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ICCAT Manual
INTERNATIONAL COMMISSION
FOR THE CONSERVATION OF ATLANTIC TUNAS

CHAPTER 2.2.1.10: SILKY SHARK	**AUTHORS: R. FORSELLEDO, A. DOMINGO, F. MAS AND P. MILLER**	**LAST UPDATED: August 2022 (Original: Spanish)**

2.2.1.10 Description of the silky shark (FAL)

1. Names

1.a Classification and taxonomy

Species name: *Carcharhinus falciformis* (Müller and Henle, 1839).

Etymology: The name of the Genus Carcharhinus comes from the Greek "*karcharos*", meaning "sharp", and "*rhinos*", meaning "nose". The name of the species falciformis comes from Latin and means "sickle-shaped", alluding to the shape of the dorsal and pectoral fins (Bonfil, 2008).

One of the species' common names - silky shark - comes from the smooth texture of its skin compared to other sharks, resulting from its densely packed miniscule dermal denticles (Bonfil, 2008).

Synomyms: *Aprionodon sitankaiensis* (Herre, 1934), *Carcharhinus atrodorsus* (Deng, Xiong and Zhan, 1981), *Carcharhinus floridanus* (Bigelow, Schroeder and Springer, 1943), *Carcharhinus menisorrah* (Valenciennes, 1839), *Carcharias menisorrah* (Valenciennes, 1839), *Carcharias falcipinnis* (Lowe, 1839), *Carcharias falciformis* (Müller and Henle, 1839), *Eulamia malpeloensis* (Fowler, 1944), *Gymnorhinus pharaonis* (Hemprich and Ehrenberg, 1899), *Eulamia menisorrah* (Müller and Henle, 1839), *Prionodon tiburo* (Poey, 1860), *Squalus tiburo* (Poey, 1860).

ICCAT species code: FAL

ICCAT names: Silky shark (English), requin soyeux (French), tiburón jaquetón (Spanish).

According to the ITIS (Integrated Taxonomy Information System), the silky shark is classified as follows:

- Phylum: Chordata
- Subphylum: Vertebrata
- Infraphylum: Gnathostomata
- Superclass: Chondrichtyes
- Class: Chondrichtyes
- Subclass: Elasmobranchii
- Superorder: Euselachii
- Order: Carcharhiniformes
- Family: Carcharhinidae
- Genus: Carcharhinus

1.b Common names

List of vernacular names used according to ICCAT, FAO and Fishbase (www.fishbase.org). The list of countries is not exhaustive, and some local names might not have been included.

Australia: Silky shark, Silky whaler.
Bahamas: Silky shark.
Brazil: Cação, Lombo preto.
Canary Islands: Jaqueta.

China: 佛罗里达真鲨，佛羅里達真鯊，大沙，平滑白眼鲛，鐮狀真鯊，镰状真鲨， 黑印真鯊，黑印真鲨，黑背真鯊， 黑背真鲨.
Chinese Taipei: 平滑白眼鮫.
Cuba: Cazón de playa, Jaquetón, Reef shark, Sickle shark, Silk shark, Silky Shark.
Denmark: Silkehaj.
Ecuador: Cazón.
Estonia: Siid-hallhai, Siidhallhai.
Finland: Haukkahai.
France: Mangeur d'hommes, Requin soyeux.
French Polynesia: Mago, Magogo, Magomago, Pe'ata, Requin soyeux, Tautukau.
Germany: Seidenhai.
Greece: Karcharinos lios, Καρχαρίνος λείος.
Guam: Silky shark.
Hawaii: Manō.
India: Blackspot shark, Karimuthu sura, Mandi sravu, Moosi, Mushi, Suga sura, मुशी, కరిముతు సురా, సుగ సుర, തര് വാട്, മണ്ടി സ്രാവ്.
Indonesia: Cucut lanjaman, Hiu lanyam, Hiu lonjor, Mungsing.
Japan: Kurotogari zame, Kurotogarizame.
Madagascar: Gofo, Maragnitsoro.
Malaysia: Silky shark, Yu, Yu jereh, Yu pasir.
Mexico: Cazón de playa, Jaquetón, Silky shark, Tiburón piloto, Tiburón sedoso.
Micronesia: Silky shark.
Mozambique: Marracho sedoso.
Netherlands: Zijdehaai.
Netherlands Antilles: Kanhaai, Ridgeback shark, Tribon berde.
New Zealand: Silky shark.
Nicaragua: Cazon, Jaqueton, Tiburon jaquetón, Tollo.
Northern Mariana Islands: Gray reef shark.
Pakistan: Gussi.
Panama: Tiburón sedoso, Tiburón tollo.
Papua New Guinea: Grey whaler shark.
Peru: Cazón-tiburón, Tollo mantequero.
Philippines: Pating.
Portugal: Marracho-luzidio, Tubarão-luzidio.
Samoa: Malie.
South Africa: Silky shark, Syhaai.
Spain: Cazón, Tiburón, Tiburón jaquetón, Tiburón lustroso, Tiburón sedoso, Tollo, Tollo mantequero.
Sri Lanka: Bala maora, Honda mora, Silky shark.
Sweden: Silkeshaj.
Tahiti: Tautukau.
Tanzania: Mbamba menyo, Papa, Papa bunshu.
Thailand: Chalarm Thao
Trinidad and Tobago: Olive shark, Tinterero.
United Kingdom: Sickle shark, Sickle silk shark, Sickle-shaped shark, Silky shark.
United States: Ridgeback shark, Shark, Silk shark, Silky shark.
Venezuela: Tiburón bobo

2. **Identification** (mainly based on Garrik 1982 and Compagno 1984).

