05/05). It is to note that Sri Lanka was the only CPC that reported important nominal catches of silky shark to the IOTC between 1986 and the early 2010s. Since 2012, catches of silky shark have been mainly reported for gillnet fisheries from Pakistan, Sri Lanka, and I. R. Iran, representing in 2019 25%, 40% and 35% of the silky shark reported catches, respectively (**Fig. 3a**).

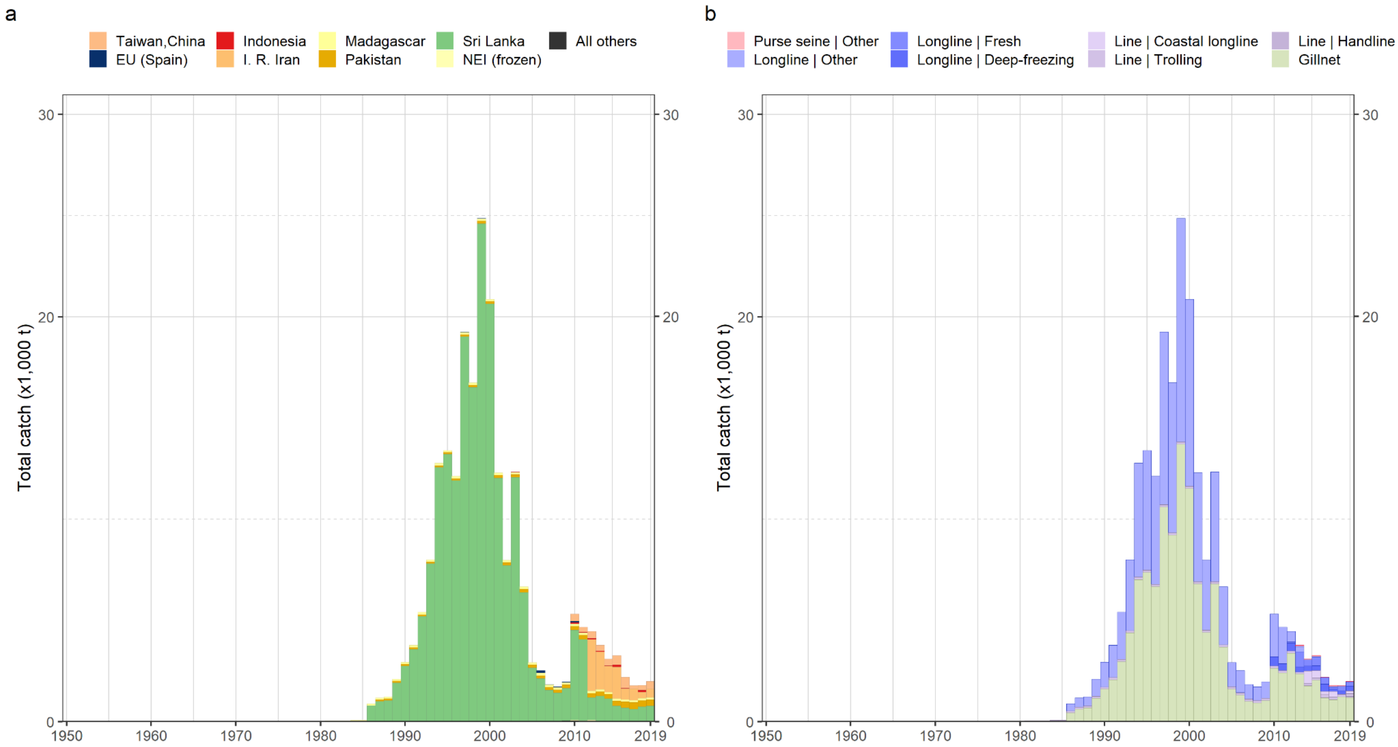

Fig. 3. Annual time series of nominal catches (t) of silky shark (a) by main fishing fleet and (b) fishery during 1950-2019

