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RESEARCH PAPER

Sharks caught by the Brazilian tuna longline fleet: an overview

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Abstract Large pelagic sharks are distributed throughout all of the oceans and are caught as bycatch in pelagic longline fisheries worldwide. In the southern Atlantic Ocean, more than a dozen shark species are caught by the Brazilian tuna longline fleet. This study compiles information of the main shark species caught by the Brazilian tuna longline fishery in the southwestern and equatorial Atlantic Ocean. Catch and effort data of 14,860 longline sets from the Brazilian chartered tuna longline fleet, between 2004 and 2010, were analyzed. The blue shark *Prionace glauca* was the main shark species captured by this fishery. Shark catches showed contrasting trends during the study period: the silky (*Carcharhinus falciformis*) and the oceanic whitetip (*C. longimanus*) sharks catch increased up to 2008 and then declined, while mako sharks (*Isurus* spp.) showed an opposite trend. Effort for the Brazilian longline fishery had a

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higher concentration from 10°N to 30°S and from 20°W to 40°W. High values of catch per unit effort of southwestern and equatorial Atlantic Ocean sharks were heterogeneously distributed and, although elasmobranchs were caught over most of the longline fishing range, only blue sharks were caught in all areas. In the southern Atlantic Ocean, high fishing effort zones overlap significantly with some nursery areas, especially for the oceanic whitetip shark, indicating that these areas are at a direct risk from the industrial longline fishery.

Keywords Southwestern and equatorial Atlantic Ocean · Bycatch · Distribution · CPUE · Length composition

Introduction

Large pelagic sharks are distributed throughout all of the oceans in the world and are caught as bycatch in pelagic longline fisheries worldwide. In Brazil, commercial pelagic tuna longline fishing has been conducted since 1956, when Japanese longliners were chartered by a Brazilian company based in Recife, state of Pernambuco (Hazin et al. 1998). The first Brazilian longline vessels targeting tunas (*Thunnus* spp.) begun to operate in 1983 based in Natal, located in the northeast Brazilian coast (Hazin et al. 2002). In 1994, part of the longline fleet based in São Paulo began targeting swordfish (*Xiphias gladius*) using monofilament longlines baited with squid and light sticks (Amorim et al. 2002). Vessels targeting swordfish set the line and hooks shallower than the ones targeting tunas. However, since 1997, at least a part of the Brazilian longline fleet has targeted, beside tunas and swordfish, some species of sharks, primarily blue *Prionace glauca* sharks (Coluchi et al. 2005).

Currently, in the southern Atlantic, more than a dozen shark species are routinely caught as target or bycatch and reported by the Brazilian tuna longline fleet. Eight species are relatively common in the longline catches: blue shark (*P. glauca*), shortfin mako (*Isurus oxyrinchus*), longfin mako (*Isurus paucus*), oceanic whitetip (*Carcharhinus longimanus*), crocodile (*Pseudocarcharias kamoharai*), bigeye thresher (*Alopias superciliosus*), common thresher (*A. vulpinus*) and silky shark (*Carcharhinus falciformis*). The blue shark is possibly the most wide-ranging shark species, with high bycatch rates in pelagic longline fisheries (Compagno et al. 2005). Shortfin and longfin makos are large temperate and tropical pelagic sharks occurring worldwide. In general, shortfin makos are much more common in the Brazilian longline fishery than longfin makos, which are caught infrequently and are commonly grouped with the shortfin as well as with other shark species in fisheries records (Amorim et al. 2002). Though there are no directed fisheries for mako sharks, fishermen always keep them due to their high market value. As a result, shortfin makos, together with blue sharks, are among the most recorded shark species in commercial fishing operations worldwide (Clarke et al. 2004). The oceanic whitetip is an oceanic epipelagic species with a circumglobal distribution, usually found offshore in the open ocean, with high abundances in the Caribbean Sea, off Brazil and western Africa. Threshers, also found worldwide, are characterized by their large eyes and a very long dorsal caudal lobe. The silky shark, also distributed in all oceans in tropical latitudes, is present in high abundance off Brazil and western Africa. Longline catches primarily occur offshore near land and less frequently in the open ocean (Compagno et al. 2005).