Characteristics of *Carcharhinus falciformis* (Figure 1)

Figure 1. Silky shark (*Carcharhinus falciformis*) (Müller and Henle, 1839). Image taken from Domingo *et al.*, 2011. Photo credit: National Marine Fisheries Service, USA.

Lengths

References to size throughout this document consistently relate to total length (TL) in centimetres, unless otherwise specified (e.g., fork length: FL, and precaudal length: PCL).

The máximum size recorded is 305 cm FL (Serafy *et al.*, 2012), that when using the size conversions published for the region of the Gulf of Mexico (Bonfil *et al.*, 1993), corresponds to 380 cm TL, being one of the largest species of the Genus Carcharhinus. However, the most common maximum lengths for males and females would be 300 cm and 305 cm, respectively (Compagno, 1984). According to Bonfil (2008), silky shark grows more and also reaches maturity at greater lengths in the northwestern Atlantic than in the East Pacific and the West Central Pacific (Bonfil, 2008).

Colour

Dorsally, from dark to tanned brown, lightening to grey on the flanks, and pale to white ventrally. In general, darker tips on the pectoral fins, second dorsal and anal fin.

External characteristics

It is a large slim shark, which is characterised by its rounded snout, moderately long, but shorter than the width of its mouth. It has a narrow interdorsal ridge. The apex of the first dorsal fin is rounded, mainly in small individuals. This fin originates behind the free rear tip of the pectoral fins. The second dorsal fin is small, and the internal margin is two or three times its height. The pectoral fins are long and slim, typically with dark tips. The dermal denticles are small, compact and superimposed, which gives the skin a relatively soft texture, even more so when compared to that of the other species, which is where the name "silky shark" comes from.

Internal characteristics

The upper teeth are moderately wide, triangular shaped and slanted, strongly serrated, a little more towards the base. The lower teeth are erect, narrow and smooth edged. It generally has 15 teeth in each jawbone, upper and lower, with 2 symphyseal teeth in the upper jawbone and 1 in the lower one. This teeth formula can vary. The upper jaw can have from 2 to 3 symphyseal teeth and between 14 and 16 teeth on each side, and the lower jaw can have 1 to 3 symphyseal teeth and from 13 to 17 teeth on each side (Garrik 1982; Compagno 1984, Knickle 2012). The spinal column comprises between 199 and 215 vertebrae, of which between 98 and 106 are located in the precaudal region (Garrik 1982; Compagno 1984).

3. Distribution and ecology of population

3.a Geographic distribution

Circumglobal distribution in tropical, subtropical and warm areas **(Figure 2)** (Compagno 1984; Last & Stevens 2009; Ebert *et al.*, 2013). In the western Atlantic, it is found from Cape Cod, Massachusetts, United States (Garrik 1982), including Bermudas, Gulf of Mexico, Caribbean Sea and Saint Peter and Saint Paul Archipelago (Garrik 1982; Compagno 2002; Ebert & Stehmann 2013), to Uruguay (Díaz *et al.*, 2004; Mas 2012; Forselledo & Domingo 2015). In the eastern Atlantic, it has been reported occasionally from the northwestern coast of Spain and Portugal (ICES, 2017), including Madeira (Biscoito *et al.*, 2018), Azores (Arruda 1977), the Canary Islands (Falcón *et al.*, 2003), Cabo Verde (Wirrtz *et al.*, 2013), to Angola (Cauquil 2011; Compagno 2016). Reports of the species in South African waters are limited to the East coast, in the province of KwaZulu-Natal (Ebert *et al.*, 2021). Previously considered to be an exotic species in the Mediterranean Sea, and currently considered as rare or occasional species, due to the expansion of its distribution (Zenetos *et al.*, 2012). This species was reported mainly in the western area, in the Alboran Sea, off the coast of Spain, Morocco and Algeria (Bauchot 1987, Serena 2005, Serena *et al.*, 2020). Beyond the western area, it has been reported in Italian waters of the Ligurian Sea and Ionian Sea (Garibaldi & Orsi 2012; Psomadakis *et al.*, 2012; Leonetti *et al.*, 2020), and in the southern Mediterranean in Tunisia (Ounifi-Ben Amor *et al.*, 2015; Béjaoui *et al.*, 2019), Libya (UNEP-MAP RAC/SPA, 2005), and Egypt (Azab *et al.*, 2019), expanding the distribution of the species. The map shown in **Figure 2** was modified in the region of the Mediterranean Sea aimed at representing the distribution of the species detailed in this section.

