		
CHAPTER 2.2.1.11: LONGFIN MAKO SHARK	AUTHORS: MAS F., DOMINGO A., FORSELLEDO R. & MILLER P.	LAST UPDATED: August 2022 (original: Spanish)

2.2.1.11 Description of the longfin mako shark (LMA)

1. Names

1. a. Classification and taxonomy

Species name: *Isurus paucus* (Guitart Manday, 1966)

Etymology: According to Castro (2011), *Isurus* comes from the Greek *isos*, meaning “equal”, and *oura*, meaning “tail”, which alludes to the similar size of the upper and lower lobes of the caudal fin. In addition, the Latin word *paucus*, means “scarce”, referring to the fact that this species rarely occurs, especially compared to its sister species the shortfin mako (*Isurus oxyrinchus*).

Synonyms: *Isurus alatus* (Garrick, 1967).

ICCAT species code: LMA

ICCAT names: Longfin mako (English), Petite taupe (French), Marrajo carite (Spanish).

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

- Phylum: Chordata
- Subphylum: Vertebrata
- Infraphylum: Gnathostomata
- Class: Chondrichthyes
- Subclass: Elasmobranchii
- Superorder: Euselachii
- Order: Lamniformes
- Family: Lamnidae
- Genus: *Isurus*

1. b. Common names

List of vernacular names used in different countries, according to ICCAT, FAO, Fishbase (www.fishbase.org) and Compagno (2001). The list of countries is not exhaustive and some local names might not have been included.

Argentina: Mako de aleta negra, marrajo

Australia: Longfin mako

Azores: Marrajo negro

Brazil: Anequim preto, mako, mestiço

Canary Islands: Marrajo carite

Chile: Marrajo de aleta larga

China: 烟仔沙, 长鳍鯖鲨, 长臂灰鯖鲛, 长鳍鯖鲨, 马加鲨

Chinese Taipei: 长臂灰鯖鲛

Colombia: tiburón mako aleta larga

Cuba: Dientuso prieto, Longfin mako

Denmark: Langfinnet makohaj

Ecuador: Marrajo carite

Estonia: Pikkuim-makohai

France: Petit taupe, Petit requin-taupe, Mako à longues nageoires, Taupe lonue aile

French Polynesia: Long finned mako shark
Germany: Langflossen-Mako
Ghana: Saape
Indonesia: Hiu anjing, Hiu mako bersirip panjang, Hiu tenggiri, Longfinned mako shark
Italy: Squalo mako dalle pinne lunghe
Japan: Bake-aozame
Madagascar: Akiho
Malasia: Jerung, Jerung-mako sirip panjang, Longfin mako
Mexico: Mako aletón, mako, marrajo, carite
Netherlands: Langvinmakreelhaai
New Zealand: Longfin mako
Nicaragua: Marrajo carite
Philippines: Longfin mako
Poland: Ostronos długopłetwy
Portugal: Tubarão-anequim-de-gadanha
South Africa: Langvin-mako, Longfin mako, Long-finned mako
Spain: Marrajo carite, Marrajo negro
Sweden: Långfenad Mako
United Kingdom: Longfin mako, longfinned mako
United States: Longfin mako
Uruguay: Moro de aleta larga, moro, marrajo

2. Identification (Based on Guitart-Manday, 1966, Garrick, 1967, Moreno & Morón, 1992; Compagno, 2001, Castro, 2011).

Characteristics of *Isurus paucus* (see Figure 1).



Figure 1. Longfin mako (*Isurus paucus* Guitart Manday 1966). Photo: CSIRO Marine and Atmospheric Research, Australia.

Lengths

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

The maximum size reported for the species is 427 cm (Castro 2011), corresponding to a female caught in Florida, United States, in February 1984. However, the author indicates that this length was estimated based on fork and precaudal length measures since the dorsal lobe of the caudal fin was damaged. Direct measures of large specimens have been reported by other authors. In the northwestern Atlantic, Gilmore (1983) reported a catch of a female of 417 cm in Florida, United States, while for North Cuba, Ruiz-Abierno *et al.* (2021a) reported maximum lengths of 390 and 357 cm for females and males, respectively. For the northeastern Atlantic and western Mediterranean Sea, Moreno and Morón (1992) recorded a maximum length of 263 cm from a total of 51 specimens sampled, while Hemida & Capapé (2008) reported the capture of a male of 280 cm in Algerian waters. Outside of the Atlantic Ocean, White (2007) recorded a female of 298 cm in Indonesia, while Varghese *et al.* (2017) reported a maximum length of 258 cm for the Arabian Sea.

