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Size and sex composition of three carcharhiniform sharks landed by a coastal artisanal fleet from the northeastern coast of Brazil

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Sharks are among the marine organisms most impacted by intense fisheries, a worrying fact since they are key components in the trophic structure of ecosystems. In this context, fish landing data can help managers in shark conservation. This study characterized the landings of *Carcharhinus acronotus*, *Mustelus* cf. *canis*, and *Sphyrna mokarran* in the Mucuripe Embayment, Ceará, Brazil, along three study periods (1998–1999, 2006–2008, and 2015–2016). A total of 223 specimens were recorded from 227 site visits. *Carcharhinus acronotus* specimens measured from 50 to 139 cm in total length (TL), with a 1.3:1 sex ratio in favor of males. Most of the specimens recorded were adults (55.1% of males and 62.9% of females). *Mustelus* cf. *canis* varied from 64 to 133 cm in TL, with a sex ratio in favor of females (3.1:1). Most of the specimens recorded were adults (50% of males and 68% of females). *Sphyrna mokarran* specimens varied from 116 to 380 cm in TL, with a sex ratio of 7:1 in favor of males. Most of the specimens recorded were juveniles. This is the first fishery-dependent study to provide information on size and sex composition of these species for most of the southwestern equatorial Atlantic.

Keywords: Conservation, Elasmobranchs, Fisheries, Landings, Sharks.

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Os tubarões estão entre os organismos marinhos mais impactados pela pesca intensa, fato preocupante uma vez que são componentes fundamentais na estrutura trófica dos ecossistemas. Nesse contexto, dados de desembarques pesqueiros podem auxiliar gestores na conservação dos tubarões. Este estudo caracterizou os desembarques de *Carcharhinus acronotus*, *Mustelus* cf. *canis* e *Sphyrna mokarran* na enseada do Mucuripe, Ceará, Brasil, ao longo de três períodos de estudo (1998–1999, 2006–2008 e 2015–2016). Um total de 223 espécimes foi registrado em 227 visitas ao local. Espécimes de *Carcharhinus acronotus* mediram de 50 a 139 cm de comprimento total (CT), com razão sexual de 1,3:1 a favor dos machos. A maioria dos espécimes registrados era adulta (55,1% dos machos e 62,9% das fêmeas). *Mustelus* cf. *canis* variou de 64 a 133 cm em CT, com razão sexual a favor das fêmeas (3,1:1). A maioria dos espécimes registrados era adulta (50% dos machos e 68% das fêmeas). Espécimes de *Sphyrna mokarran* variaram de 116 a 380 cm em CT, com razão sexual de 7:1 a favor dos machos. A maioria dos espécimes registrados era juvenil. Este é o primeiro estudo dependente da pesca a fornecer informações sobre tamanho e composição sexual dessas espécies para a maior parte do sudoeste do Atlântico Equatorial.

Palavras-chave: Conservação, Desembarques, Elasmobrânquios, Pesca, Tubarões.

INTRODUCTION

Some coastal and pelagic shark species are among the most overexploited groups of marine animals due to high fishing mortality, slow growth, late sexual maturation, and low fecundity (Holden, 1974; Cortés, 2000; Lucifora *et al*., 2011). This is worrying because they are key components in the trophic structure of tropical, subtropical and temperate areas (Ferretti *et al*., 2008, 2010; Navia *et al*., 2010; Bornatowski *et al*., 2014). Sharks are essential for marine ecosystems since they are top and mesopredators (Cortés, 1999; Rupp, Bornatowski, 2021) and the loss of the populations of these apex predators can significantly impact the trophic chain of marine ecosystems, affecting ecological processes and biogeochemical cycles (Estes *et al*., 2011), in addition to affecting the structure of coastal ecosystems (Ferretti *et al*., 2010). Therefore, evaluating and monitoring the population status of shark species is important for species conservation and, consequently, to the environment. Some factors such as the characteristics and variations of small-scale fisheries, in addition to sustainable fisheries management measures (closed fishing season, selectivity of fishing gear and others) were considered among the leading research priorities for conserving chondrichthyans in Latin America (Becerril-García *et al*., 2022). This information may become the basis for assessing stocks of these species and enabling the development of management plans later for overexploited shark species.

Despite the need to acknowledge basic biological aspects of sharks, there is a lack of information about the capture of sharks in several areas worldwide, and a complete lack of basic biological information in many areas, especially in the western equatorial Atlantic along the northeastern Brazil coast. It is estimated that the northeast region

has about 40% of the fishermen's colonies distributed in 23 state federations in Brazil (Vasconcellos *et al*., 2007; Menezes *et al*., 2019). In this region, the Mucuripe Embayment, in Fortaleza, Ceará State, stands out as one of the main traditional fishery ports used to land and trade catches made by an artisanal fleet through multiple fishing gear (Aragão, Castro e Silva, 2006), being considered the main fishing point for comprising the largest artisanal fishing fleet in Fortaleza/Ceará (Menezes *et al*., 2019). Fisheries landings in the Mucuripe Embayment includes teleost fishes, crustaceans, mollusks, but sharks, and rays are also common (Faria *et al*., 2009; Santander-Neto *et al*., 2011a,b, 2020; Santander-Neto, Faria, 2020). Despite the knowledge about captured and landed elasmobranch diversity, there is a lack of information concerning their landings composition and population aspects (Santander-Neto *et al*., 2020). While the population structure of the nurse shark, *Ginglymostoma cirratum* (Bonnaterre, 1788) (Orectolobiformes) (Santander-Neto *et al*., 2011b) and blacktip shark, *Carcharhinus limbatus* (Valenciennes, 1839) (Santander-Neto *et al*., 2020) are already described for sharks landed by this fleet, the Carcharhinidae and Sphyrnidae families from the Carcharhiniformes order are among the groups with the least information available. For example, carcharhiniform species that lack such information are the blacknose, *Carcharhinus acronotus* (Poey, 1860), the hammerheads, *Sphyrna* spp., and the dusky smoothhound, *Mustelus canis*.

The blacknose, *C. acronotus* (Carcharhinidae) (Siegfried, Brooks, 2007; Afonso *et al*., 2014; Carlson *et al*., 2021a), is considered Endangered globally by the International Union of the Conservation of Nature (IUCN) (Carlson *et al*., 2021a) and Vulnerable in Brazil (Brasil, 2022). Also, several hammerhead species (Sphyrnidae) (Baum *et al*., 2003; Ferretti *et al*., 2008; Gallagher *et al*., 2014; Barreto *et al*., 2016; Rigby *et al*., 2019), including the great hammerhead, *Sphyrna mokarran* (Rüppell, 1837), are considered Critically Endangered globally by the IUCN (Rigby *et al*., 2019) and by the Ordinance 300 in Brazil (Brasil, 2022). On the other hand, populations of triakid shark species have relatively life history aspects that apparently make them less susceptible to fishing pressure. An example is the dusky smoothhound, *Mustelus canis* (Mitchell, 1815), which is considered more resilient to fishing pressure (Kiraly *et al*., 2003; Carlson *et al*., 2021b). This characteristic may be explained by its capture management (quotas), fast growth, and intrinsic population growth rate in the portion comprising most of the species geographic distribution (Rountree, Able, 1996; Conrath *et al*., 2002; Carlson *et al*., 2021b; Boscolo-Palo *et al*., 2022). This species is considered Near Threatened globally by the IUCN (Carlson *et al*., 2021b) and Endangered in Brazil by Ordinance 300 (Brasil, 2022).

Given the need of knowledge about the basic biological aspects of carcharhiniform sharks in northeastern Brazil, the goal of the present study was to describe the landings composition of three carcharhiniform species caught and landed by a coastal artisanal fleet from northeastern Brazil: *Carcharhinus acronotus*, *Mustelus canis* and *Sphyrna mokarran*.