Georeferenced catches in weight of silky shark have been reported since 1994 and are mainly dominated by gillnet fisheries, consistently with the pattern observed in the nominal catches. After that, the composition of georeferenced reported catches in weight includes various types of purse seine, line and longline fisheries (**Fig. 4 - Top panel**). The coverage of georeferenced catches in weight in relation with nominal catches reported in 2019 are 89% for purse seiners, 77% for longliners, 50% for line and 40% for gillnet fisheries, respectively. Also, since 2009 georeferenced catches in numbers have been reported for longline fisheries, essentially by Taiwan,China (**Fig. 4 - Bottom panel**).

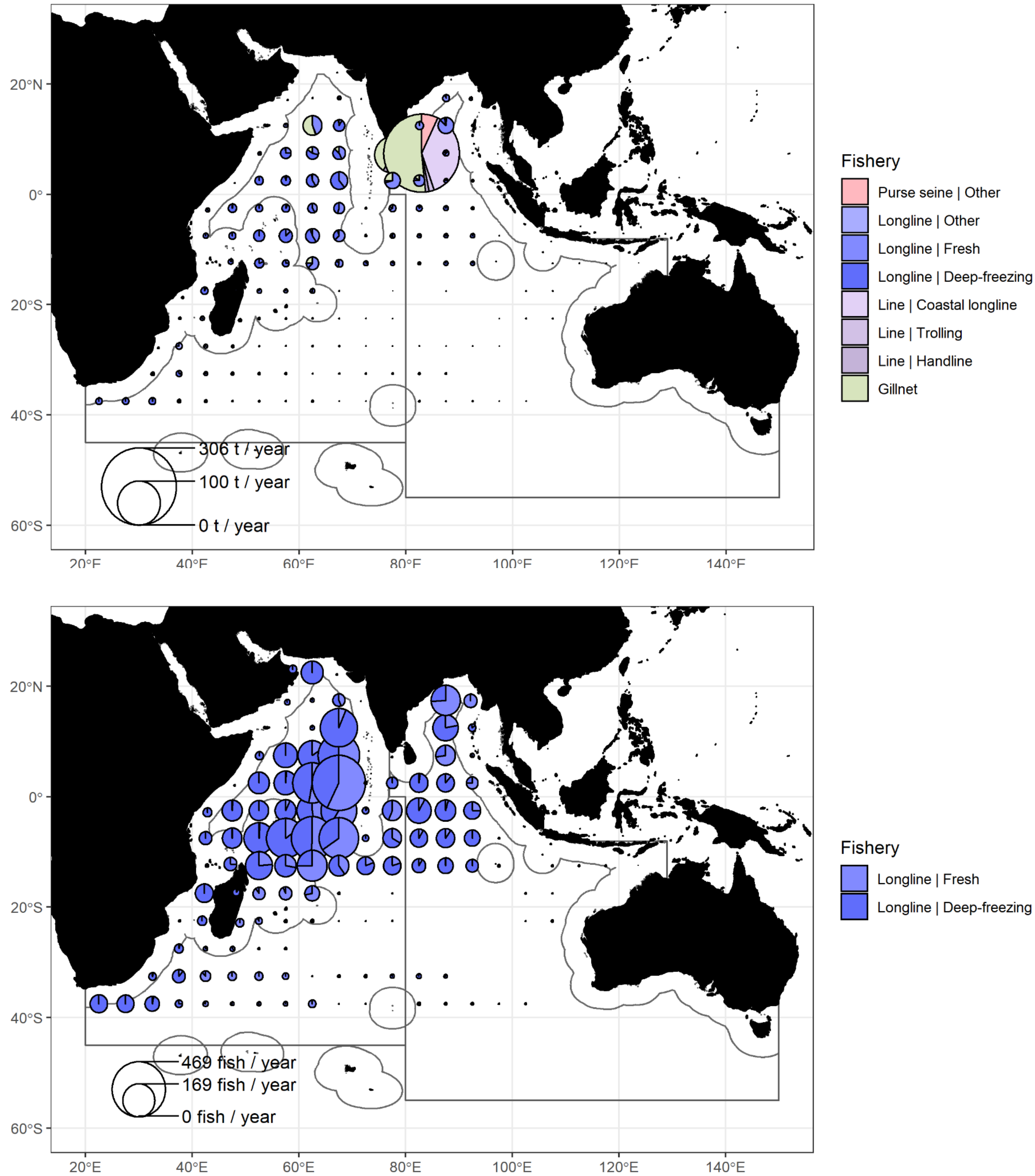

Fig. 4. Spatial distribution of mean annual catches of silky shark by fishery by (top panel) weight (t) and (bottom panel) number as reported for the period 2010-2019

Size composition

More than 15,000 size samples from catches of silky shark have been reported to the IOTC by 10 CPCs during 2009-2015, with the majority coming from Taiwan,China and Sri Lanka. The data set includes a small component of size data (4.4%) collected at sea by scientific observers onboard Asian longliners and purse seiners. After converting size data into fork length and excluding the size data collected onboard industrial purse seiners (see below), the distributions available from the remaining 14,112 size data highlight the difference in selectivity between fisheries (**Fig. 5**). Deep-freezing and fresh longline fisheries catch a large size range of silky sharks, with median fork lengths at 175 cm (~55 kg) and 160 cm (~42 kg), respectively. The few size samples available for EU longliners targeting swordfish (n = 77) suggest they catch smaller silky sharks, described by a median fork length of 125 cm (~20 kg). Size data from Sri Lankan gillnetters indicate this fleet may catch silky sharks in the same size range as swordfish-targeting longliners (85-170 cm FL), although more data are required as the distributions are based on few samples. Finally, the few samples available for Sri Lankan ringnetters (n = 168) indicate that the silky sharks caught with small purse seines in this fishery are mainly juveniles with a median fork length of 113 cm (~15 kg) and a maximum fork length less than 200 cm (**Fig. 5**).