Colouring

Dark blue to greyish black on the dorsum (**Figure 1**). The ventral area of the body is white in juveniles, but the bottom part of the trunk and mouth gradually become darker in large juveniles and adults. In adult individuals, the flanks display dark colouring which extends ventrally toward the abdomen. Dark grey pectoral fins on the dorsum and white on the ventral side, except for a thin strip on the leading edge (in large adult specimens the ventral side may be partially speckled). Dark coloured pelvic fins on the dorsum, white on the ventral side with a prominent dark edge. Dark first dorsal fin, the same colour as the dorsum, the anal fin is also dark except its trailing edge and free rear tip which are white in colour.

External characteristics

Spindle shaped body, relatively tapered head, short and pointed trunk. Relatively large-sized eyes, especially compared with its sister species *Isurus oxyrinchus*. Parabolic shaped mouth, and the front teeth of the lower jaw protrude slightly outwards. Almost straight pectoral fins on its leading edge and large in size, representing between 23 and 31% of the total length (proportionally larger in juvenile individuals) and equal to or larger than the length of the head. The apexes of the pectoral fins are wide and rounded. The first dorsal fin originates from behind the free rear tip of the pectoral fins, has a wide and rounded apex in juveniles and adults, and its height is greater than the length of its base (although shorter in embryos). The shape of the anal fin is very similar to the second dorsal fin but slightly larger, its origin is very slightly behind or on a level with of the axilla of the second dorsal fin. The caudal fin is crescent shaped, and the dorsal lobule is slightly larger than the ventral lobule. The caudal peduncle is dorsoventrally compressed, with a prominent lateral keel on each side. Small, superimposed dermal denticles, with three dorsal ridges and three tips on the trailing edge.

Internal characteristics

Large, smooth, dagger-shaped teeth, no secondary cusps or serrated edges. Symphyseal teeth absent. The anterior teeth of both jaws have a wide base, are straight and only slightly curved; the first one has a complete lateral edge which runs from the cusp to the base. In comparison, the anterior teeth of *I. oxyrinchus* are thinner, strongly curved and the first anterior tooth has an incomplete lateral edge (except in large adults). As common in Lamniformes, the third anterior tooth of the upper jaw is considerably smaller in size compared to the first two. The intermediary and lateral teeth are shorter and become gradually more curved towards the corners of the mouth. The upper jaw has between 24 and 26 rows of teeth, and the lower jaw between 22 and 24. The spinal column comprises 111-112 precaudal vertebrae, 83-86 caudal vertebrae, and a total of between 195 and 197.

3. Distribution and ecology of population

3.a Geographic distribution

Isurus paucus has a circumglobal distribution in tropical and warm temperate waters, occurring in neritic waters and oceanic waters proper of the Atlantic, Indian and Pacific Oceans (**Figure 2**). In the western Atlantic, it is found from New York to Florida in the United States (Dodrill & Gilmore, 1979; Gilmore 1983; Compagno 2001; Castro 2011; Kohler & Turner, 2019), Bahamas (Hueter *et al.*, 2017), Cuba (Guitart Manday, 1966, 1975; Aguilar *et al.* 2014; Ruiz-Abierno *et al.* 2021a, b), Gulf of Mexico (Killam & Parsons 1986; Wakida-Kusunoki & de Anda-Fuente 2012; Kohler & Turner 2019), the Caribbean Sea (Castro, 2011; Barrera *et al.* 2012; Kohler & Turner 2019; Mignucci-Giannoni *et al.*, 2020), Venezuela (Tavares & Arocha, 2008), Brazil (Sadowsky *et al.*, 1986; Amorim *et al.*, 1998; Gadig, 2001) and Uruguay (Mas 2012; Forselledo & Domingo 2015). Queiroz *et al.* (2006) and Mucientes *et al.*, (2013) reported the presence of the species in remote oceanic waters of the central northern Atlantic, including around the Azores (Santos *et al.*, 2020). In the eastern Atlantic, it occurs around the Iberian Peninsula (Muñoz-Chápuli, 1985; Moreno & Morón, 1992; Buencuerpo *et al.*, 1998; Carneiro *et al.*, 2014) and off Morocco, western Sahara, the Canary Islands, Mauritania, Guinea-Bissau, Liberia and Ghana (Muñoz-Chápuli, 1985; Moreno & Morón, 1992; Compagno, 2001; Ebert *et al.*, 2013; Sekey *et al.*, 2022). Compagno (2001) suggested that its presence in the southeastern Atlantic would range to South Africa but did not provide specific references. Ebert *et al.* (2021) confirmed its presence in South African waters based on a jaw of a specimen caught off Cape Agulhas. It is considered rare in the Mediterranean Sea (De Maddalena *et al.*, 2016, Ebert & Dando, 2020; Serena *et al.*, 2020), however, there are records of the species in the western basin, from Morocco (Hemida & Capapé, 2008) and Algeria (De Maddalena *et al.*, 2016). Whilst nominally reported from Egyptian waters (Shaban & El-Tabakh, 2019), further confirmation of the occurrence of the species in the eastern Mediterranean is required.