MATERIAL AND METHODS

Fisheries area and fleet. The carcharhiniform sharks examined in the present study were captured on the northeastern coast of Brazil. More specifically, the fishing area extends along the Ceará Basin, from Paracuru to Aquiraz (central coast of Ceará State). This fishing area is located between the following coordinates: 03°43'S 38°05'W; 03°23'S 38°05'W and 03°25'S 38°48'W; 03°01'S 38°49'W (Fig. 1). Fisheries are conducted in depths ranging from 10 to 120 m. The fishing fleet is harbored in the Mucuripe Embayment, in Fortaleza.

The fishing fleet responsible for captures is mainly artisanal (small-scale). The vessels are motorboats (10 to 13 m in length) and fishing rafts (5 to 8 m in length). The motor boats remain from one to five days at sea, with an average of three days and the fishing rafts remain from three to six days at sea in depths ranging from 19 to 140 m (Freitas, 2020). Three fishing gears are used: (1) hook and line, which is composed of nylon line between 0.7 and 1 mm, hook size number 4 to 10 (up to 100 hooks are used in any given fishing trip); (2) longline, which is composed of nylon line of 2 mm and between 100 and 150 hooks with sizes varying from number 1 to 10; (3) surface and bottom gill-

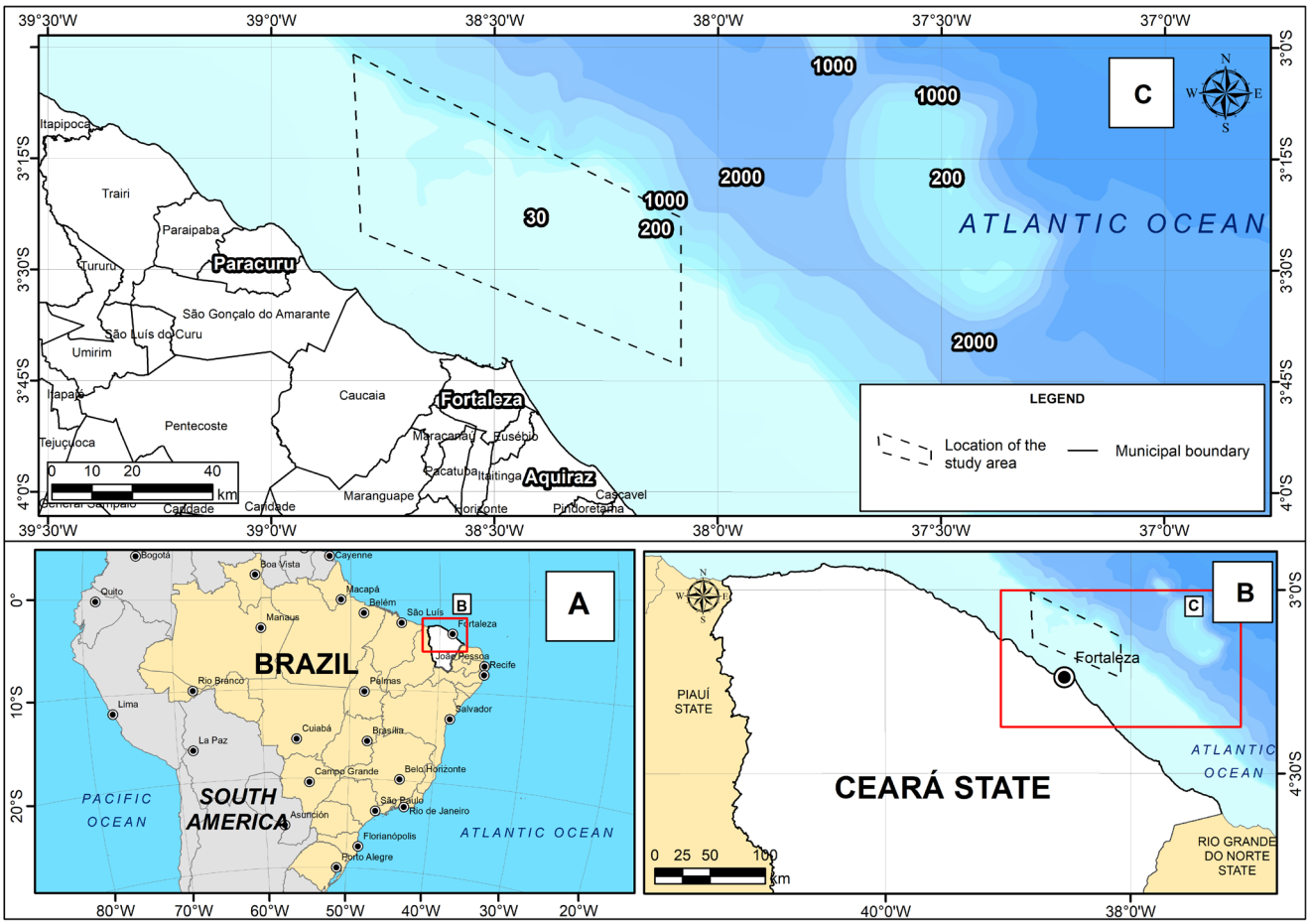

FIGURE 1 | Operational area of the artisanal fishing fleet based in the Mucuripe Embayment, Fortaleza, Ceará (delimited by dotted lines). Bathymetric curves and the municipalities' location on the Ceará coast are indicated as additional references to the limit of the fleet operation in the study area, highlighting the Ceará State.

nets, with mesh composed of nylon line with 0.5 to 0.9 mm, varying in the opening from 9 to 12 cm between opposite knots, each net having 100 m of longitudinal length and 4.8 m vertical length, around 100 nets being cast for each day of fishing. The hooks are used in "J" shape, usually for hook and line, and in circle hooks, usually used in longlines, or combined (Tab. 1).

Field data. Three carcharhiniform species, blacknose, *Carcharhinus acronotus*, dusky smoothhound, *Mustelus* cf. *canis*, and great hammerhead, *Sphyrna mokarran*, landed by the Mucuripe Embayment fisheries fleet were recorded during three periods encompassing a time span of around 20 years. Study period 1 extended from May/1998 to April/1999. Study period 2 extended from November/2006 to October /2008. Study period 3 extended from August/2015 to July/2016. The site visits were conducted weekly. All the individuals landed and available for trade were sexed and measured for Total Length in straight-line (TL; in cm) using a tape measure. Species identification followed Compagno (1984), Gadig (2001), Rosa (2009), Gomes *et al.* (2010), and Rosa, Gadig (2010). Due to the dynamics associated to a fish landing port, since all sharks are sold, and taking into consideration taxonomic difficulties involving the identification smoothhound sharks (Bigelow, Schroeder, 1940; Heemstra, 1997), all individuals identified as *Mustelus canis* at the landing site were referred as *Mustelus* cf. *canis* in the present study. Animal welfare laws, guidelines or policies were not applicable because no live fish was sampled/captured or collected during the present study, which was based on landed specimens being sold to the public by fishermen.

Data analysis. The three species were characterized for: (1) total number of specimens landed; (2) minimum, maximum, and average total length (TL); (3) sexual proportion; and (4) number of specimens per study period. In addition, the most abundant species, *C. acronotus*, was also characterized for monthly variations on the number of specimens recorded.

The maturity proportion was also characterized for all three species. The specimens were classified as 'juveniles' or 'adults' based on their TL, following the smaller mature individuals for each species described in the literature. *Carcharhinus acronotus* matures at 103 (female) and 104 (male) cm (Hazin *et al*., 2002). *Mustelus* cf. *canis* matures at 97 (female) and 81 (male) cm (Conrath, Musick, 2002). *Sphyrna mokarran* matures between 210 and 237 cm (female) and between 217 and 227 cm (male) (Stevens, Lyle, 1989; Cliff, 1995; Harry *et al*., 2011a). The distribution of TL classes was determined for each species. This provided a graphic depiction of the occurrence of juveniles and adult specimens in the landings.

TABLE 1 | Fishing gears used to capture the sharks landed in Mucuripe Embayment.