Sharks are one of the most threatened groups of marine animals worldwide (Lucifora et al. 2012). Since most species of this group have low reproductive potential, late sexual maturity, and long life spans, they are consequently less resilient to fishing pressure, requiring a longer time for populations to recover from overfishing (Cortés 2008; Smith et al. 2008). In recent years, there has been an increasing concern about the deteriorating status of the world's pelagic shark and ray populations (Dulvy et al. 2008, 2014). Several approaches to estimate the vulnerability (Cortés et al. 2010; Gallagher et al. 2012) and to develop management strategies, have been adopted to conserve individual species of sharks (Camhi et al. 2008), including regulation which prohibited catches and retention of the oceanic whitetip and silky shark by the International Commission for the Conservation of Atlantic Tunas (ICCAT). A geographic conservation approach, in contrast, would be useful as it may include a wide variety of species of different ecological characteristics in a given area (Lucifora et al. 2012). Specifically in the tropical coastal Atlantic Ocean, local species richness is high (Dulvy et al.

2014) but also information is scarce, mainly in the south portion of this ocean. One of the biggest challenges to compiling estimates of global threats towards sharks is that there is very limited data available for many species (Dulvy et al. 2014). Indeed, nearly half of the shark and ray species are formally classified as 'Data Deficient' according to the International Union for the Conservation of Nature (IUCN) Red List Criteria, which is one of the highest proportions of any class of species (Hoffmann et al. 2010).

According to ICCAT data base, among the top five countries in terms of numbers of blue and mako sharks landed, Brazil ranked third and fifth, respectively in the southwestern and equatorial Atlantic Ocean. Considering Brazil is responsible for substantial portions of shark catches and also given the scarcity of the information in the region, this study compiles information on distribution, catch per unit effort (CPUE), sex ratio and spatial patterns in length composition of the main shark species caught by the Brazilian tuna longline fishery in the area. This information will certainly contribute to better management of this group at a regional basis, which in the Atlantic is carried out by ICCAT, and also for the National Plan of Action (NPOA) of Brazil.

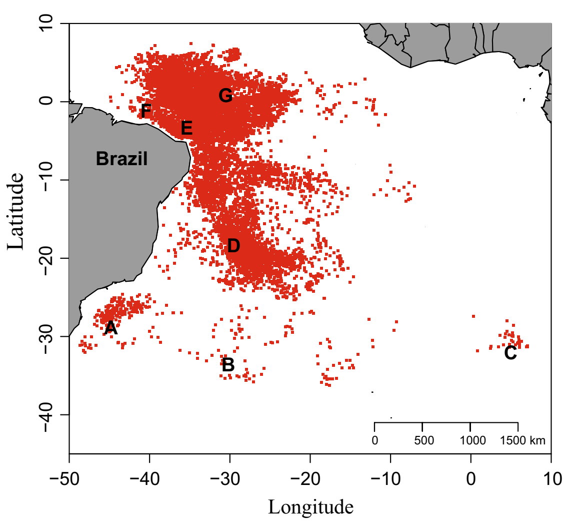

Fig. 1 Spatial distribution of fishing sets by the Brazilian chartered tuna longline fleet in the southwestern and equatorial Atlantic, from 2004 to 2010: *A* Santos Plateau, *B* Rio Grande Rise, *C* Jamestown and St. Helena islands, *D* Trindade and Martin Vaz Islands, *E* Fernando de Noronha Archipelago and Rocas Atol, *F* North Brazilian Chain, and *G* St. Peter and St. Paulo Archipelago

Materials and methods

Catch and effort data from 14,860 longline sets (21,156,374 hooks), carried out by the Brazilian chartered tuna longline fleet from 2004 to 2010, in a wide area of the equatorial and southwestern Atlantic Ocean (Fig. 1), was analyzed. Data were obtained by on-board observers of the National Observer Program from foreign vessels (Spain, Panamá, Honduras, Morocco, Portugal, United Kingdom) operating out of ports located in northeastern Brazil. The program includes coverage of approximately 30 % of the entire Brazilian chartered tuna longline fleet. The logbooks contained information on the number of hooks, the number of fish caught by species, and the geographic position at the beginning of each set. Nominal CPUE, by 5° × 5° squares, was calculated as the number of sharks caught by 1,000 hooks. Catch and effort data were analyzed for blue, silky, oceanic whitetip, aggregated makos (*I. oxyrinchus* and *I. paucus*), and aggregated threshers (*A. superciliosus* and *A. vulpinus*). To evaluate the importance of the main shark species by year and fleet within the South Atlantic, information on both the National Observer Program and the ICCAT data base (TASK 1—from 1990 to 2012) were considered. In this study, "billfishes" category refers to all billfish species except swordfish.