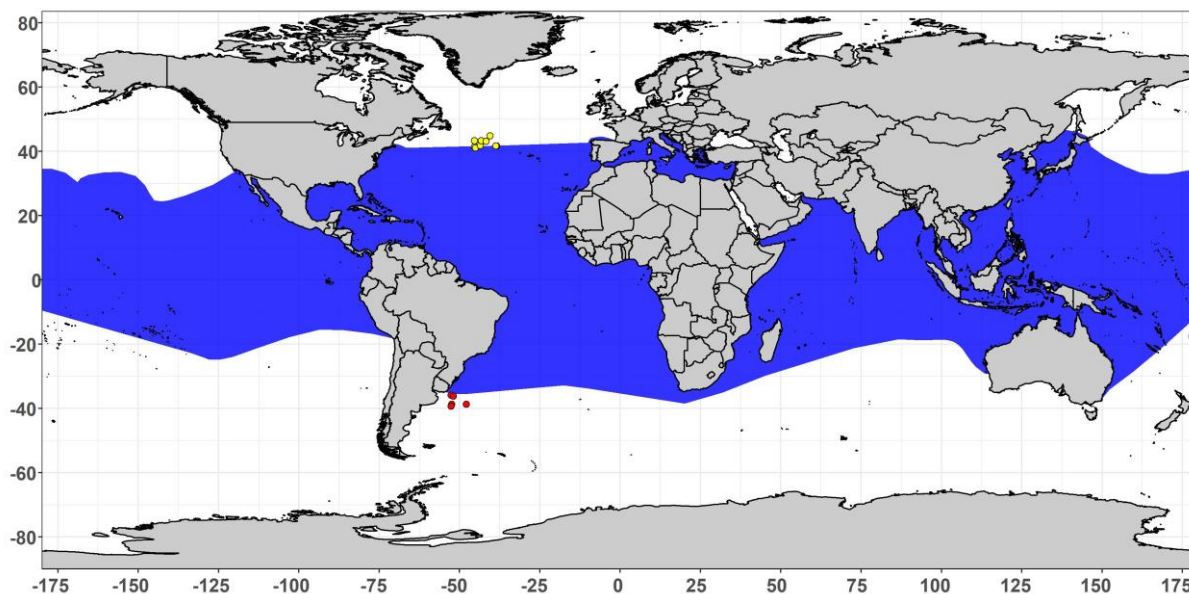


Figure 2. Geographic distribution of *Isurus paucus* in the Atlantic. Taken and modified from the UCIN (IUCN SSC Shark Specialist Group 2018. *Isurus paucus*. The IUCN Red List of Threatened Species. Version 2021-1). Red (DINARA, unpublished data) and yellow dots (Mucientes *et al.*, 2013) depict confirmed records of the species beyond the range distribution proposed by the IUCN. The revision of new records outside the IUCN distribution range was carried out only for the Atlantic Ocean and its adjacent seas.

3. b Habitat preferences

Knowledge on the environmental preferences and habitat use of *I. paucus* is particularly scarce. According to Compagno (2001), it is an oceanic and migratory species that inhabits tropical and warm temperate waters. Unlike *I. oxyrinchus*, its body is relatively less robust, together with its wide and large pectoral fins suggest that *I. paucus* is a less active species and more similar in terms of habits to other oceanic species such as *Prionace glauca* and *Carcharhinus longimanus* (Compagno, 1990, 2001).

The most detailed information on its habitat preferences comes from a single study to date in which the species was fitted with satellite transmitters. Hueter *et al.* (2017) tagged two adult males in the Gulf of Mexico in 2012 and 2015, which both displayed broad use of the water column, from the surface down to a depth of 1,076 m, experiencing a wide range of temperatures from 4.0 to 28.8°C. Compared with *I. oxyrinchus*, *I. paucus* is a mesopelagic species, which spends a larger percentage of the time at depths greater than 200 m, contrasting with the more epipelagic habit of its most closely related species (Loefer *et al.*, 2005; Vaudo *et al.*, 2016).