Fishing gears	Number of hooks	Nylon line thickness (mm)	Length (nets)	Vessel	Days at sea
Hook and line	Up to 100 hooks	0.7 to 1	–	Fishing rafts	3 to 6 days
Longline	100 to 150 hooks	2	–	Motor boats	1 to 5 days
Gill nets	–	0.5 to 0.9	100 m in longitudinal and 4.8 m in vertical	Motor boats	1 to 5 days

Statistical analyses. Normality tests were applied to each dataset of 'male/female TL' and 'number of landed specimens per study period' before statistical analyses. Two tests were performed with this purpose: the Kolmogorov-Smirnov test when sample sizes were greater than 50 ($\alpha = 0.05$) and the Shapiro-Wilk test when sample sizes were smaller than 50 ($\alpha = 0.05$). To test for homoscedasticity, the male/female TL dataset was submitted to the *F*-Test to compare two variances ($\alpha = 0.05$). The Bartlett's Test was applied for the number of landed specimens per study period to verify if variances were equal across the three periods ($\alpha = 0.05$). The dataset was log-transformed when the assumption of normality and homoscedasticity was not met. Then, the non-parametric tests described below in each subsection were applied, as recommended by Zar (2010).

Differences in the sex ratio of males and females were tested using the chi-square test. Differences in TL between sexes were tested for the most abundant species, *C. acronotus* and *M.* cf. *canis*, through the non-parametric Student's *t*-test (Wilcoxon-Mann-Whitney, $\alpha = 0.05$) (Zar, 2010).

The most abundant species, *C. acronotus* and *M.* cf. *canis*, were tested to identify any sign of changes for their landings composition between three periods. All specimens (*i.e.*, juveniles and adults) were considered for calculating each period's number of individuals landed. The statistical significance of each comparison was tested using Kruskal-Wallis ($\alpha = 0.05$). In cases where significant differences were detected, a procedure for multiple post hoc comparisons was adopted (Nemenyi Test) (Tabs. **S1**, **S2** and **S3**). The statistical analyses were performed using the software R v. 3.3.3 (R Development Core Team, 2018).

RESULTS

A total of 223 individuals of three carcharhiniform sharks, *Carcharhinus acronotus*, *Mustelus* cf. *canis*, and *Sphyrna* mokarran, were recorded from 227 site visits (Tab. 2).

TABLE 2 | Summary of the number of individuals (N) and days of sampling by species and sampling period.

Species	Period	Sampling period	N	Effort (days of sampling)
Carcharhinus acronotus	1	May/1998 – Apr/1999	90	75
	2	Nov/2006 – Oct/2008	45	102
	3	Aug/2015 – Jul/2016	5	50
Mustelus cf. *canis*	1	May/1998 – Apr/1999	4	75
	2	Nov/2006 – Oct/2008	54	102
	3	Aug/2015 – Jul/2016	9	50
Sphyrna mokarran	1	May/1998 – Apr/1999	3	75
	2	Nov/2006 – Oct/2008	6	102
	3	Aug/2015 – Jul/2016	7	50

Carcharhinus acronotus. A total of 140 individuals were recorded, resulting in an approximate rate of one specimen per two days of site visits. These specimens varied between 50 and 139 cm in total length (TL). Most specimens (25%) measured from 120 to 130 cm TL, while 12% of them measured from 130 to 140 cm TL. The average TL for males was 99.7 ± 25.7 cm and the average TL for females was 106.6 ± 27.3 cm. Overall, females were larger than males in TL (W = 2949.5; p = 0.026). About their sex, 78 specimens were males and 62 were females, which resulted in a 1.3:1 sex ratio that was not significantly different from the expected ratio of 1:1 (x^2 = 1.829; p = 0.2049, GL = 1). Most of the specimens recorded were adults (55.1% of males and 62.9% of females) (Fig. 2A).

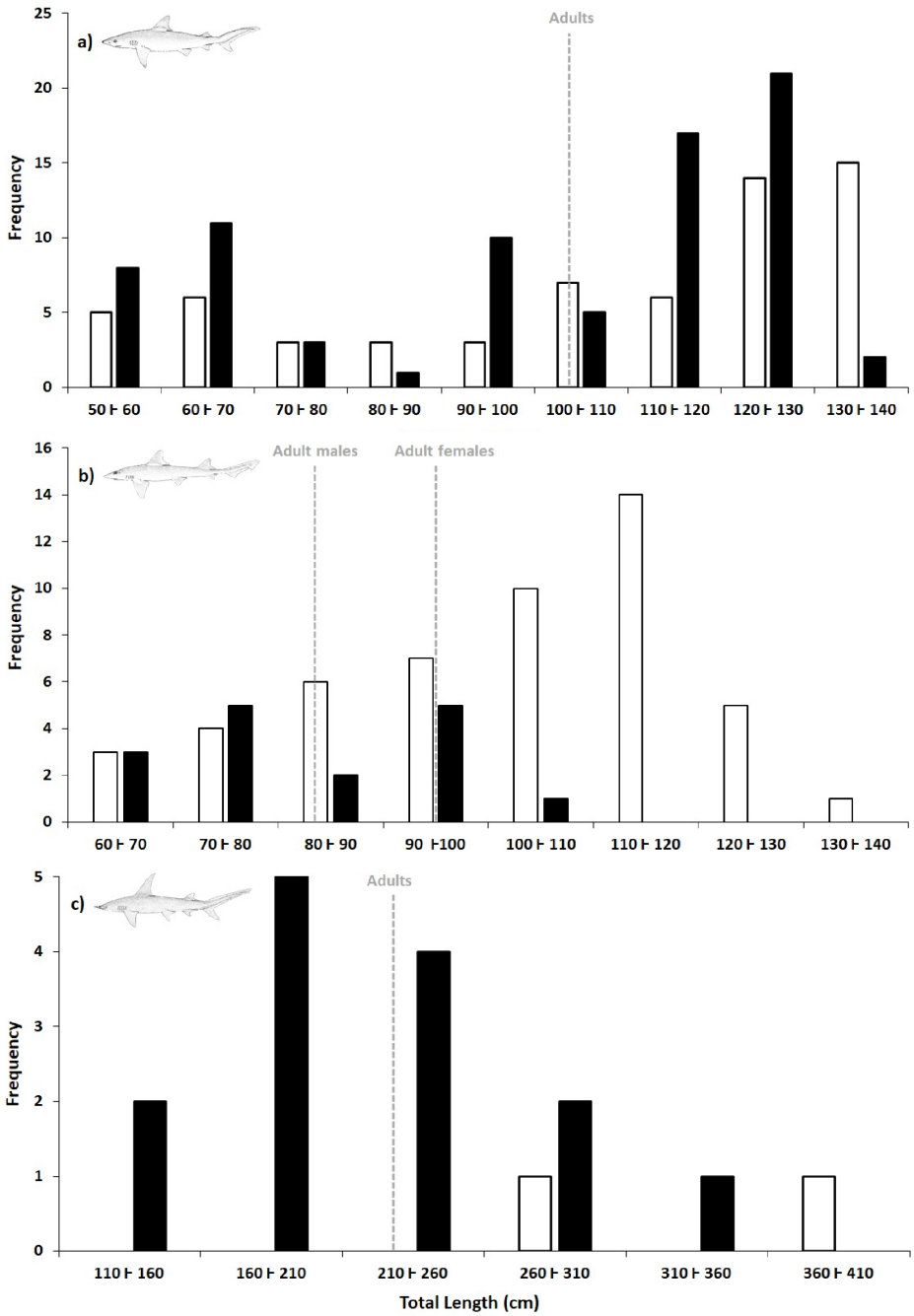

FIGURE 2 | Total length frequency for the (**A**) blacknose, *Carcharhinus acronotus*, **(B)** dusky smoothhound, *Mustelus* cf. *canis*, and (**C**) great hammerhead, *Sphyrna mokarran*, landed at the Mucuripe Embayment, Fortaleza, Ceará. White bars, female; black bars, male. The grey dashed line indicates maturation size for male (M), female (F) or for both sexes.

The number of specimens recorded differed (KW = 6.303; p = 0.042, GL = 2) along the study periods [90 individuals for period 1 (64%), 45 for period 2 (32%), and 5 for period 3 (4%)] (Tab. 2; Fig. 3). For periods 1 and 2, 57 individuals were juveniles (42.2%) and 78 were adults (57.8%). For period 3, only one juvenile and four adults were recorded and several TL classes of *C. acronotus* were not recorded in landings during this period (Fig. 3A). Regardless of study period and considering landings per month of any given year, juveniles (75.9%) were mostly recorded between December and March, while adults (62.19%) were mostly recorded for April, July, August, and November.