From 2005 to 2010, total length (TL), fork length (FL) and inter-dorsal (ID) lengths were also measured by laying the sharks on the deck and measuring them in a straight line. Whenever the TL was not available, the FL and the ID were converted to TL using conversion equations ("Appendix"). A total of 7,295 specimens of five species (blue, silky, oceanic whitetip and shortfin mako sharks) were measured. Total lengths of blue, silky, oceanic whitetip, and shortfin mako sharks were examined by means of the Natural Neighbor interpolation method. This method does not extrapolate values beyond the range of data and it is particularly suitable for data sets containing dense data in some areas and sparse data in other areas (see Sambridge et al. 1995 for details). Sex of a subsample of the main species was reported and the sex ratio calculated. A Chi-square test with Yates correction (Snedecor and Cochram 1980) was applied to evaluate possible sex ratio differences (considering a significance level of $P < 0.05$).

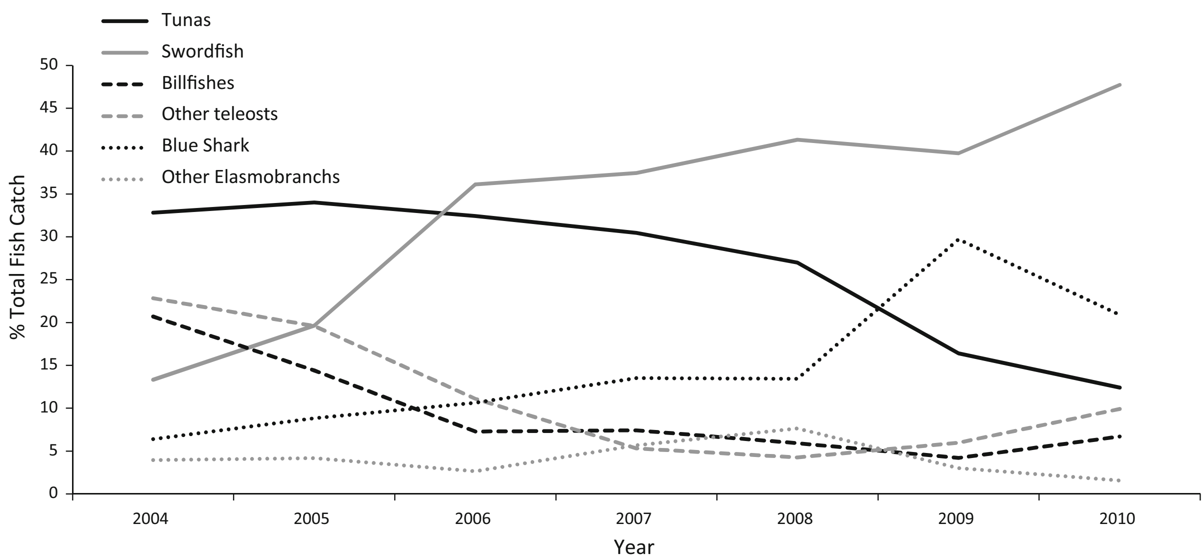

Fig. 2 Annual trends (in terms of annual percentages in number) of the catches of the main species and species-complexes caught in the fishery. *Source*: National Observer Program

Results

Catch composition

The occurrence of swordfish and blue sharks in the total catch, from 2004 on, grew throughout the years, while those of tunas and billfishes decreased (Fig. 2). Tunas were the most important species caught from 2004 to 2005, when they accounted for over 30 % of the total catch in number. Since then, their participation gradually declined, reaching 12.4 % in 2010 (Fig. 2). On the other hand, swordfish, which represented 13.3 % in 2004, accounted for almost half (47.2 %) of the catches in 2010 and sharks, which represented 10 % in 2004, accounted for 33 % in 2009. The proportion of blue sharks, which has always been the most important shark caught in this fishery, increased from 6.4 % in number in 2004 to more than 20 % in 2009 (Fig. 2). This species in 2004, represented 61.7 % of the elasmobranch catch, reaching almost 90 % in 2009–2010 (88–89 %). Mako sharks were the second most common bycatch species representing an average of 5.41 % of the total individuals caught during the study period. The relative contribution of the other elasmobranch species has been very limited: 3.09 % for pelagic stingrays, 2.92 % for oceanic whitetips, 1.97 % for crocodile sharks, 1.45 % for thresher sharks, and 1.15 % for silky sharks. In 2004, threshers were the 3rd most important elasmobranch group, but disappeared from the catches after 2006.