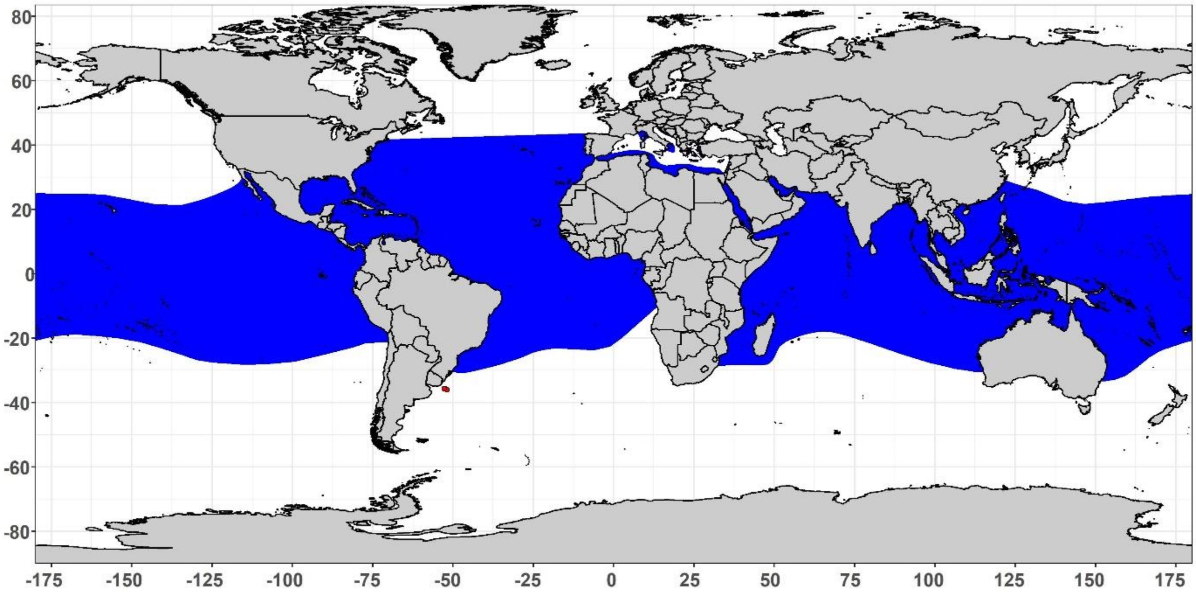

Figure 2. Map showing the distribution of the silky shark (*Carcharhinus falciformis*). Taken and modified from IUCN (International Union for Conservation of Nature (IUCN) 2012. *Carcharhinus falciformis.* The IUCN Red List of Threatened Species. Version 2021-2). The red dots in the southwestern Atlantic (DINARA - Uruguay, unpublished) refer to the records confirmed by the species in waters outside the distribution range suggested by IUCN. The revision of new records outside the distribution of IUCN was conducted only for the Atlantic Ocean and adjacent seas.

3.b Habitat preferences

It is an epipelagic species that inhabits tropical and subtropical waters throughout the world. It is mainly found in areas close to the shelf edges, occurring also in oceanic waters, reef areas, and to a lesser extent in coastal waters. It is distributed from the surface down to 500 m, with occasional reports in areas with depths of up to 18 m (Garrik 1982, Compagno 1984, Bonfil 2008, Ebert *et al.*, 2013). According to Strasburg (1958), in the tropical area of the East Pacific, the species becomes more abundant on approach to the continental shelf. In turn, Garrik (1982) indicates that the species appears to have a wider latitudinal distribution in areas close to the shelf edges.

In general, newborns and juveniles use reefs, coastal and shelf areas as breeding grounds, while subadults and adults are found further from the coast, in deeper oceanic waters (Branstetter 1987; Bonfil 1997; Beerkircher *et al.,* 2002; Bonfil, 2008). When individuals reach a length of around 130 cm, they move to more oceanic environments where they are normally observed associated with schools of pelagic fishes such as tunas (Rice & Harley, 2013). In Brazil, in areas between 30 and 80 m deep close to the coast, but corresponding to the outer part of the shelf, only juvenile individuals less than 110 cm were observed (Yokota & Lessa 2006). This species is usually found in waters with temperatures of over 23°C, and its movements are associated with sea temperatures (Last & Stevens 2009). In a satellite telemetry study, it was observed that the species spent 99% of the time in the first 50 metres of the water column and 45% in the top 5 metres at temperatures of between 28° and 30°C (55% of the time) on the Pacific coast of Costa Rica (Kohin *et al.,* 2006). In another study carried out on the east coast of the Pacific, differences were observed in the behaviour of individuals North and South of 10° N. Individuals to the south of this latitude remained in the surface layers and at uniform temperatures, while those in the north remained at lower depths and at colder temperatures (Musyl *et al*., 2011).

In the Indian Ocean, telemetry studies observed that tagged individuals spent most of the time (99%) in the first 100 m of the water column. These individuals carried out daytime vertical migrations and displayed oscillatory diving behaviour, diving to depths of over 300 m, with the deepest dive recorded for this species reaching 1,112 m (Curnick *et al.,* 2020).

Lopez *et al*., (2020) analysed the species' habitat preferences based on catch data corresponding to the purse seine fleet operating in the Atlantic and environmental variables. The results of the models used suggest that there are complex relationships between the species' presence and certain oceanographic conditions, particularly those related to productivity processes. Regarding temperature and the change rate, there is a higher probability of finding the species in waters with temperatures between 24° and 30° C, mainly those with change rates reflecting a drop in temperature of 3° to 4° C throughout a week. Marked seasonal changes were also observed in the species' distribution, associated with ocean dynamics in the region.