Hueter *et al.* (2017) reported a vertical behaviour which is similar to that observed in other pelagic sharks (Stevens *et al.*, 2010; Coelho *et al.*, 2015; Howey *et al.*, 2017) and is characterised by more extensive use of the water column during the daytime and more time in surface waters at night, dawn and dusk being intermediate phases. According to these authors, moonlight did not appreciably affect the vertical behaviour of the species, but it did affect the degree of stratification of the water column. According to the results obtained through the transmitters, during the day *I. paucus* remained at greater depths (> 200 m) without travelling to the surface when it encounters unstratified warm waters, but its behaviour varied radically, carrying out repeated trips between the surface and deep waters in the presence of stratified waters. Furthermore, Hueter *et al.* (2017) also reported a relationship between temperature, speed of vertical travel, and time between dives, observing faster speeds and shorter times between dives at lower temperatures. The authors suggested that this differential behaviour between stratified and slightly stratified waters could be related to thermoregulation, which implies the need for the individuals to return to the warm surface to “warm up” after prolonged periods of diving in deep cold waters.

3. c Migrations

Knowledge on the horizontal movements of *I. paucus* is also limited. There are few studies to date providing information through conventional or satellite tracking tagging programmes.

Based on data from the National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program, Kohler & Turner (2019) reported a recapture rate of 5.7% of the total of tagged specimens (n=106). The maximum distance travelled according to the study was 1,852 nm (~3,430 km) and the maximum time at liberty was 5.5 years. The recaptures reported in the study evidenced large scale movement, as is expected in migratory pelagic species, including two individuals tagged in the Gulf of Mexico and recaptured on the eastern coast of Florida and off northwest Cuba, and an individual tagged in central Atlantic waters (10°N) and recaptured in Venezuelan waters. The longest distance documented to date refers to a specimen tagged in the northwestern Atlantic (10°N) and recaptured in oceanic waters adjacent to the state of Delaware, United States (~38°N).

To date, there is only one study published using satellite telemetry to study the movements of this species. Hueter *et al.* (2017) tagged two adult males, one in the Gulf of Mexico and another off northwest Cuba, and provided the first high resolution data on horizontal movements of *I. paucus*. Both specimens displayed similar movements. They spent part of the time in waters of the Gulf of Mexico and then entered the northwestern Atlantic, crossing the Straits of Florida, and migrated northwards, reaching oceanic waters close to the States of Virginia and Delaware, United States. It should be noted that, while the specimens were tagged in different years (2012 and 2015), the individuals started their migration at the same time, leaving the Gulf of Mexico in May, migrating North in May-June, and remaining in waters in the North between the States of Virginia and New Jersey between late June and July. The total distances travelled by these specimens were 6,809 and 8,826 km, with average travel rates of 75.7 and 58.8 km/day, respectively.

The findings of Hueter *et al.* (2017) and Kohler & Turner (2019) are consistent with the hypotheses of other authors who suggested that there is connectivity between waters of the Gulf of Mexico, Caribbean Sea and the Gulf Stream in the northwestern Atlantic (Guitart-Manday, 1975; Castro, 2011). However, the new information provided by Hueter *et al.* (2017) only refers to two adult males, and it is still not yet known if female adults and juveniles of both sexes undertake similar movements. According to Castro (2011), the occurrence of gravid females in waters of the Caribbean Sea suggests that these could migrate to this region to spawn in late January and March. In addition, Hueter *et al.* (2017) suggested that migrations to the North Atlantic by both adult males could be associated with a migration to a summer feeding ground. Moreover, based on an estimate that 58% of females and 46% of males in this region would be adults, the authors suggested that this region could also be an important mating area, although empirical evidence of mating activity is needed to support this hypothesis.

To date there are no records of either transatlantic migrations or between hemispheres for this species, but a recent study based on mitochondrial DNA has demonstrated a high genetic flow between eastern and western regions of the Equatorial Atlantic (Magalhães, 2018). Given the oceanic and migratory character of the species, there may be connectivity between distant regions of the Atlantic, however, the degree and extension remains unknown.

4. Biology

4.a Growth

To date there are no studies published on age and growth of *I. paucus*.