Considering the two main shark species, historically, Brazil is responsible for substantial portions of blue shark and mako catches in the South Atlantic Ocean, placing it as a major contributor to the fishing mortality of this species. Between 1990 and 2012, for instance, Brazil accounted for around 9 % of the total catches of South Atlantic mako shark and 12 % of blue shark (Fig. 3).

Longline fishing distribution

The 21,156,374 hooks set between 2004 and 2010 by the chartered Brazilian longline fleet were spread over a broad area in the southwestern and equatorial Atlantic Ocean, with a higher concentration from 7°N to 30°S and from 20°W to 45°W. The highest fishing effort occurred near the equator (including areas E, F and G) and to the south, around Trindade and Martin Vaz islands (D) characterized by some upwelling processes associated with equatorial divergence, oceanic islands and seamounts (Travassos et al. 1999) (Fig. 4).

Spatial trends in CPUE

Although elasmobranchs were caught over the largest part of the longline fishing range, only blue sharks

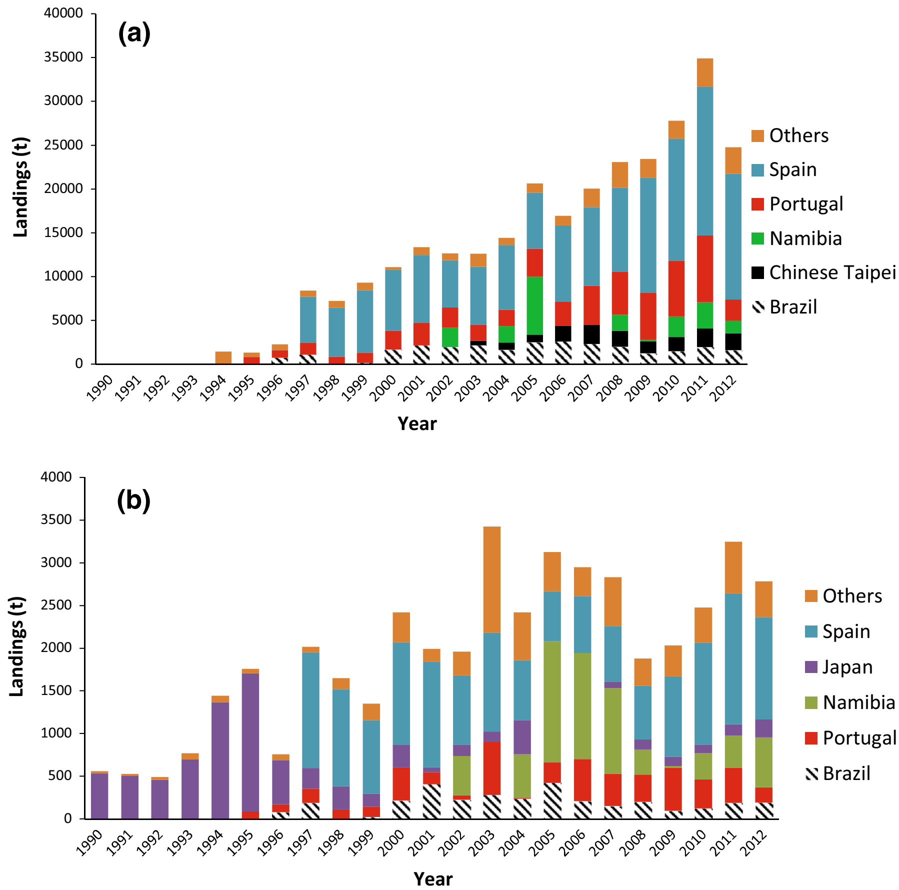

Fig. 3 Annual catches (1990–2012) of South Atlantic blue shark (**a**) and mako shark (**b**) using the TASK I database from ICCAT