3.c Migrations

As the silky shark is a large species with widespread distribution in all oceans, it is estimated that the species is capable of migrations covering great distances. Despite this, most records correspond to short distances and there are very few long-distance movements on record. As part of the *Cooperative Shark Tagging Program,* carried out by the US *National Marine Fisheries Service* in the NE Atlantic Ocean, 1,238 silky shark individuals were tagged between 1962 and 2013, 65 of which were recaptures (recapture rate of 5.3%). The maximum distances observed by these individuals in the Pacific Ocean were 2,385 km and 1,339 km, and the maximum time at liberty was 8.6 years (Kohler & Turner 2001, 2019). By means of a telemetry study, it was observed that 90% of the movements by individuals monitored recorded were under a 50 km range. However, a maximum movement of 2,200 km was recorded in the East Pacific (Lara-Lizardi *et al.,* 2020). Also, other studies in the East Pacific Ocean, recorded higher average distances, from 677 km (Musyl *et al.*, 2011), 948 km (Schaefer *et al.*, 2020) to 1.072 km (Schaefer *et al.,* 2019). In these studies authors discuss on the shortest distances recorded and the possibility that these are associated to time at liberty and site fidelity of individuals. Likewise, it is suggested that the species also has a relatively quick great capacity of dispersion. In the Indian Ocean, a recent satellite telemetry study showed that individuals of this species displayed a certain degree of site fidelity. However, they can also perform long-distance migrations and one individual travelled 3,549 km, with a distance calculated of 4.782 km (Curnick *et al.,* 2020). Also in the Indian Ocean, it was observed that juvenile individuals can associate with drifting floating objects for periods of up to 30 days (Filmalter *et al.,* 2015).

4. Biology

4.a Growth

At world level, there are several studies on age and growth of the species. As indicated for the maximum sizes recorded in the different regions, the results observed on the species' growth are variable. The maximum ages estimated for the Gulf of Mexico are 20 years for males and 22 years for females (Bonfil *et al.,* 1993). The estimated age in the southwestern Equatorial Atlantic is 27 years, with an 8.6 age of maturity and 9.9 for males and females, respectively (Santander-Neto *et al.,* 2021), although other studies have estimated for females a maximum age of 27 years (Chen & Yuan 2006). In the West Pacific, differences in maximum ages observed exist reported in different studies, 8 years for males and 13 years for females (Oshitani *et al.,* 2003), 14 years for males and 11 years for females (Joung *et al.,* 2008), and 23 years for males and 28 for females (Grant *et al.,* 2018). As regards the máximum estimated age, Joung *et al.*, (2008) report 28.6 years for males and 35.8 years for males, whilst Grant *el al.*, (2018) report 42 years for both sexes. In the Indian Ocean it was estimated that males and females reach a maximum age of 20 and 19 years, respectively (Hall *et al.*, 2012). Differences in estimations of the maximum observed age and the resulting growth parameters could possibly be due to differences in the methods used, such as the use of multiple readers to count vertebrae bands (Grant *et al.*, 2018).

Table 1. Growth parameters for *Carcharhinus falciformis*. L_∞: maximum asymptotic length (cm), k: growth coefficient (years^{-1}), t_0: theoretical age at length 0 (years^{-1}); L_0: size-at-birth (cm).

Growth parameter			*Area*	*Reference*	*Sex*	*Method*
L_∞	*k*	*L_0/ t_0*				
291 (TL)	0.15	72 (TL)	Gulf of Mexico	Branstetter (1987)	Both	Vertebrae
311 (TL)	0.101	-2.781	Gulf of Mexico	Bonfil *et al.*, (1993)	Both	Vertebrae
240 (TL)	0.14	81.9 (TL)	West Pacific	Sánchez-de Ita *et al.*, (2011)	Both	Vertebrae
288 (PCL)	0.15	66.8 (TL)	Central Pacific	Oshitani *et al.*, (2003)	Both	Vertebrae
332 (TL)	0.083	68.3 (TL)	Chinese Taipei	Joung *et al.*, (2008)	Both	Vertebrae
268 (TL)	0.14*	82.7 (TL)	West Central Pacific	Grant *et al.*, (2018)	Both	Vertebrae
299 (TL)	0.066	81.2 (TL)	Indian	Hall *et al.*, (2012)	Both	Vertebrae
283 (TL)	0.0987	-3.47	Southwestern Atlantic	Santander-Neto *et al.*, (2021)	Both	Vertebrae

TL: Total length; PCL: Precaudal length; *Growth rate of the logistic growth function (in years $^{-1}$).

4.b. Length-weight relationship

Table 2 presents the length-weight relationships published for the species' distribution areas, with particular emphasis on the Atlantic Ocean.

Table 2. Published length-weight relationships for the silky shark (*Carcharhinus falciformis*). N: number of individuals. In this column, it is also specified whether the relationship is made for both sexes combined (C), males (M) or females (F). TW: total weight (kg); GW: gutted weight (kg); TL: total length (cm); PCL: precaudal length (cm); FL: fork length (cm).