***Mustelus* cf. *canis*.** A total of 67 specimens were recorded on landings, resulting in a rate of one specimen per three days of site visits. These specimens varied from 64 to 133 cm in TL. Most specimens (22%) measured from 110 to 120 cm in TL (Fig. 2B). The average TL for males was 82.3 ± 13.2 cm and the average TL for females was 101.2 ± 17.8 cm. Overall, females were larger than males in TL (W = 657; p = 0.0008). About their sex, 66 out of the 67 recorded specimens were sexed, in which 50 were females and 16 were males, which resulted in a sex ratio of 3.1:1. This pattern in the sex ratio of

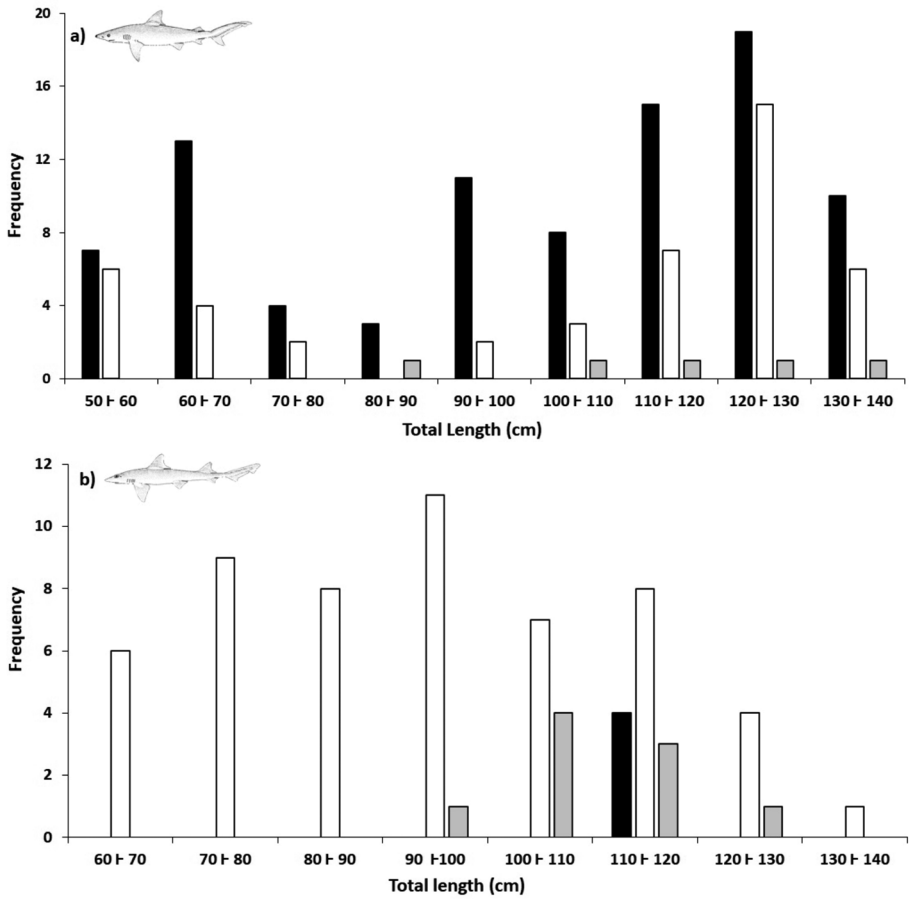

FIGURE 3 | Total length frequency for the (**A**) blacknose, *Carcharhinus acronotus*, and (**B**) dusky smoothhound, *Mustelus* cf. *canis*, landed at the Mucuripe Embayment, Fortaleza, Ceará, over three periods. Black bars, May 1998 to April 1999; white bars, November 2006 to October 2008; grey bars, August 2015 to July 2016.

females and males was significantly different ($x^2 = 17.515$; $p < 0.0001$, GL = 1). Most of the specimens recorded were adults (50% of males and 68% of females) (Fig. 2B). The number of specimens recorded in landings did not significantly differ among the three study periods (KW = 3.530; p = 0.171, GL = 2) [4 specimens (6%) in period 1, 54 in period 2 (81%), and 9 in period 3 (13%)] (Tab. 2; Fig. 3).

Sphyrna mokarran. A total of 16 specimens were recorded in landings, resulting in a rate of approximately one specimen per 14 days of site visits. These specimens varied from 116 to 380 cm in TL, with the modal class of 160–210 cm being the most representative among the individuals sampled (31% of the individuals) (Fig. 2C). The average TL for males was 197.4 ± 55.1 cm and the average TL for females was 330 ± 70.7 cm. These were 14 males and two females, which resulted in a sex ratio of 7:1 that was significantly different from the expected ratio of 1:1 (p = 0.006). Most of the specimens recorded were juveniles (nine of the 14 males representing 64.3%) (Fig. 2C). As for the only two females recorded, they were 280 and 380 cm in TL (the latter carrying 34 embryos). The distribution of specimens per study period was as follows: 3 specimens for period 1 (19%), 6 for period 2 (37%), and 7 for period 3 (44%).

DISCUSSION

This is the first fishery-dependent study to provide information on size and sex composition of *Carcharhinus acronotus*, *Mustelus* cf. canis, and *Sphyrna mokarran* landed by any fishing fleet for most of the southwestern equatorial Atlantic. The data obtained in the present study does not allow inferences on species abundance, since it lacks fishing effort data. But it is an improvement on the knowledge about shark landings in the region. This is because information such as number of individuals landed, total length, sexual proportion and others are under the research priorities for conserving the chondrichthyans in Latin America (Becerril-García *et al*., 2022). Local data are crucial for management and conservation of aquatic organisms since they can serve for the establishment of management approaches (Carr, Heyman, 2016). This kind of information is also especially important because no official fisheries statistics has been collected in Brazil for over a decade already (Gonçalves-Neto *et al*., 2021). Besides, lack of data with enough taxonomic resolution also prevents any use of traditional models based on catch per unit of effort in stock assessments (Dulvy *et al*., 2014).

Shark fisheries developed in the northeast region seem to follow the same pattern regarding the use of fishing gear. The Mucuripe Embayment fleet uses multiple fishing gears to capture sharks, following the same pattern used in other fisheries developed in the northeast region (Lessa, 1986a,b; Hazin *et al*., 2002; Meneses *et al*., 2005; Yokota, Lessa, 2006; Fischer *et al*., 2009; Afonso *et al*., 2011; Barreto *et al*., 2011; Zagaglia *et al*., 2011). The Mucuripe Embayment fleet fishes both in distant areas and near the coast, with a stable fishing effort over the years, mainly due to the constant use of rafts and motorboats, such as fishing vessels, and gill nets, hook and lines and longlines, as fishing gear (Menezes *et al*., 2019). In addition to the use of longlines to capture sharks, it should be noted that it is common for these individuals to be captured by gill nets and hook and lines as by-catch fauna of other types of fishing resources captured and landed by this fleet.

A large part of these fish landings in Ceará State originate from artisanal fisheries. The artisanal vessels represent over 70% of the maritime fishing fleet and are responsible for more than half of all fish production landed on the Ceará coast (Brasil, 2002), demonstrating their great capacity for capturing several species. The elasmobranch fauna landed at the Mucuripe Embayment has been studied in the recent years (Faria *et al*., 2009; Santander-Neto *et al*., 2011a,b, 2020, 2022; Santander-Neto, Faria, 2020), where there was little variation in the fishing gears used in the fisheries. This fleet trade sharks without distinction of species, considering only the size of individuals as a price differential.