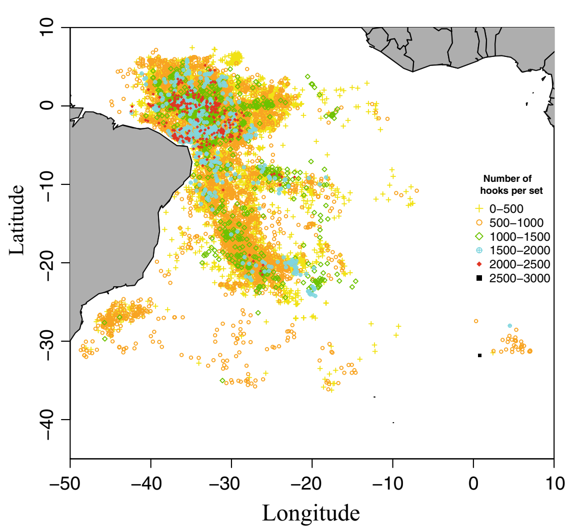

Fig. 4 Distribution of fishing effort (number of hooks per set) by the Brazilian chartered tuna longline fleet in the Atlantic Ocean, from 2004 to 2010

were caught in all areas (Fig. 5). Blue and mako sharks had a rather similar trend in spatial distribution, with higher CPUE values observed below 20°S and to the east of 20°W. The oceanic whitetip shark was mostly caught within the tropical waters mainly at the Santos Plateau and off Western Africa. Silky shark catch rates were highest near the Brazilian coast, with two points of high relative CPUE in the middle of the Atlantic (0°S–5°S; 10°W–15°W; and 30°S–35°S; 10°W–15°W). The CPUE of threshers was very low and scattered across the southern Atlantic (Fig. 5), although two points of higher CPUE in areas similar to those of the silky shark were observed.

Sex ratio and length composition

Sharks caught by the Brazilian tuna longline fleet were mainly caught between the size interval of 120–240 cm TL (Fig. 6). Overall, sampled individuals