Equation	*N*	*Length range*	*R^2*	*Area*	*Reference*
$TW = 1.54x10^{-5}$ x $(FL)^{2.9221}$	85 (C)	73 - 212	0.97	NW Atlantic	Kohler *et al.*, (1995)
$TW = 0.88x10^{-5}$ x $(TL)^{3.091}$				NW Atlantic	Compagno (1984)
$TW = 6x10^{-6}$ x $(FL)^{2.99}$	42	60 - 270	0.96	North Brazil	Assano-Filho *et al* (2004)
$TW = 0{,}8782\ x10^{-5}$ x $(TL)^{3{,}09}$				NE Atlantic Cuba	Guitar Manday (1975)
$TW = 1x10^{-5}$ x $(TL)^{2.943}$	32 (F)		0.878	NE Pacific	Alejo Plata *et al* (2016)
$TW = 1x10^{-6}$ x $(TL)^{3.42}$	53 (M)		0.825	NE Pacific	Alejo Plata *et al* (2016)
$GW = 5.84x10^{-4}$ x $(FL)^{2.093}$	14 (C)	80 - 120	0.914	East Tropical Atlantic	García-Cortés & Mejuto (2002)
$GW = 1.81x10^{-6}$ x $(FW)^{3.24}$	8 (C)	80 - 145	0.993	Central Tropical Atlantic	García-Cortés & Mejuto (2002)
$GW = 1.93x10^{-6}$ x $(FL)^{3.20}$	21 (C)	90 - 160	0.958	North Pacific	García-Cortés & Mejuto (2002)
$GW = 1.13x10^{-5}$ x $(FL)^{2.92}$	411 (C)	50 - 220	0.968	West Indian Ocean	García-Cortés & Mejuto (2002)

*TW in grams, Assano-Filho *et al* 2004.

4.c Conversion factors

Table 3 presents the length-length relationships published for the species' distribution areas, with particular emphasis on the Atlantic Ocean.

Table 3. Published length-length relationships for the silky shark (*Carcharhinus falciformis*). N, number of individuals. TL: total length (cm); PCL: precaudal length (cm); FL: fork length (cm); DL: second dorsal length (distance between the snout and the start of the second dorsal fin) (cm).

Equation	*N*	*Length range*	R^2	*Area*	*Reference*
FL = 0.5598 x (TL) + 17.666	135	155 - 371 (TL)	0.89	Southwest Atlantic	Domingues *et al.*, (2016)
FL = 0.8388 x (TL) – 2.6510	15	90 - 258 (TL)	0.99	Northwest Atlantic	Kohler *et al.*, (1995)
PCL = 1.1443 x (DL) + 1.1505	196		0.99	Gulf of Mexico	Bonfil *et al.*, (1993)
FL = 1.2305 x (DL) + 2.8007	192		0.99	Gulf of Mexico	Bonfil *et al.*, (1993)
TL = 1.5275 x (DL) + 5.3314	145		0.99	Gulf of Mexico	Bonfil *et al.*, (1993)
FL = 1.0758 x (PCL) + 1.307	292		0.99	Gulf of Mexico	Bonfil *et al.*, (1993)
TL = 1.3358 x (PCL) + 3.4378	283		0.99	Gulf of Mexico	Bonfil *et al.*, (1993)
TL = 1.2412 x (FL) + 1.8878	280		0.99	Gulf of Mexico	Bonfil *et al.*, (1993)
TL = 1.20 x (FL) – 1.16	108		0.99	Gulf of Mexico	Branstetter (1987)

4.d Reproduction

Gestation and parturition

It is a placental viviparous species, with a reproductive cycle that can be annual or biennial, and a gestation period of approximately 12 months, after which between 2 to 15 pups are born of approximately 52 to 80 cm (Fowler & Cavanagh, 2005; Bonfil, 2008; Alejo-Plata *et al.*, 2016). The reproductive parameters of this species vary greatly, often associated with its geographic distribution. Likewise, in some places, strong seasonality in the reproductive cycle has been observed. In the Gulf of Mexico, pupping and mating occur from late spring and in summer (Branstetter, 1987; Bonfil *et al.*, 1993). On the Oaxaca coast, in the Mexican Pacific, pupping was observed during most of the year, with the largest proportion in the months of May to August (Alejo-Plata *et al.*, 2016). In the west Equatorial Atlantic, pregnant females were observed throughout almost the entire year and different embryo sizes were seen in very similar periods, which also suggests that the species' reproductive cycle does not define seasonality (Hazin *et al.*, 2007; Lana 2012). Differences observed between reproductive cycle seasonality in the Gulf of Mexico and the equatorial region could be associated with sea temperatures, as temperatures remain constant throughout the year in the equatorial zone (Lana, 2012).

Fecundity

Observed global fecundity was between 2 and 15 embryos per litter (Fowler and Cavanagh 2005). In the west equatorial Atlantic, Lana (2012) observed litters of between 7 and 25 embryos, with an average of 16. This is the largest reported in literature. Based on an analysis of 153 females in the Pacific Ocean, litters of between 1 and 16 embryos were observed, with an average of 6.2. There was also a positive relationship between the size of the female and the number of embryos (Oshitani *et al* 2003). Cadena-Cárdenas (2001) also observed this positive correlation between the size of the mother and the number of pups in the litter, while Alejo-Plata *et al.*, (2016) found no significant correlation.