4.b Length-weight relationships

There are no length-weight conversions available for the species. **Table 2** summarises the specimens of the species for which the corresponding size and weight have been reported. Based on these data, a simple regression of the type $TW = a(TL)^b$ was fitted, obtaining the conversion equation $TW = 2.760 \times 10^{-6}(TL)^{3.152}$ (N = 12). For the conversion equation, gravid females were omitted, as well as those reported by Queiroz *et al.* (2006) since the measurements were taken differently compared to the other studies.

Table 2. Summary of specimens of *Isurus paucus* reported in the bibliography with the corresponding size and total weight. TL: total length; STL: total length with the dorsal lobule of the caudal fin stretched on the longitudinal axis of the body. *gravid females.

Size (cm)	Measurement	Sex	Total weight (Kg)	Reference
121	TL	NA	11.3	Castro (2011)
151	TL	NA	23	Castro (2011)
180,7	TL	NA	39	Castro (2011)
184	TL	Male	33	Amorim <i>et al.</i> (1998)
215	STL	Male	56	Queiroz <i>et al.</i> (2006)
218	TL	NA	70	Garrick (1967)
220	TL	NA	70	Castro (2011)
220	TL	Female	58	Amorim <i>et al.</i> (1998)
215	STL	Female	91	Queiroz <i>et al.</i> (2006)
247,6	TL	NA	100	Castro (2011)
272	TL	NA	118	Castro (2011)
274	TL	NA	139	Castro (2011)
310	TL	Female	200	Bustamante <i>et al.</i> (2009)
330	TL	Female*	409	Casey (1986)
333	TL	Female*	315	Mignucci-Giannoni <i>et al.</i> (2020)
372,8	TL	Female	351	Gilmore (1983)

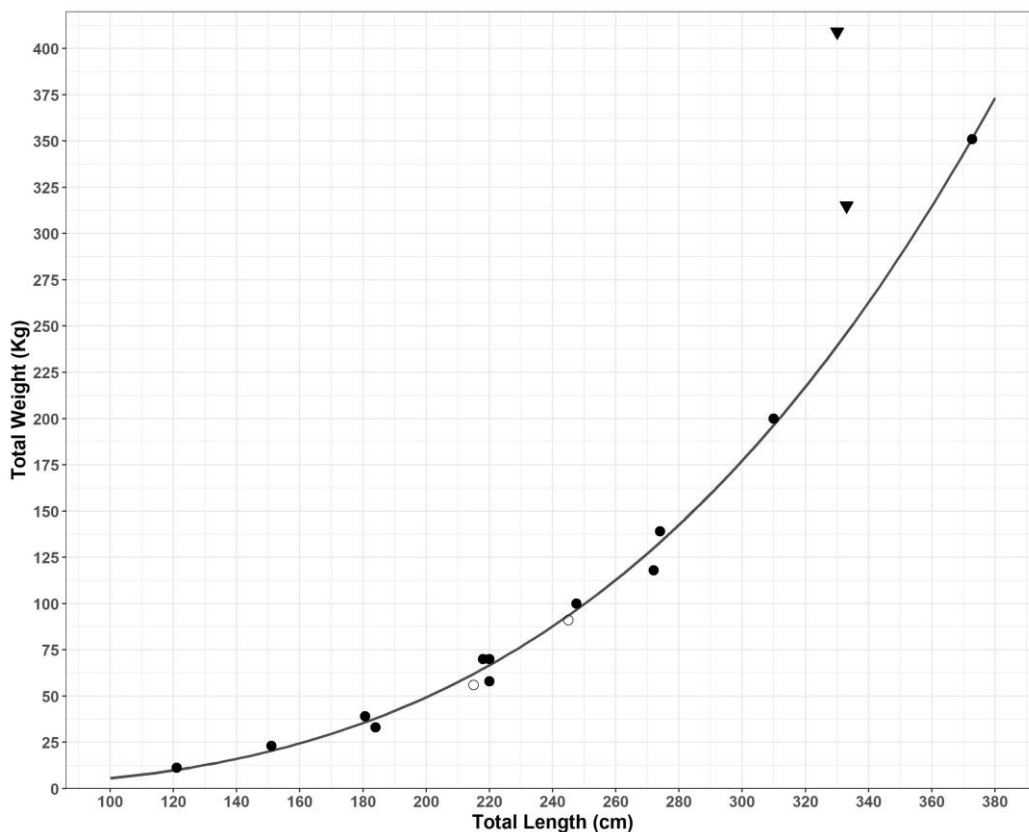


Figure 3. Relationship between the total length and total weight of the longfin mako, *Isurus paucus*. The black line indicates adjustment of potential type to data. Gravid females (inverted triangles) and specimens with total lengths measured without the caudal fin in the natural position (white circles) were omitted for the adjustment of the curve.