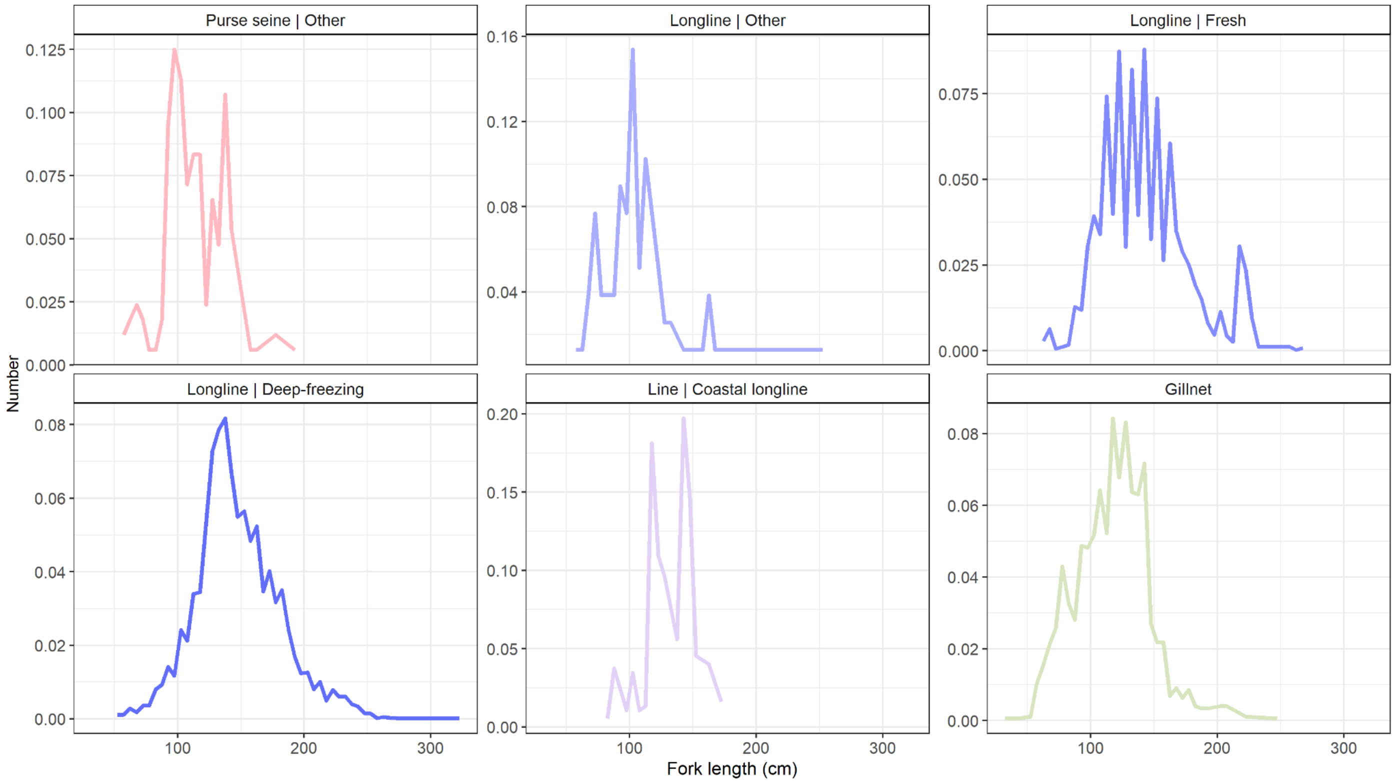

Fig. 5. Relative fork length frequency distributions (%) of silky shark derived from the samples reported between 2005 and 2019 in 5 cm length classes

Finally, size data of silky sharks caught by industrial purse seiners are available from observations at sea made by scientific observers who sampled about 30,000 fish for length during 2005-2019. Silky shark sizes show very similar distributions for the fleets of EU,Spain, EU,France, and Seychelles with a median fork length of 130-145 cm (**Fig. 6**).