Maturity

There are several studies that report information on size at maturity of the silky shark. In the Gulf of Mexico, the size at first sexual maturity reported for males is between 215-225 cm and at an age between six and 10 years, while for females, the size is between 232-246 cm and the age from seven to 12 years (Branstetter 1987; Bonfil *et al.*, 1993; Bonfil 2008).

In the Equatorial Atlantic, there are differences in the sizes reported by the different studies. Hazin *et al.*, (2007) reported a size at first sexual maturity of some 230 cm for females, and between 210 and 230 cm for males, similar to what has been observed in the Gulf of Mexico. Tavares & Arocha reported that 18% of the females caught were pregnant and measured between 188 and 280 cm, and therefore estimated a size-at-maturity of 216 cm (± 25.7 cm s.d.). Lana (2012) reported a size-at-maturity of between 180 and 205 cm for males and 205 cm and 210 cm for females in a region close to the aforementioned studies, these latter sizes being more similar to those reported for the Pacific and Indian Oceans.

As mentioned earlier, according to the information reported, silky shark grow to longer lengths, and also reach maturity at larger sizes and older ages in the Atlantic than in other regions (Bonfil 2008). In the East Pacific Ocean, it was observed that the size at maturity for males and females was 180-182 cm and at ages 7-8 years (Sánchez-de Ita *et al.,* 2011; Hoyos-Padilla *et al.,* 2012; Galván-Tirado *et al.,* 2015). In the West Pacific, the results presented in different studies present greater variability, with maturity sizes for males reported between 180 to 213 cm, and ages between 5 and 11.6 years, and females at 193-220 cm and ages between 6 and 14 years (Oshitani *et al.*, 2003; Joung *et al.*, 2008; Grant *et al.,* 2018). In the Indian Ocean, it was estimated that males matured at a length of 208 cm and 13 years, and females at 216 cm and 15 years (Hall *et al.*, 2012), these lengths and ages being similar to those observed in the Atlantic Ocean.

Sex ratio

Taking into account the different studies considered herein, there is currently no evidence of sexual segregation, ratios of 1:1 (Hazin *et al.,* 2007; Lana 2012), 1:1.1 (Bonfil *et al.,* 1993; Tavares & Arocha 2008) 1:1.2 (Branstetter 1987), 1:0.95 (Clavareau *et al.*, 2020) having been observed. Lana (2012) observed some months when males could be dominant and others when females could be dominant, but the data are not sufficient to determine whether these variations are due to a sexual reproduction segregation or if they are associated with migratory behaviour and habitat preferences. In embryos from the same litter, the sexual proportion does not significantly differ from the ratio 1:1 (Bonfil *et al.,* 1993; Oshitani *et al.,* 2003; Hazin *et al.,* 2007; Lana 2012; Grant *et al.,* 2018).

4.e Diet

It is an opportunistic predator that feeds mainly on a wide variety of bony fish, cephalopods, and to a lesser extent, crustaceans, with a calculated trophic level of 4.2 (Cortés, 1999; Bonfil, 2008). In the Gulf of Guinea, numerous individuals of the species have been observed, associated with and feeding on shoals of yellowfin tuna (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*) and little tunny (*Euthynnus alletteratus*) (Bane, 1966).

Studies on the species' diet in the Atlantic are scarce. Therefore, this section sets out mainly the results obtained in the East Pacific region. According to several studies, ontogenic changes are observed in the species' diet associated with its distribution. In juvenile individuals that are found in more coastal and shelf areas, cephalopods constitute one of the main components of diet (Duffy *et al.*, 2015; Flores-Martínez *et al.*, 2017; Estupiñán-Montaño *et al.*, 2018). For example, in the Mexican Pacific, through analysis of stomach contents in juvenile individuals (122 cm median length) caught in a coastal area, the presence was observed of 11 species, mainly pelagic, the main prey (% Index of Relative Importance, IRI) being Humboldt squid (*Dosidicus gigas*) (34.0 %), followed by three species of bony fish (spot-fin porcupinefish (*Diodon hystrix*) 21.7 %, black skipjack tuna (*Euthynnus lineatus*) 17.6%, and silver weakfish (*Isopisthus remifer*) 10.1 % (Flores-Martinez *et al.*, 2017). In Ecuadorian waters, it was observed that in individuals with a median length of 174 cm, bony fish constitute the main component of the species' diet (87.8 % IRI), followed by cephalopods (11.9 %), the main prey being yellowfin tuna (Estupiñán-Montaño *et al.*, 2018). Duffy *et al.*, (2015), in the Equatorial area of the East Pacific, observed changes in the species' diet longitudinally, comparing oceanic areas with areas closer to the shelf and coast. The frequency of occurrence of cephalopods in the stomach contents ranged from 17.2% in oceanic areas, to 32.8% in areas closer to the shelf, unlike scombrids, which ranged from 79.0% in oceanic areas to 45.3% in areas closer to the shelf and coastal areas.