***Carcharhinus acronotus*.** The discussion about the biology, fisheries and conservation of blacknose is essential to clarify its life history and assess the fishing pressure exerted on this species. *Carcharhinus acronotus* has relatively high fishing mortality (80% mortality rate; Afonso *et al*., 2014), it is susceptible to several fishing gears and captured primarily as a bycatch along its distribution range (Nichols, 2007; Barreto *et al*., 2011). As a coastal species, it is inevitably vulnerable to gill-net fisheries (Trent *et al*., 1997). Furthermore, different populations of *C. acronotus* seem to show regional differences between the life history parameters ($L\infty$, k, longevity) along their distribution (Driggers *et al*., 2004), corroborating the need for fisheries data that can support management initiatives related to *C. acronotus* as separate stocks.

The sex ratio indicated a greater number of males than females in fishing landings but was not significantly different from the expected ratio of 1:1. This pattern differed from the capture pattern of individuals of this species in Pernambuco, Brazil (Hazin *et al*., 2002; Barreto *et al*., 2011), where a greater number of females were captured compared to males. The variation in this study may be related to the seasonal pattern of females that seem to move away from coastal waters during specific periods of the year (Afonso *et al*., 2014).

Both juvenile and adult blacknose used to be caught and landed by the studied local fleet, but juveniles were not recorded in the last of the three studied periods. Blacknose juveniles occur mainly in coastal waters (Afonso *et al*., 2014) and are caught by fisheries in other parts of northeastern Brazil (Barreto *et al*., 2011). Being a coastal species, *C. acronotus* can be captured by several fishing devices and all length classes are vulnerable once the Mucuripe Embayment fleet also deploys its fishing gears in shallow waters (Freitas, 2020). All length classes were recorded during the first two periods, but this pattern changed in the third study period when fewer adults were recorded, and the lower-length classes were no longer recorded. Since fishing effort data is lacking, it is not known if this pattern reflects a change in local relative abundance or any change that might have occurred in the fishing fleet or fishing effort in the past years. For instance, selectivity of the hooks was considered one potential cause for the low number of juveniles recorded for coastal waters of Pernambuco State, also in northeastern Brazil (Afonso *et al*., 2014). On the other hand, declines in captures of *C. acronotus* have already been detected in other parts of coastal northeastern Brazil (Pernambuco; Afonso *et al*., 2014) and southern USA (Florida; Siegfried, Brooks, 2007). Therefore, further assessments that include fishing effort data are needed to better clarify the difference in the number of individuals landed over time detected in the present study.

***Mustelus* cf. *canis*.** The fisheries in the region capture mainly adults, notably females, which are larger than males in fishing landings at Mucuripe Embayment. This

distribution for the species was also observed on the north atlantic coast of the United States (Dell'Apa *et al*., 2018) and in northeastern coast of Brazil (Zagaglia *et al*., 2011) and may be related to the behavior of females that inhabit shallow inshore coastal waters compared to adult males that appear to have a seasonal pattern in their occurrence (Dell'Aapa *et al*., 2018).

The higher frequency of females in coastal waters can be directly related to the number of juveniles. In an estuary in the south of New Jersey, 96% of juveniles of the year of *M. canis* were caught by a variety of fishing gear (Rountree, Able, 1996). The predominance of juveniles in coastal waters shown in this study has also been described for other shark species in northeastern Brazil (Lessa, 1986a; Lessa, Almeida, 1997; Yokota, Lessa, 2006; Lessa *et al*., 2016). This pattern has also already been detected for the nurse shark, *Ginglymostoma cirratum*, and blacktip shark, *Carcharhinus limbatus*, captured by this same fishing fleet (Santander-Neto *et al*., 2011b, 2020).

The landings of *M.* cf. *canis* in the area did not differ between periods. As already mentioned, the lack of fishing effort data in this study prevents inferring any population trend. However, it is important to emphasize the relatively lower susceptibility of this species to fishing pressure. *Mustelus canis* grows quicker and reaches sexual maturity at a younger age in comparison to other shark species as for example *M. lenticulatus* Phillipps, 1932, *M. antarticus* Günther, 1870, *M. henlei* (Gill, 1863), *M. californicus* Gill, 1864, *Carcharhinus obscurus* (Lesueur, 1818), *Rhizoprionodon taylori* (Ogilby, 1915) (Conrath *et al*., 2002), which likely provides more productivity and resistance to fisheries exploitation (Conrath *et al*., 2002). A previous data on fisheries for this species in Ceará, where 154 specimens were captured between 1997 and 2001 using bottom longlines between 100 and 350 m with a capture per unit of effort (CPUE) of 0.18 individuals per 100 hooks, considered the population of this species as "sustainable" for those years (Brasil, 2006).

***Sphyrna mokarran*.** The low frequency of observed landings suggests that the captures of the great hammerhead by the Mucuripe artisanal fishing fleet are accidental or eventual. The broad variation in length classes from sampled individuals (116–380 cm) is likely related to gears used by the studied fishing fleet, which includes fishing gears specific to capture large sharks (longlines) and other types of fishing gears including nets that capture other mesopredator sharks as bycatch. Besides gear selectivity, it is not known if catches of this species in the past had any major impact on its population, leading to the low numbers recorded nowadays in the landings once this species has high vulnerability to fishing pressure (Rosa *et al*., 2018). *Sphyrna mokarran* is experiencing population declines worldwide (Rigby *et al*., 2019), including South Africa (Cliff, 1995; Gullak *et al*., 2015), Indian Ocean, Northwest Atlantic, and Gulf of Mexico (Rigby *et al*., 2019). Some factors emphasize the vulnerability of the species to fishing, such as the high value and trade of its fins (Rigby *et al*., 2019; Cardeñosa *et al*., 2020), their easy catch in coastal regions by commercial pelagic fisheries (Calich, 2016), and due to their relevance for sport fishing (Shiffman, Hammerschlag, 2014).

The landings of *S. mokarran* by the Mucuripe fleet are primarily composed of juvenile males, a typical capture pattern for the species. World records indicate a larger number of juveniles, primarily males, in South Africa (Cliff, 1995) and in coral reef areas in Australia (Harry *et al*., 2011b), indicating that juvenile individuals are more susceptible

to coastal fisheries. This pattern is likely because females move to tropical coastal waters to give birth (Gallagher *et al*., 2014). In addition, males breed annually while females reproduce every two years (Stevens, Lyle, 1989), further justifying why males, juvenile or adult, can be more frequent than females in coastal areas, since females take longer to approach coastal waters to give birth.

Considerations for shark conservation. In 2014, Ordinance N° 445/2014 (Brasil, 2014) was published in Brazil, which listed 475 taxa of fish and aquatic invertebrates of the Brazilian fauna as threatened with extinction. Furthermore, with the cooperation of several scientists, the Red Book of Brazilian Fauna Threatened with Extinction was published, which is divided into 7 volumes according to the group studied (mammals, fish, birds, invertebrates and others) (ICMBio, 2018). However, mainly for political reasons, Ordinance 445/2014 was revoked and amended by several other ordinances that would reduce the sanctions for those who fished species that were considered endangered species (Ordinance N° 98/2015; Brasil, 2015), extended the deadline for maintaining the landing of species classified as "Endangered" and "Critically Endangered" (Ordinance N° 163/2015; Brasil, 2015), reclassified and allowed the landing of some endangered species (Ordinance N° 395/2016; Brasil, 2016) and enabled the "sustainable use" of endangered species (Ordinance N° 73/2018; Brasil, 2018). Recently, it was published Ordinance No. 300/2022, through the National List of Endangered Species, that recognized *C. acronotus* as a "Vulnerable" species in Brazil (Brasil, 2022). Management measures for this species, such as establishing catch sizes, may be necessary to avoid populations of this species to reach a greater risk of extinction (*i.e*., from 'Vulnerable' to 'Endangered').