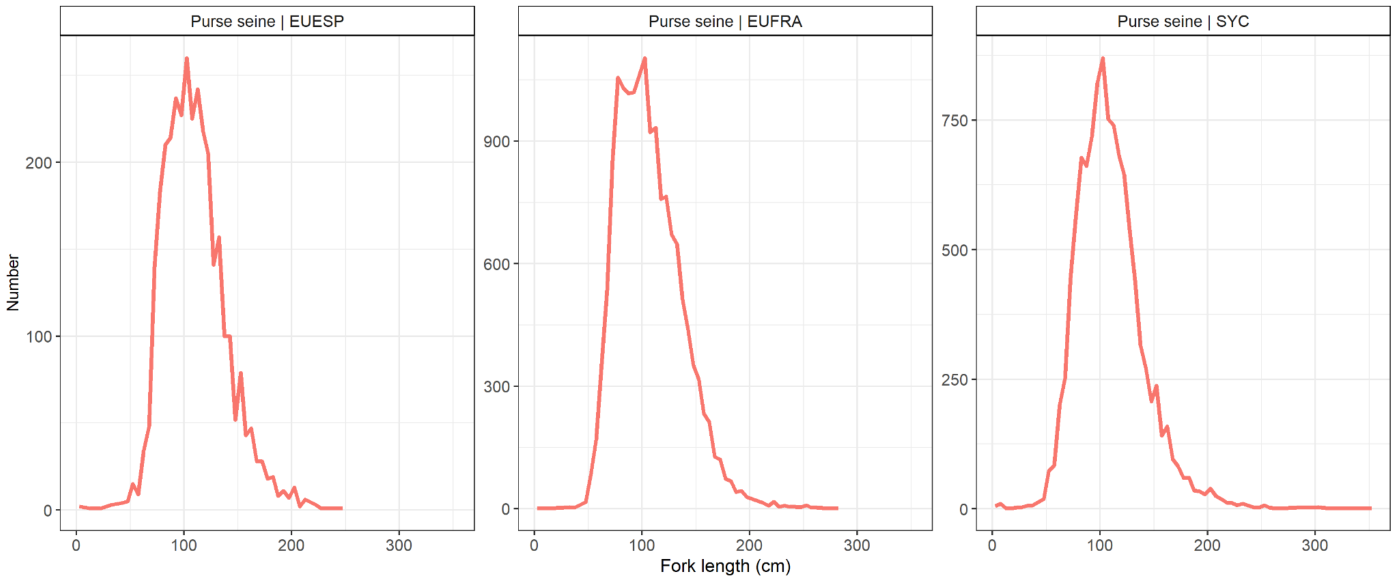

Fig. 6. Fork length frequency distributions (numbers) of silky shark derived from observer samples reported between 2005 and 2019 in 5 cm length classes

Silky shark interactions by fishery (ROS data)

The recorded interactions of silky sharks with purse seiner and longline fisheries were recorded by observers and classified by fate condition. According to currently available ROS data, 98% of silky sharks interactions recorded by purse seiners were of discarded specimens (**Fig. 7 - Top panel**). For longline fisheries, 85% of the interactions were recorded as discards, 8.5% as retained and 56 as unclassified (**Fig. 7 - Bottom panel**).