In the Indian Ocean, in a study on the diet of *C. falciformis* carried out based on juvenile individuals (median length 108 cm) caught in association with drifting floating objects (FADs), it was observed that teleosts constituted the category of most important prey, in terms of number of individuals, mass and frequency of occurrence. Crustaceans were much less important, and cephalopods ranked third in order of importance (Filmalter *et al.*, 2016).

4.f Physiology

No studies highlighting particular aspects of this species' physiology were found.

4.g Mortality

Natural mortality (M) is one of the most important parameters in stock assessment. However, it is also one of the most difficult to estimate and direct estimation is extremely rare for sharks. Consequently, M is often indirectly estimated based on life history traits, using relationships derived from longevity, lengths and growth parameters. Based on published information regarding growth parameters, Chen & Yuan (2006), estimate a natural mortality of 0.155 $years^{-1}$ for this species in the southeast United States. More recently, Grant *et al* (2020) estimated M for several regions of the oceans using various methodologies, also mainly based on growth parameters. M was estimated for two regions in the Atlantic Ocean: Campeche Bank and the Gulf of Mexico. For the former, estimated M values were between 0.12 and 0.15 $years^{-1}$ in all methodologies that do not depend on age class. When age class was considered, M was estimated at 0.30 $years^{-1}$ for age class 1, and at 0.11 $years^{-1}$ for age class 27. For the Gulf of Mexico, estimated M values were between 0.16 and 0.31 $years^{-1}$ in all methodologies that do not depend on age class. When age class was considered, M was estimated at 0.24 $years^{-1}$ for age class 0, and at 0.12 $years^{-1}$ for age class 18.

As regards catch mortality in longline fisheries, different values have been reported in various studies. Coelho *et al.,* (2012) reported a mortality of 55.8% based on 310 individuals caught in the Atlantic. In the pelagic longline fishery operating in the southeast United States, on-board observers recorded a mortality of 66.3 % in a total of 1,446 individuals (Beerkircher *et al.,* 2002). Musyl *et al.,* (2011) reported a mortality of 11.4 % for the Hawaiian fishery based on 35 individuals. Based on satellite tagging, the same study observed that 100 % of released individuals survived. In another study, also carried out in the Pacific Ocean and based on satellite tagging, a post-catch survival of 80 % was observed (Musyl & Gilman, 2018). Also, high values of post-harvest survival were recorded in longline fisheries in Mexico (84.8 %) (Schafer *et al.,* 2020) and Costa Rica and Ecuador (94.3 %) (Schafer *et al.,* 2019).

Between 2005 and 2017, the European purse seine fleet (EU-Spain and EU-France) recorded the catch of 14,722 individuals of this species in the Atlantic Ocean, with a mortality rate of 51.73 %, lower than the rate recorded for the Indian Ocean (59.98 %) (Clavareau *et al.,* 2020). Also, for purse seine fisheries in the Indian Ocean, Poisson *et al.,* (2014) estimated a maximum mortality of 85 % for this species based on the number of dead individuals taken on board and a satellite study of individuals that reach the boat alive.

5. Fisheries biology

5.a. Populations/ stock structure

A study that sequenced the mitochondrial DNA control region of 276 individuals caught in different regions of the Atlantic, Indian and Pacific Oceans, found high haplotype diversity (0.86) for this species, the third highest of the 15 shark species analysed in other studies, behind the blue shark (*Prionace glauca*) and the whale shark (*Rhincodon typus*), two widely distributed pelagic species (Clarke *et al.,* 2015).

Clarke *et al* (2015) observed that there was no population structure between the north and south in the western Atlantic. By contrast, a low yet statistically significant population differentiation was observed between most sites in the Indian and Pacific Oceans. Population studies carried out in the Pacific Ocean indicate that the species displays low genetic variability between regions, and that the East Pacific and West Pacific stocks can be separated (Galván-Tirado *et al.,* 2013). In the East Pacific, it is also suggested that there are possibly two different substocks (Aires da Silva *et al.,* 2013).

5.b. Description of fisheries

The silky shark is one of the most fished tropical shark species worldwide, and concern is growing as regards its conservation status. The species is caught in many artisanal and industrial fisheries all around the world, including pelagic longline, purse-seine, trawling and gillnet fisheries (Cavanagh 2005; Bonfil 2008). Even today and despite the management measures established, some small-scale fisheries direct part of their fishing effort toward this species. In the case of industrial fisheries, most catches are incidental. The main driver behind catches of this species is international demand for shark fins, mainly in Hong Kong, where silky shark fins account for 3.5% of fin trade (Clarke *et al.,* 2006a, 2006b). Recent studies have shown that the fins of this species continue to be traded on a regular basis, being the second most common species in commercial areas of Hong Kong during the last two decades (Cerdeñosa *et al.,* 2018; Fields *et al.,* 2018).

In the Gulf of Mexico, the silky shark and oceanic whitetip shark (*C. longimanus*) were the most caught shark species and catches of both species have experienced significant population decreases. *C. falciformis* was the most frequently caught elasmobranch species by the United States longline fleet operating in the Atlantic between 1992 and 2000, with a total of 1,446 individuals representing 31.4 %. The authors observed a large drop in catch per unit effort (CPUE) compared to previous periods, decreasing from 11.22 individuals for every 1,000 hooks in the 1981-83 period to 3.49 individuals for every 1,000 hooks in the 1992-2000 period (Beerkircher *et al.*, 2002). Based on information from the US pelagic longline fishery's logbooks, in the 1992-2005 period catches of this species fell by 50 %. Based on information from the observer programme on board this fleet, the decrease was 46 % (Cortés *et al.*, 2007).