4.c Length-length relationships

There are no length-length conversions for this species, although Killam & Parsons (1986) mention a relationship of the type $TL = 1.152 \times FL$. The authors indicate that this relationship was provided by Harold Pratt (NMFS, NOAA) based on 7 large specimens, but no other details are given.

4.d Reproduction

Information on reproductive biology of *I. paucus* is scarce for the Atlantic Ocean and at global level. To date, a small number of studies address this species directly and in detail.

Gestation and parturition

Like all other representatives of the order Lamniformes, the reproduction method of this species is aplacental viviparity with oophagy whereby the embryos, once the reserves of the yolk sack have been exhausted, continue to feed at the expense of the continued production of unfertilised eggs by the mother (Gilmore, 1983, 1993; Gilmore *et al.*, 2005). Some authors (Compagno 1984, 2001; Ebert *et al.* 2013) suggest that the species also displays intrauterine cannibalism (adelphophagy), which implies that the larger embryos eat the smallest ones inside the uterus, as has been documented in other Lamniform sharks (Gilmore, 1993; Joung & Hsu, 2005). Joung & Hsu (2005) reported two events of intrauterine cannibalism in specimens of *I. oxyrinchus* caught in the North West Pacific, but since litter size is typically between 11-12 embryos (Mollet *et al.*, 2000) these events probably occur occasionally and are likely due to significant differences in embryo growth (Joung & Hsu, 2005). Nonetheless, to date there is no empirical evidence to corroborate whether these events also occur.

The duration of the gestation period of *I. paucus* is unknown. In *I. oxyrinchus*, the species most closely related to *I. paucus*, the gestation time has been estimated by several authors in different regions and varies between 9 and 25 months (Cliff *et al.*, 1990; Mollet *et al.*, 2000; Duffy & Francis, 2001; Joung & Hsu, 2005; Semba *et al.*, 2011). The size-at-birth of *I. paucus* has been reported between 97 and 135 cm (Gilmore, 1983; Garrick, 1967; Guitart Manday, 1975; Compagno, 2001; Castro, 2011). Gilmore (1983) observed on a gravid female carrying an embryo measuring 97 cm in the left uterus whose tail protruded outwards through the cloaca, while Casey (1986) reports on a female with 8 embryos of sizes between 109 and 125 cm. It should be noted that Gilmore (1993) and subsequently Compagno (2001) present a range lower than 92 cm based on the work by Guitart Manday (1966, 1975), however, the measurement taken by this author refers to precaudal length and not total length. In addition, recently, Ruiz-Abierno *et al.* (2021a) reported the catch of a female of 86 cm in waters of northwestern Cuba, which represents the smallest size reported for an individual born of the species.

The potential pupping ground or grounds of *I. paucus* in the Atlantic are unknown. According to Castro (2011) the fact that most of the gravid females reported with at term embryos (> 120 cm) have been caught in tropical waters between 18 and 20° North of the western Atlantic suggests that the Caribbean Sea could be a pupping ground, and that females could give birth between late January and March. In addition, Muñoz-Chápuli (1984) suggested that the immediate surroundings of Canary Islands could be an important reproduction area based on the report of a gravid female carrying three embryos between 84 and 87 cm total length.

Maturity

To date, the most extensive work on the maturity of *I. paucus* has been carried out off northwestern Cuba by Ruiz-Abierno *et al.* (2021a). In total, 46 males (135-357 cm) and 71 females (86-390 cm) were analysed, and the sizes-at-first-maturity (L_{50}) were estimated at 215 and 230 cm for males and females, respectively. The smallest sizes of mature individuals for males and females were 208 and 220 cm, respectively, while the largest sizes of immature individuals were 257 and 224 cm. The results of this work are consistent with the maturity estimates published by other authors based on more limited and sporadic records in the Atlantic (Guitart Manday, 1966; Gilmore, 1993; Castro, 2011) and other Oceans. In the Arabian Sea, Varghese *et al.* (2017) analysed 11 males, and the smallest sized adult measured 225 cm. In Indonesian waters, White (2007) analysed 5 males of which only one (228 cm) was an adult, suggesting that the size-at-maturity would be around 205-228 cm.