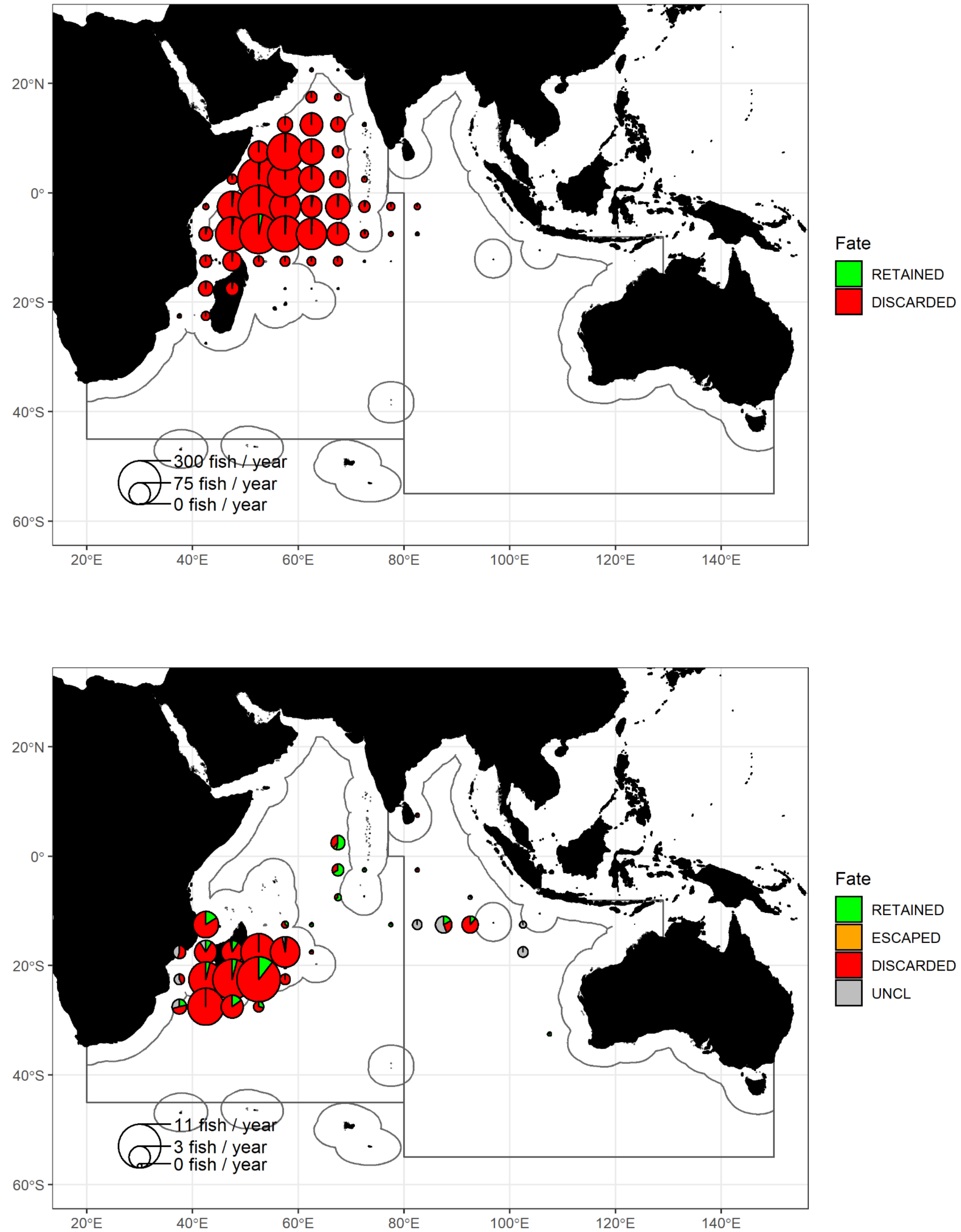

Fig. 7. Silky shark interactions with (top panel) purse seine and (bottom panel) longline fisheries from 2005 to 2019

Markets

The markets for sharks have previously been mostly focused around shark fins but since the relatively recent introduction of various anti-finning regulations around the world - which aim to encourage the full utilization of sharks - the market for shark meat has risen considerably. This has led to an increase in targeting of sharks rather than them only being caught as bycatch in other fisheries including those targeting tunas (Dent & Clarke 2015). However, shark fins (which are among the most expensive seafood items globally) have retained a considerably higher value than shark meat.

Internationally, there are largely distinct markets for meat and fins. However, due to the aggregation of both, there is a paucity of trade data to distinguish the two product types, meaning that a separate analysis of the markets is challenging (Dent & Clarke 2015). The vast majority of shark fins end up in countries in East and Southeast Asia while for shark meat there is a broader range of destinations for the products, with the largest consumers of meat found in South America and Europe (Dent & Clarke 2015).

Silky shark is on Appendix II of CITES, meaning that the species is protected in at least one country which has asked other CITES Parties for assistance in controlling the trade of the species.

In addition to the global trade of shark products, it is believed that elasmobranch subsistence fisheries are active in parts of the Indian Ocean, such as along the coast of Madagascar (McVean et al. 2006, Robinson & Sauer 2013).

Assessment & Management Measures

Stock assessment

In absence of information on population structure, one single stock unit is considered in the Indian Ocean. No quantitative stock assessment for Indian Ocean silky shark has been undertaken by the IOTC Working Party on Ecosystems and Bycatch.

Silky shark has been assessed by IUCN to be Vulnerable.

The ecological risk assessment (ERA) conducted for the Indian Ocean by the WPEB and SC in 2018 consisted of a semi-quantitative risk assessment analysis to evaluate the resilience of shark species to the impact of a given fishery by combining the biological productivity of the species and its susceptibility to each fishing gear type. Silky sharks received a high vulnerability ranking (No. 2) in the rank for longline gear as it was estimated to be one of the least productive shark species and with a high susceptibility to longline gear. Silky shark was also estimated to be the fifth most vulnerable shark species in the ERA ranking for purse seine gear, due to its low productivity and high susceptibility to purse seine gear (Murua et al. 2018).

Conservation and Management Measures

Silky 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 silky sharks must be recorded by longline and purse seine fleets (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 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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