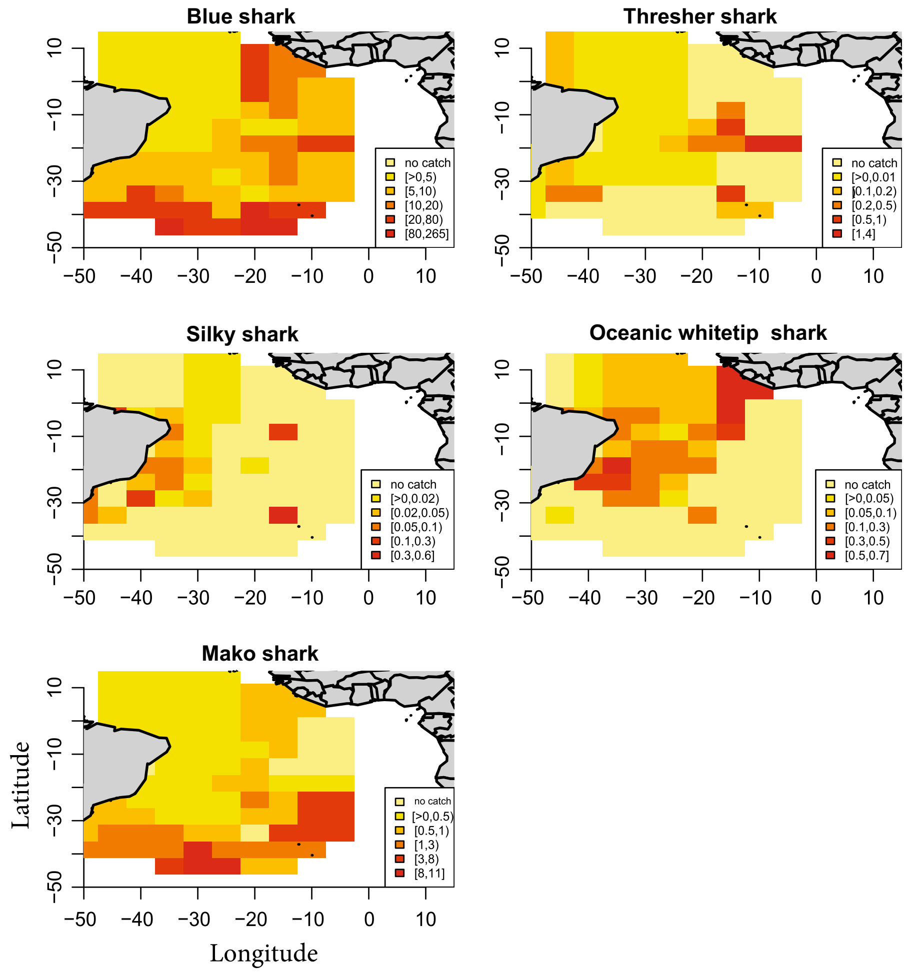

Fig. 5 Longline catch per unit effort (CPUE individuals per 1,000 hooks) of the Brazilian chartered tuna longline fleet for the main elasmobranch species: blue shark (BSH), thresher shark (THR), silky shark (FAL), oceanic whitetip shark (OCS), mako shark (MAK). Note the different legends for each panel

of all species were larger near the central part of the fishing area (along the 10°S latitude). Oceanic whitetip sharks in the equatorial and southern Atlantic were comprised of the smallest individuals throughout the fishing ground, with 78 % measuring <180 cm and most likely juveniles (Lessa et al. 1999). Most of the silky sharks captured were also juveniles, while mako sharks showed a wide range of sizes (Fig. 6). Most of the blue shark specimens sampled were smaller than 170 cm TL. Larger individuals (>260 cm TL) were mainly found near the northeast Brazilian coast. Makos sampled were smaller than 170 cm TL everywhere but in the central fishing area. The silky sharks were smaller in the equatorial zone of the fishing area whereas smaller oceanic whitetip sharks were found in the northern and southern part of their distribution range (Fig. 7). The sex ratio favored males for mako sharks, females for the oceanic whitetip and silky sharks (Chi-square, $P < 0.05$), and was not significantly different between sexes for the other species (Table 1).

Discussion

Sharks are quite common in the high seas and are caught in most longline fishing operations targeting tunas and swordfish (e.g. Baum et al. 2003; Carvalho et al. 2010). Most shark species that have low reproductive potential are more vulnerable to sustained heavy fishing pressure and populations have a limited ability to recover from overfishing (Cortés 2008; Smith et al. 2008). Recent studies supported this principle by identifying declines in the shark biomass,