The IUCN Red List criteria, in addition to other factors, use population declines to determine the species conservation status. The IUCN recommends that while the criteria are quantitative, the absence of high-quality data should not preclude its application since any uncertainty in the dataset can be considered in a Red List assessment. In this sense, the IUCN criteria employ the terms Observed, Estimated, Projected, Inferred and Suspected to refer to the type of evidence (IUCN, 2022). A suspected population decline may be based on some factor related to population abundance or distribution, provided that the relevance of these factors can be reasonably argued (see IUCN, 2022). The results obtained in this study lack information about fishery effort and therefore does not permit population trend inference. Thus, further research on fishing effort and CPUE for this artisanal fleet is recommended, with the establishment of time series to provide data sets for accurate IUCN estimates under the criterion "A2bd". Still, the data collection under time series in artisanal fleets in this and other areas along the Brazilian coast is challenging due to pulverized landings, the absence of fisheries statistics (Gonçalves-Neto *et al*., 2021), and the lack of species-level identification of elasmobranchs in past governmental fisheries records, which adopted an identification system using only "cação" (common name for sharks) and rays (Furtado-Neto, Barros-Júnior, 2006). Long-term monitoring efforts of size, composition and distribution of these species can be necessary to determine the biological significance of possible changes that may occur in their populations. Therefore, we reinforce the need for studies using CPUE data for the region, with the aim of better characterizing the population structure and abundance of these species in the northeastern coast of Brazil.

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REFERENCES

- **Afonso AS, Andrade HA, Hazin FHV.** Structure and dynamics of the shark assemblage off Recife, northeastern Brazil. PLoS ONE. 2014; 9(7):e102369. https://doi.org/10.1371/journal.pone.0102369
- **Afonso AS, Hazin FHV, Carvalho F, Pacheco JC, Hazin H, Kerstetter DW, Murie D, Burgess GH.** Fishing gear modifications to reduce elasmobranch mortality in pelagic and bottom longline fisheries off Northeast Brazil. Fish Res. 2011; 108:336–43. https://doi.org/10.1016/j.fishres.2011.01.007
- **Aragão JAN, Castro e Silva SMM.** Censo estrutural da pesca coleta de dados e estimação de desembarques de pescado. Brasília: IBAMA, 2006; 180p.
- **Barreto RR, Lessa RP, Hazin FH, Santana FM.** Age and growth of the blacknose shark, *Carcharhinus acronotus* (Poey, 1860) off the northeastern Brazilian. Fish Res. 2011; 110(1):170–76. https://doi.org/10.1016/j.fishres.2011.04.003
- **Barreto R, Ferretti F, Flemming JM, Amorim A, Andrade H, Worm B, Lessa R.** Trends in the exploitation of South Atlantic shark populations. Conserv Biol. 2016; 30(4):792–804. https://doi.org/10.1111/cobi.12663
- **Baum JK, Myers RA, Kehler DG, Worm B, Shelton JH, Penny AD.** Collapse and conservation of shark populations in the northwest Atlantic. Science. 2003; 299(5605):389–92. https://doi.org/10.1126/science.1079777
- **Becerril-García EE, Arauz R, Arellano-Martínez M, Bonfil R, Ayala-Bocos A, Castillo-Géniz JL, Carrera-Fernández M, Charvet P, Chiaramonte G, Cisneros-Montemayor AM, Concha F, Espinoza M, Ehemann NR, Estupiñán-Montaño C, Fuentes K, Galván-Magaña F, Graham R, Hacohen-Domené A, Hazin F, Hernández S, Hoyos-Padilla EM, Ketchum JT, Kingma I, Méndez O, Oddone MC, Pérez-Jiménez JC, Petatán-Ramírez D, Polo-Silva C, Rangel B, Salinas-de-León P, Santana-Morales O, Zanella I, Vélez-Zuazo X, Godard-Codding CAG.** Research priorities for the conservation of chondrichthyans in Latin America. Biol Conserv. 2022; 269:109535. https://doi.org/10.1016/j.biocon.2022.109535
- **Bigelow HB, Schroeder WC.** Sharks of the genus *Mustelus* in the Western Atlantic. Proc Boston Soc Nat Hist. 1940; 41(8):417–38.
- **Bornatowski H, Navia AF, Braga RR, Abilhoa V, Corrêa MFM.** Ecological importance of sharks and rays in a structural foodweb analysis in southern Brazil. ICES J Mar Sci. 2014; 71(7):1586–92. https://doi.org/10.1093/icesjms/fsu025
- **Boscolo-Palo G, Di Lorenzo M, Gancitano S, Ragonese S, Mazzoldi C, Colloca F.** Sharks do not always grow slowly: Tagging data reveal a different pattern of growth, longevity and maturity for threatened smooth-hounds in the Central Mediterranean Sea. J Mar Sci Eng. 2022; 10(11):1647. https://doi.org/10.3390/jmse10111647
- **Brasil.** Ministério do Meio Ambiente. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA, Boletim estatístico da pesca marítima e estuarina do Nordeste do Brasil, Tamandaré: Centro de Pesquisa e Extensão Pesqueira do Nordeste do Brasil; 2002.

- **Brasil.** Ministério do Meio Ambiente. Programa REVIZEE. Avaliação do Potencial Sustentável de Recursos Vivos na Zona Econômica Exclusiva: Relatório Executivo, Secretaria de Qualidade Ambiental, 2006.
- **Brasil.** Ministério do Meio Ambiente. Portaria MMA N° 445, de 17 de dezembro de 2014. Diário Oficial da União, seção 1, p.126, 18 de dezembro de 2014.
- **Brasil.** Ministério do Meio Ambiente. Portaria MMA N° 98, de 28 de abril de 2015. Diário Oficial da União, seção 1, p.86, 29 de abril de 2015.
- **Brasil.** Ministério do Meio Ambiente. Portaria MMA N° 163, de 8 de junho de 2015. Diário Oficial da União, seção 1, p.48, 9 de junho de 2015.
- **Brasil.** Ministério do Meio Ambiente. Portaria MMA N° 395, de 1 de setembro de 2016. Diário Oficial da União, seção 1, p.46, 2 de setembro de 2016.
- **Brasil.** Ministério do Meio Ambiente. Portaria MMA N° 73, de 26 de março de 2018. Diário Oficial da União, seção 1, p.160, 28 de março de 2018.
- **Brasil.** Ministério do Meio Ambiente. Portaria MMA N° 300, de 13 de dezembro de 2022. Diário Oficial da União, Edição 234, seção 1, p.75, 14 de dezembro de 2022.
- **Calich HJ.** Identifying suitable habitat for three highly migratory sharks (Great hammerhead, tiger, and bull) and assessing their spatial vulnerability to commercial longline fishing in the Southwest Atlantic Ocean and Gulf of Mexico. [Master Dissertation]. Coral Gables: University of Miami; 2016.
- **Cardeñosa D, Fields AT, Babcock EA, Shea SKH, Feldheim KA, Chapman DD.** Species composition of the largest shark fin retail-market in mainland China. Sci Rep. 2020; 10(1):1–10. https://doi.org/10.1038/s41598-020-69555-1
- **Carlson J, Charvet P, Avalos C, Blanco-Parra MP, Briones Bell-lloch A, Cardenosa D, Espinoza E, Morales-Saldaña JM, Naranjo-Elizondo B, Pérez Jiménez JC, Schneider EVC, Simpson NJ, Talwar BS, Crysler Z, Derrick D, Kyne PM, Pacoureau N.** *Carcharhinus acronotus.* The IUCN Red List of Threatened Species. 2021a: e.T161378A887542. https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T161378A887542.en
- **Carlson J, Charvet P, Blanco-Parra MP, Briones Bell-lloch A, Cardeñosa D, Derrick D, Espinoza E, Morales-Saldaña JM, Naranjo-Elizondo B, Pacoureau N, Pérez Jiménez JC, Schneider EVC, Simpson NJ, Talwar BS, Pollom R.** *Mustelus canis*. The IUCN Red List of Threatened Species. 2021b: e.T39359A2908200. https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T39359A2908200.en
- **Carr LM, Heyman WD.** Testing fisher-developed alternatives to fishery management tools for community support and regulatory effectiveness. Mar Policy. 2016; 67:40–53. https://doi.org/10.1016/j.marpol.2016.01.027
- **Cliff G.** Sharks caught in the protective gill nets off KwaZulu-Natal, South Africa. 8. The Great hammerhead shark *Sphyrna mokarran* (Rüppell). S Afr J Mar Sci. 1995; 15(1):105–14. https://doi.org/10.2989/025776195784156331
- **Compagno LJV.** FAO species catalogue. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2: Carcharhiniformes, FAO Fisheries Synopsis. 1984; 4(125):538–54.
- **Conrath CL, Gelsleichter J, Musick JA.** Age and growth of the smooth dogfish (*Mustelus canis*) in the northwest Atlantic Ocean. Fish Bull. 2002; 100(4):674–82.
- **Conrath CL, Musick JA.** Reproductive biology of the smooth dogfish, *Mustelus canis*, in the northwest Atlantic Ocean. Environ Biol Fishes. 2002; 64:367–77. https://doi.org/10.1023/A:1016117415855
- **Cortés E.** Standardized diet compositions and trophic levels of sharks. ICES J Mar Sci. 1999; 56(5):707–17. https://doi.org/10.1006/jmsc.1999.0489
- **Cortés E.** Life history patterns and correlations in sharks. Rev Fish Sci. 2000; 8(4):299–344. https://doi.org/10.1080/10408340308951115
- **Dell'Apa A, Pennino MG, Bangley CW, Bonzek C.** A hierarchical bayesian modeling approach for the habitat distribution of smooth dogfish by sex and season in inshore coastal waters of the U.S. Northwest Atlantic. Mar Coast Fish. 2018; 10(6):590–605. https://doi.org/10.1002/mcf2.10051