On the coasts of Venezuela, the silky shark is one of the main species in the mid-water artisanal longline fishery targeting sharks. It is the second most caught species, accounting for 30.15 % of the total individuals caught. This fishery operates at depths of between 20 and 394 m, and the main fishing effort can be found between 80 and 120 m (Tavares, 2005). In a subsequent study performed in the same area but with a fishery that mainly operates at depths of between 3 and 10 m, this species was seen to account for a much smaller proportion of catches, representing 4 % of the total individuals caught (Tavares, 2009). Tavares & Arocha (2008) analysed data from the Venezuelan industrial longline fleet operating in the southern region of the Caribbean Sea and the central west Atlantic between 1994 and 2003. The silky shark accounted for 8.5% of total shark catch, mainly of sizes between 100 and 190 cm. A negative trend was observed in catches over the study period, which suggests a decrease in the species' abundance (Tavares & Arocha 2008).

In the eastern Atlantic Ocean, mainly in the most tropical areas, catches of this species are very significant in purse seine fisheries targeting tropical tunas. This fishery takes various elasmobranch species as by-catch, including *C. falciformis* (Lezama-Ochoa *et al.*, 2018; Escalle *et al.*, 2019; Clavareau *et al.*, 2020). Between 2005 and 2017, the European purse seine fleet (EU-Spain and EU-France) recorded the catch of 14,722 individuals in the Atlantic Ocean, representing 77.6 % of the total elasmobranch catch (Clavareau *et al.*, 2020). Based on the sizes-at-maturity reported for the species, it was observed that 93.11 % of these individuals were juveniles and 51.26 %were female (Clavareau *et al.*, 2020).

5.c State of the stocks

Currently, there is no stock definition for the silky shark in the Atlantic Ocean, nor has a stock assessment been carried out.

The silky shark is one of the most fished tropical shark species in the world, and currently there is growing concern regarding its state of conservation. Like all other sharks, owing to its life characteristics, the species is very vulnerable to fishing overexploitation. According to some studies, its global population has experienced decreases of 90 %. More recent studies estimated that the trend in the weighted world population is a decrease of 47-54 % for the equivalent of three generation periods. This is the best estimate based on the most reliable data currently available for each region (Rigby *et al.*, 2017). Since changes have been observed in the stock numbers of all oceanic areas, and there are no stock estimates, the species has been included in the red list of the IUCN as *Least concern* (Bonfil, 2000), to *Near threatened* (Bonfil *et al.*, 2009; Rigby *et al.*, 2016) and more recently as *Vulnerable* (Rigby *et al.*, 2017).

An ecological risk assessment (ERA) was carried out for 11 pelagic elasmobranch species in the Atlantic Ocean by ICCAT's Sharks Species Group. As a result of this analysis, it was observed that *C. falciformis* is the most vulnerable species to longline fisheries, occupying first place in terms of vulnerability, due to its low productivity and high susceptibility to the fishing gear (Cortés *et al.*, 2010). This study was updated in 2015 (Cortés *et al.*, 2015) and the species was considered as two stocks - north and south - but this division was mainly due to the availability of biological and fishing information relating to these two areas rather than the existence of different stocks. The results for both populations no longer classify it as one of the most vulnerable species to the longline fishery but continue to consider it one of the most vulnerable species. This is mainly due to changes in the methodology used, such as the assignment of values for *availability, encounterability* and the update of species distribution with new information (Cortés *et al.*, 2015).

Given the result of the first ERA performed by Cortés *et al*., (2010), in 2011 ICCAT approved Recommendation 11-08, in accordance with which it is prohibited to retain onboard, transship, land, store, sell, or offer for sale any part or whole carcass of specimens of silky sharks, taken in the Convention area in association with ICCAT fisheries.

Within the Indian Ocean Tuna Commission (IOTC), assessments conducted for this species in 2018 were considerably uncertain. Although there is a lack of information on stock assessment, it is suggested that the Commission should consider adopting a precautionary approach through the implementation of certain management actions for silky sharks (IOTC, 2021). However, Murua *et al.,* (2018) conducted an ERA whereby the species turned out to be the second with the highest risk rate for longline fisheries, and fifth for purse seine fisheries. In a more recent study, Cramp *et al.,* (2021) conducted a new stock assessment based on a new time area series of estimated catch. The different assessments conducted showed that the stock status of the species is overfished and undergoing overfishing, therefore the authors recommend adopting a precautionary approach and the implementation of specific management measures for the species in the Indian Ocean.

Within the Western & Central Pacific Fisheries Commission (WCPFC), it was noted that the stock assessment conducted in 2018 presents a degree of uncertainty, therefore, the estimations of stock status should be considered as indicative only. The results of the assessment conclude that the species is undergoing overfishing, without being overfished (WCPFC, 2019).

This species is listed in Appendix II of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora). Since 2014, the species has also been listed in Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS).

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