Records of gravid females are strikingly scarce at global level and, to date, the records published relate to the northwestern Atlantic, between Florida and the Caribbean Sea (Guitart-Manday, 1966, 1975; Gilmore, 1983; Casey, 1986; Castro, 2011, Mignucci-Giannoni *et al.*, 2020), except for a specimen caught close to the Canary Islands (Muñoz-Chápuli, 1984). The minimum size reported for a gravid female of *I. paucus* is of 303.5 cm (Castro 2011).

Sex ratio

Information on sex ratio and sex segregation is very limited. According to Aguilar *et al.* (2014) and the recent work of Ruiz-Abierno *et al.* (2021a), catches of *I. paucus* by the artisanal fishery off northwestern Cuba are biased towards females throughout the year, which represent 61% of the total catch recorded (Ruiz-Abierno *et al.* 2021a).

Fecundity

According to the bibliography, litter sizes range from 2 to 8 embryos (Garrick, 1967; Guitart-Manday, 1975; Gilmore, 1983; Muñoz-Chápuli, 1984; Casey, 1986; Compagno, 2001; Castro, 2011). Recently, Mignucci-Giannoni *et al.* (2020) reported on a female adult of 333 cm stranded on a beach in Puerto Rico, which was carrying 17 embryos in her reproductive tract. This report represents the maximum number of embryos in a litter reported and suggests that its fecundity could be greater than previously considered, and more similar to what has been reported for its sister species, *I. oxyrinchus* (Mollet *et al.*, 2000). However, the lengths of the embryos were not reported and, if intrauterine cannibalism does occur, may not reflect the true reproductive output.

4. e Diet

To date there are no specific studies on the diet of *I. paucus*, but opportunistic analysis of some stomachs suggests that the diet is based mainly on fish and pelagic squid (Dodrill & Gilmore, 1979; Compagno, 2001; Bustamante *et al.*, 2009; Castro, 2011). Bowman *et al.* (2000) analysed the stock content of 10 specimens captured on the East coast of the United States. Four of these stomachs were empty while in the other six, fish represented 91.9% in weight, followed by cephalopods (4.9%), and the remainder of the animals were unidentified (3.2%). Among the fish, the authors identified the remains of chondrichthyans (*Carcharhinus sp.*, 12.1%), *Pomatomus saltatrix* (6.2%), *Thunnus thynnus* (73.2%) and *Xiphias gladius* (0.4%).

A recent study based on the analysis of Carbon and Nitrogen stable isotopes in muscle and vertebrae of one individual has suggested that *I. paucus* has a wide trophic niche, and may switch from coastal feeding grounds to oceanic feeding grounds as they grow (Estupiñán-Montaño & Delgado-Huertas 2022).

4. f Physiology

According to Compagno (2001), *I. paucus* would appear to be an endothermic species, with the same physiological adaptations in the musculature, eyes, brain and viscera as other species of the order Lamniformes, including its sister species *I. oxyrinchus* (Carey & Teal, 1969; Block & Carey, 1985; Bernal *et al.*, 2001).

4. g Mortality

Due to the species' large size at birth and the large size of sub-adult and adult specimens, *I. paucus* probably has few natural predators over the course of its life. Nonetheless, it is not certain whether the species has natural predators during at least the first years of life.

Knowledge on post-capture mortality of the species is virtually non-existent. There is a single report of a female specimen of 307 cm stranded in Florida, United States, which probably died due to damage caused by a retained hook (Adams *et al.*, 2015). Coelho *et al.* (2012) reported a hooking mortality of 30.7% (N = 167) based on the Portuguese industrial longline fleet. Recently, Pan *et al.* (2022) reported a 50% hooking mortality in the Chinese bigeye tuna (*Thunnus obesus*) pelagic longline fishery from the Atlantic Ocean.

5. Fisheries biology**5. a Populations/stock structure**

The only work on genetic structuring of *I. paucus* in the Atlantic has been carried out recently by Magalhães (2018). Based on the control region of mitochondrial DNA, Magalhães (2018) analysed samples from 113 specimens caught by industrial longline vessels in the western and eastern Equatorial Atlantic Ocean. The results of this study evidenced low genetic diversity and absence of population structuring between sampling sites, which suggests the existence of a single stock with high genetic flow between both sides of the Atlantic. A more comprehensive study which considers a larger number of regions within the Atlantic Ocean and Mediterranean Sea is necessary to understand more fully the population structuring and genetic flow of the species in the Atlantic.

To date there are no studies that analyse the degree of connectivity between populations of *I. paucus* between the Atlantic Ocean and the Indo-Pacific, nor between the Atlantic Ocean and the Mediterranean Sea.