- **Driggers W, Carlson J, Cullum B, Dean JM, Oakley D.** Age and growth of the blacknose shark, *Carcharhinus acronotus*, in the western North Atlantic Ocean with comments on regional variation in growth rates. Environ Biol Fishes. 2004; 71:171–78. https://doi.org/10.1007/s10641-004-0105-z
- **Dulvy NK, Fowler SL, Musick JA, Cavanagh RD, Kyne PM, Harrison LR, Carlson JK, Davidson LNK, Fordham SV, Francis MP, Pollock CM, Simpfendorfer CA, Burgess GH, Carpenter KE, Compagno LJV, Ebert DA, Gibson C, Heupel MR, Livingstone SR, Sanciangco JC, Stevens JD, Valenti S, White WT.** Extinction risk and conservation of the world's sharks and rays. eLife. 2014; 3:e00590. https://doi.org/10.7554/eLife.00590
- **Estes JA, Terborgh J, Brashares JS, Power ME, Berger J, Bond WJ, Carpenter SR, Essington TE, Holt RD, Jackson JBC, Marquis RJ, Oksanen L, Oksanen T, Paine RT, Pikitch EK, Ripple WJ, Sandin SA, Scheffer M, Schoener TW, Shurin JB, Sinclair ARE, Soulé ME, Virtanen R, Wardle DA.** Trophic downgrading of Planet Earth. Science. 2011; 333(6040):301–06. https://doi.org/10.1126/science.120510615
- **Faria VV, Venancio IM, Basilio TH, Silveira LM, Jucá-Queiroz B, Gadig OB, Furtado-Neto MAA.** Tubarão-baleia, *Rhincodon typus*, capturado ao largo do Ceará, Nordeste do Brasil. Pan-Amer J Aquat Sci. 2009; 4(4):599–604. Available from: http://panamjas.org/pdf_artigos/PANAMJAS_4(4)_599-604.pdf
- **Ferretti F, Myers RA, Serena F, Lotze HK.** Loss of large predatory sharks from the Mediterranean Sea. Conserv Biol. 2008; 22(4):952–64. https://doi.org/10.1111/j.1523-1739.2008.00938.x
- **Ferretti F, Worm B, Britten GL, Heithaus MR, Lotze HK.** Patterns and ecosystem consequences of shark declines in the ocean. Ecol Lett. 2010; 13:1055–71. https://doi.org/10.1111/j.1461-0248.2010.01489.x
- **Fischer AF, Hazin FVV, Carvalho F, Viana DL, Rêgo MG, Wor C.** Biological aspects of sharks caught off the coast of Pernambuco, Northeast Brazil. Braz J Biol. 2009; 69(4):1173–81. https://doi.org/10.1590/S1519-69842009000500023
- **Freitas MC.** Caracterização da pesca artesanal com linha de mão praticada com jangadas sediadas na Enseada do Mucuripe, município de Fortaleza Ceará. In: Barbosa FC, Ulhôa JLR, editors. Engenharia de Pesca: Produtividade e Sustentabilidade. Piracanjuba: Conhecimento Livre; 2020. p.612–29.
- **Furtado-Neto MAA, Barros-Júnior FVP.** Análise da produção pesqueira de elasmobrânquios no estado do Ceará, Brasil, de 1991 a 2003. Arq Cienc Mar. 2006; 39:110–16. Available from: http://www.repositorio.ufc.br/handle/riufc/53947
- **Gadig OBF.** Tubarões da costa do Brasil. [PhD Thesis]. Rio Claro: Instituto de Biociências, Universidade Estadual Paulista "Júlio de Mesquita Filho"; 2001.
- **Gallagher AJ, Hammerschlag N, Shiffman DS, Giery ST.** Evolved for extinction: The cost and conservation implications of specialization in hammerhead sharks. Bioscience. 2014; 64(7):619–24. https://doi.org/10.1093/biosci/biu071
- **Gomes UL, Signori C, Gadig OTF, Santos EHRS.** Guia para identificação de tubarões e raias do Rio de Janeiro. Rio de Janeiro: Technical Books; 2010.
- **Gonçalves-Neto JB, Goyanna FAA, Feitosa CV, Soares MO.** A sleeping giant: the historically neglected Brazilian fishing sector. Ocean & Coastal Management. 2021; 209(1):105699. https://doi.org/10.1016/j.ocecoaman.2021.105699
- **Gullak SJB, Santiago AJR, Carlson JK.** Hooking mortality of scalloped hammerhead *Sphyrna lewini* and great hammerhead *Sphyrna mokarran* sharks caught on bottom longlines. Afr J Mar Sci. 2015; 37(2):267–73. https://doi.org/10.2989/1814232X.2015.1026842
- **Harry AV, Macbeth WG, Gutteridge AN, Simpfendorfer CA.** The life histories of endangered hammerhead sharks (Carcharhiniformes, Sphyrnidae) from the east coast of Australia. J Fish Biol. 2011a; 78(7):2026–51. https://doi.org/10.1111/j.1095-8649.2011.02992.x
- **Harry AV, Tobin AJ, Welch DJ, Simpfendorfer CA, Welch DJ, Mapleston A, White J, Williams AJ, Stapley J.** Evaluating catch and mitigating risk in a multispecies, tropical, inshore shark fishery within the Great Barrier Reef World Heritage Area. Mar Fresh Res. 2011b; 62(6):710–21. https://doi.org/10.1071/MF10155