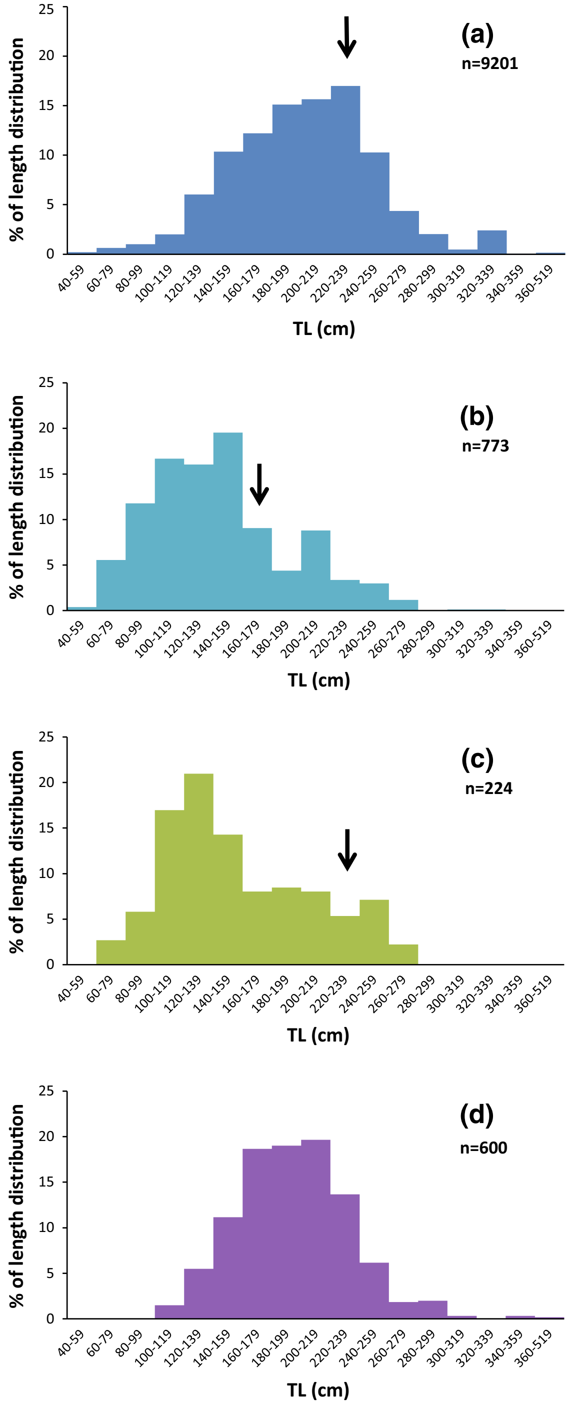

Fig. 6 Length distribution (total length) of **a** blue shark (BSH), **b** oceanic whitetip shark (OCS), **c** silky shark (FAL) and **d** mako shark (MAK) captured by the Brazilian tuna longline fleet. *Black arrows* indicate the length at first maturity

over the world's oceans (e.g. Hutchings and Reynolds 2004; Ferretti et al. 2010). One of the causes for the overfishing of shark species is the high market value of shark fins in response to the elevated demand (Musick et al. 2000), increasing the concern about their future and conservation status (Dulvy et al. 2008, 2014).

Management of large pelagic species is difficult due to their highly migratory nature crossing national and international waters (Carvalho et al. 2011). Also, as many shark and ray species are bycatch, often being discarded, the assessment of their stocks, when available, is commonly highly uncertain and conditioned to a large range of assumptions used in the models due to a lack of biological information and data limitations (Cortés 1998). Therefore, in order to better manage shark stocks, the necessity to better understand the ecology, distribution, and abundance of the main shark species by identifying their main areas of occurrence relative to different size classes and periods of the year has been widely recognized.

In the southwestern and equatorial Atlantic Ocean, Brazilian pelagic longlining for tunas began more than 50 years ago, in the northeastern region (Paiva and Le Gall 1975), with sharks having always accounted for an important part of the bycatch (Hazin et al. 1998). The total landings of elasmobranchs caught in association with tuna longline fisheries in Brazil have fluctuated around 3,000 t in the last 10 years and the occurrence of swordfish and blue sharks in the total catch were gradually replacing those of tunas and billfishes. Changes of the relative contribution of the catches amongst species can probably be explained by changes in fishing strategies as effort distribution of the different fleets operating in the area. Between 2004 and 2005, fishing sets were deployed mainly in areas located in the equatorial Atlantic between 7°N and 5°S (see Tolotti et al. 2013). From 2006 onwards, however, fishing sets were more common in higher latitudes, around 20°S. Carvalho et al. (2011) noticed that these latitudes have more nutrient-rich superficial waters than the equatorial region, and also present higher abundance of swordfish and blue shark. During the last 10 years, elasmobranchs have represented about 25 % of the total catch with seven species (but mainly the blue shark) being the main components of the shark bycatch.

Blue sharks have been caught by many fisheries all over the world oceans. In the Atlantic Ocean, they are