5. b Description of fisheries

At global level, *I. paucus* is caught in local small-scale fisheries and by industrial vessels in national and international waters, including gillnet, purse seine and longline (Camhi *et al.*, 2008; Babcock & Nakano 2008; Aguilar *et al.*, 2014; Rigby *et al.*, 2019; Seidu *et al.*, 2022). Although it is not considered a target or secondary species in the fisheries, *I. paucus* is traded for its flesh, fins and liver on the local and international markets (Camhi *et al.*, 2008; Clarke *et al.*, 2006; Dent & Clarke, 2015).

In the local fisheries of northern Cuba, *I. paucus* is the second most landed species and while it is not considered a target species, the specimens caught are landed and traded (Aguilar *et al.*, 2014; Ruiz-Abierno *et al.*, 2021b). In addition, the industrial pelagic longline fisheries are one of the greatest threats for the species, being taken as bycatch throughout most of its distribution range in the Atlantic Ocean (Moreno & Morón, 1992; Amorim *et al.*, 1998; Buencuerpo *et al.*, 1998; Hazin *et al.*, 2008; Coelho *et al.*, 2012; Mucientes *et al.*, 2013; Forselledo & Domingo, 2015; Lynch *et al.*, 2018). Given its similarity with *I. oxyrinchus* it is likely that part of the global catches of the species are landed and reported without being correctly identified (Castro, 2011).

The data obtained by Hueter *et al.* (2017) based on satellite telemetry, suggest that *I. paucus* is a species with mesopelagic habits, spending most of the time in deeper strata of the water column compared with *I. oxyrinchus*. Given this characteristic it is more difficult for pelagic longline fleets to find, being less susceptible to surface longline fisheries compared to *I. oxyrinchus*.

5. c Stock status

In general, pelagic sharks tend to use their energy initially in somatic growth, delaying sexual maturity and living longer than small coastal sharks. In addition, they grow at a faster rate, reach maturity earlier and live shorter than the large coastal species (Cortés 2000, 2002). In particular, *A. paucus* is considered to be one of the least productive species of pelagic shark (Snelson *et al.* 2008; Cortés *et al.* 2015), however, several aspects of its reproductive biology are not yet known exactly.

To date, no stock assessment has been conducted on the species within the Atlantic Ocean. Based on the results of an Ecological Risk Analysis for pelagic sharks in relation to the longline fisheries in the Atlantic, *I. paucus* was identified as one of the least productive species and the second most vulnerable, after bigeye thresher (*Alopias superciliosus*) (Cortés *et al.*, 2015). It should be noted that during this analysis, and as a result of the scarce biological information available on *I. paucus*, most of the biological and demographic parameters used for this species were assumed to be the same as those of *I. oxyrinchus*. While closely related, the life habits of both species of the genus *Isurus* appear to differ and it is likely that at least some of the parameters considered in that study were not necessarily representative of *I. paucus*.

The recent data on reproductive maturity and habitat use provided by Ruiz-Abierno *et al.* (2021a), Mignucci-Giannoni *et al.* (2020) and Hueter *et al.* (2017) as well as the new studies that build on the knowledge of the species' ecology and biology are vitally important for future demographic analyses and assessments. A recent study based on the United States longline fleet reported a drastic decrease in catches from the late 1980s, followed by apparent stability in the catch yields (although 4 to 5 times lower compared to the 1980s) until the end of the period analysed in 2013 (Lynch *et al.* 2018).

The global conservation status of *I. paucus* has recently been assessed by the International Union for Conservation of Nature (IUCN) and has been classified as “Endangered” (Rigby *et al.*, 2019). According to the authors, the catch time series for the species are inexistent for the vast majority of its distribution range except for the East coast of the United States. Based on this data series (1992-2015) the analysis revealed a 3.7% annual rate of decrease, consistent with an estimated average decrease of 93.4% over three generation times (75 years). Due to the scarce information on fisheries statistics at global level for the species, it is not possible to carry out a robust analysis on the current state of the population and conservation status of the species. However, the authors of this analysis considered that its global decrease could be similar to that estimated for *I. oxyrinchus* i.e. 50-79% over three time periods (Rigby *et al.*, 2019). These authors emphasized the need to repeat the analyses and assessment when there is information and fishing statistics from more regions of the globe.

Isurus paucus has been included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 2019. In the United States, it has been prohibited to retain *I. paucus* on board in commercial and recreational fisheries since 2000 (NMFS 2006). *Isurus paucus* is also listed on Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS).

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