- **Hazin FHV, Oliveira PG, Broadhurst MK.** Reproduction of the blacknose shark (*Carcharhinus acronotus*) in coastal waters off northeastern Brazil. Fish Bull. 2002; 100(1):143–48. Available from: https://aquadocs.org/handle/1834/31051
- **Heemstra PC.** A review of the Smooth-Hound Sharks (genus *Mustelus*, family Triakidae) of the Western Atlantic Ocean, with descriptions of two new species and a new subspecies. Bull Mar Sci. 1997; 60(3):894–928.
- **Instituto Chico Mendes de Conservação da Biodiversidade (ICMBIO).** Livro Vermelho da Fauna Brasileira Ameaçada de Extinção. Brasília: ICMBio; 2018.
- **International Union for Conservation of Nature (IUCN). Standards and petitions subcommittee.** Guidelines for using the IUCN Red List categories and criteria. Version 14 [Internet]. Gland; 2022. Available from: https://www.iucnredlist.org/resources/redlistguidelines
- **Holden MJ.** Problems in the rational exploitation of elasmobranch population and some suggested solutions. In: Harden-Jones FR, editor. Sea Fisheries Research. Halsted Press New York; 1974. p.117–37.
- **Kiraly SJ, Moore JA, Jasinski PH.** Deepwater and other sharks of the U.S. Atlantic Ocean Exclusive Economic Zone. Mar Fish Rev. 2003; 65(4):1–63. Available from: https://aquadocs.org/handle/1834/26344
- **Lessa RP.** Contribuição ao conhecimento da biologia de *Carcharhinus porosus* Ranzani, 1839 (Pisces, Chondrichthyes) das reentrâncias Maranhenses. Acta Amazon. 1986a; 16:73–86. https://doi.org/10.1590/1809-43921986161086
- **Lessa RP.** Levantamento faunístico dos elasmobrânquios (Pisces, Chondrichthyes) do litoral ocidental do Estado do Maranhão, Brasil. Bol Lab Hidrobiol. 1986b; 7(1):27–41.
- **Lessa R, Almeida Z.** Analysis of stomach contents of the smalltail shark *Carcharhinus porosus* from northern Brazil. Cybium. 1997; 21(2):123–33. Available from: https://sfi-cybium.fr/en/node/1774
- **Lessa R, Batista VS, Santana FM.** Close to extinction? The collapse of the endemic daggernose shark (*Isogomphodon oxyrhynchus*) off Brazil. Global Ecol Conserv. 2016; 7:70–81. https://doi.org/10.1016/j.gecco.2016.04.003
- **Lucifora LO, García VB, Worm B.** Global diversity hotspots and conservation priorities for sharks. PLoS ONE. 2011; 6(5):e19356. https://doi.org/10.1371/journal.pone.0019356
- **Meneses TS, Santos FN, Pereira CW.** Fauna de elasmobrânquios do litoral do Estado de Sergipe, Brasil. Arq Cienc Mar. 2005; 38(1–2):79–83.
- **Menezes CR, Delgado JF, Lima LS, Corrêa TR, Mello SLM, Fonseca EM.** Diagnóstico da pesca artesanal na área de influência do porto do Mucuripe, em Fortaleza (CE): subsídios à gestão pesqueira regional. Rev Eletrônica Sist Inf Gest. 2019; 14(3):279–90. https://doi.org/10.20985/1980-5160.2019.v14n3.1554
- **Navia AF, Cortés E, Mejía-Falla PA.** Topological analysis of the ecological importance of elasmobranch fishes: a food web study on the Gulf of Tortugas, Colombia. Ecol Modell. 2010; 221(24):2918–26. https://doi.org/10.1016/j.ecolmodel.2010.09.006
- **Nichols S.** Bycatch of small coastal sharks in the offshore shrimp fishery. National Marine Fisheries Service. SEDAR 13-DW-32. Miami, Florida; 2007.
- **R Development Core Team.** A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. 2018. Available from: https://www.r-project.org/
- **Rigby CL, Barreto R, Carlson J, Fernando D, Fordham S, Francis MP, Herman K, Jabado RW, Liu KM, Marshall A, Pacoureau N, Romanov E, Sherley RB, Winker H.** *Sphyrna mokarran*. The IUCN Red List of Threatened Species. 2019: e.T39386A2920499. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T39386A2920499.en
- **Rosa MR.** Revisão taxonômica do gênero *Mustelus* Linck, 1790, do Brasil (Chondrichthyes, Carcharhiniformes, Triakidae). [Master Dissertation]. Rio Claro: Instituto de Biociências, Universidade Estadual Paulista "Júlio de Mesquita Filho; 2009.
- **Rosa MR, Gadig OBF.** Taxonomic comments and an identification key to species for the Smooth-hound sharks genus *Mustelus* Link, 1790 (Chondrichthyes: Triakidae) from the Western South Atlantic. Pan-Amer J Aquat Sci. 2010; 5(3):401–13. Available from: http://panamjas.org/pdf_artigos/PANAMJAS_5(3)_401-413.pdf

- **Rosa RS, Soto JMR, Barreto RRP, Lessa RPT.** *Sphyrna mokarran* (Rüppell, 1837). In: Instituto Chico Mendes de Conservação da Biodiversidade, organizer. Livro Vermelho da Fauna Brasileira Ameaçada de Extinção: Volume VI - Peixes. Brasília: ICMBio; 2018. p.971–75.
- **Rountree RA, Able KW.** Seasonal abundance, growth, and foraging habits of juvenile smooth dogfish, *Mustelus canis*, in a New Jersey estuary. U.S. Fish Bull. 1996; 94:522–34.
- **Rupp A, Bornatowski H.** Food web model to assess the fishing impacts and ecological role of elasmobranchs in a coastal ecosystem of Southern Brazil. Environ Biol Fishes. 2021; 104(8): 905–21. https://doi.org/10.1007/s10641-021-01120-9
- **Santander-Neto J, Faria VV, Castro ALF, Burgess GH.** New record of the rare ragged-tooth shark, *Odontaspis ferox* (Chondrichthyes: Odontaspidae) from the south-west Atlantic identified using DNA bar coding. Mar Biodivers Rec. 2011a; 4:e75. https://doi.org/10.1017/S1755267211000698
- **Santander-Neto J, Shinozaki-Mendes RA, Silveira LM, Jucá-Queiroz B, Furtado-Neto MAA, Faria VV.** Population structure of nurse sharks, *Ginglymostoma cirratum* (Orectolobiformes), caught off Ceará State, Brazil, South-western Equatorial Atlantic. J Mar Biol Assoc UK. 2011b; 91(6):1193–96. https://doi.org/10.1017/S0025315410001293
- **Santander-Neto J, Faria VV.** Sharks and rays caught by a small-scale fisheries in the western equatorial Atlantic. J Appl Ichthyol. 2020; 36(6):830–33. https://doi.org/10.1111/jai.14103
- **Santander-Neto J, Yokota L, Meneses TS.** Parturition time for the blacktip shark, *Carcharhinus limbatus* (Carcharhiniformes: Carcharhinidae), in Southwestern Atlantic. Neotrop Ichthyol. 2020; 18(3):e20029. https://doi.org/10.1590/1982-0224-2020-0029
- **Santander-Neto J, Rincon G, Jucá-Queiroz B, Paes da Cruz V, Lessa R.** Distribution and new records of the bluntnose sixgill shark, *Hexanchus griseus* (Hexanchiformes: Hexanchidae), from the Tropical Southwestern Atlantic. Animals. 2022; 13(1):91. https://doi.org/10.3390/ani13010091
- **Shiffman DS, Hammerschlag N.** An assessment of the scale, practices, and conservation implications of Florida's charterboat-based recreational shark fishery. Fisheries. 2014; 39(9):395–407. https://doi.org/10.1080/03632415.2014.941439
- **Siegfried KI, Brooks EN.** Assessment of Blacknose, Bonnethead, and Atlantic Sharpnose sharks with a state-space, age-structured production model. National Marine Fisheries Service. SEDAR 13-AW-03. Miami, Florida; 2007.
- **Stevens JD, Lyle JM.** Biology of three hammerhead sharks (*Eusphyra blochii*, *Sphyrna mokarran* and *Sphyrna lewini*) from northern Australia. Aust J Mar Freshw Res. 1989; 40(2):129–46. https://doi.org/10.1071/MF9890129
- **Trent L, Parshley DE, Carlson JK.** Catch and bycatch in the shark drift gillnet fishery off Georgia and East Florida. Mar Fish Rev. 1997; 59(1):19–28. Available from: https://aquadocs.org/handle/1834/26449
- **Vasconcellos M, Diegues ACSA, Sales RR.** Limites e possibilidades na gestão da pesca artesanal costeira". In: Costa, AL, editor. Nas redes da pesca artesanal, Brasília: IBAMA – MMA; 2007.
- **Yokota L, Lessa RP.** A nursery area for sharks and rays in Northeastern Brazil. Environ Biol Fishes. 2006; 75(3):349–60. https://doi.org/10.1007/s10641-006-0038-9
- **Zagaglia CR, Damiano C, Hazin FHV, Broadhurst MK.** Reproduction in *Mustelus canis* (Chondrichthyes: Triakidae) from an unexploited population off northern Brazil. J Appl Ichthyol. 2011; 27(1):25–29. https://doi.org/10.1111/j.1439-0426.2010.01573.x
- **Zar JH.** Biostatistical Analysis. Fifth Edition, London: Prentice Hall; 2010.

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