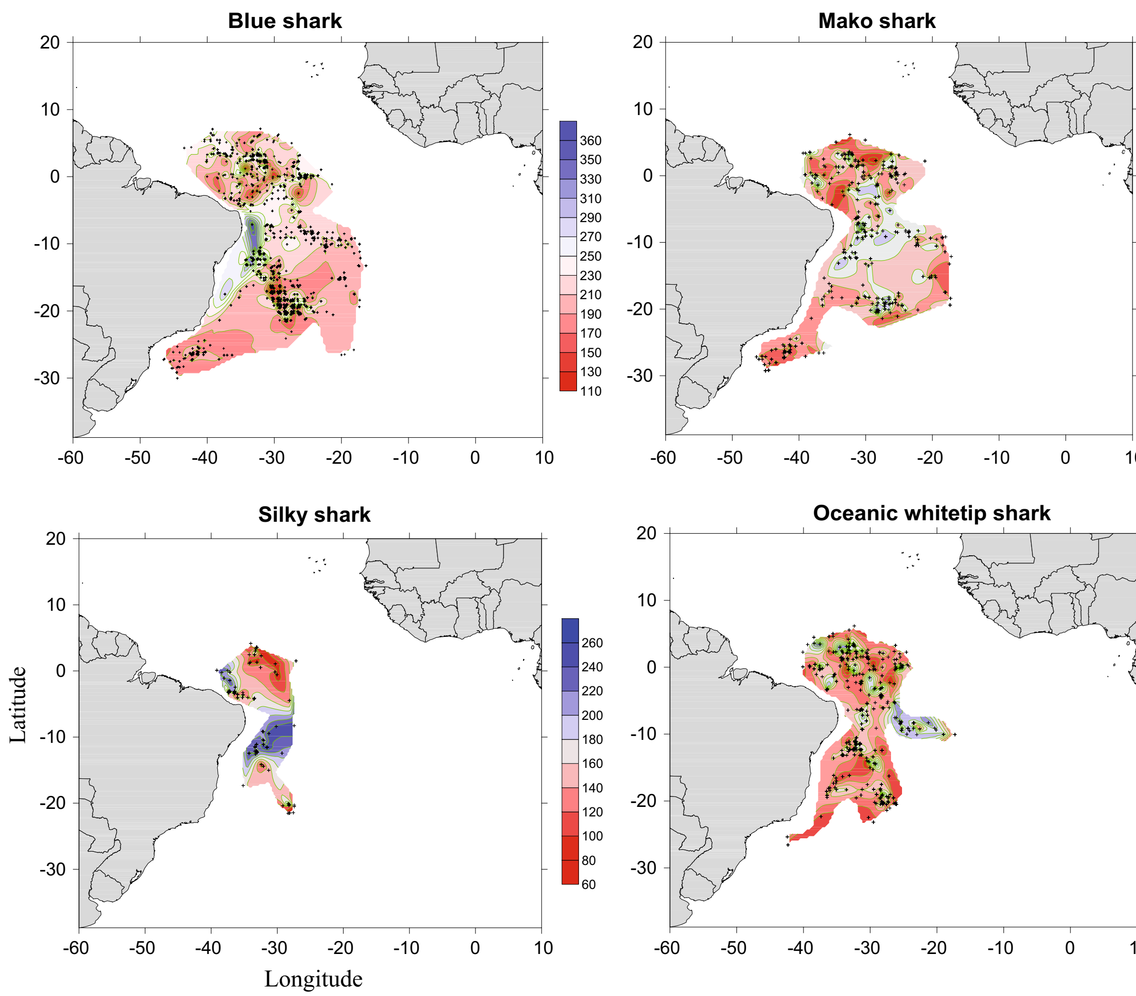

Fig. 7 Spatial distribution of median sizes of the main shark species [blue shark (BSH), silky shark (FAL), mako shark (MAK), and oceanic whitetip shark (OCS)] caught by Brazilian tuna longline fishery in the western Atlantic Ocean. Note the different legends for each panel

Table 1 Sex ratio of the main shark species [blue (BSH), threshers (THR), silky (FAL), mako (MAK), and oceanic whitetip (OCS) sharks] caught by Brazilian chartered tuna longline fleet in the western Atlantic Ocean

Species	Sex		Total	*P* value
	F	M		
BSH	3,942	4,036	7,978	0.292
THR	27	18	45	0.179
FAL	125	90	215	0.016*
MAK	220	280	500	0.007*
OCS	378	319	697	0.025*

mainly taken as bycatch in the pelagic longline fisheries (Carvalho et al. 2010; Montealegre-Quijano and Vooren 2010; Coelho et al. 2012; Tavares et al. 2012). However, more recently, there has been an increasing retention and targeting of blue sharks due to diverse factors such as market demands, enhanced preservation systems onboard, and/or less availability of higher value target species (Camhi et al. 2009; Mejuto et al. 2009). In Brazil, blue sharks have always dominated the elasmobranch bycatch, with their participation in landings increasing particularly after 1996 (Carvalho et al. 2010).

Although information on the current status of exploitation of the blue shark in the Atlantic Ocean is highly uncertain, the most recent stock assessments concluded that the stocks seemed to be exploited at levels below the maximum sustainable yield (ICCAT 2009), while the ecological risk assessment (ERA) concluded that blue sharks have intermediate vulnerability to pelagic longline fisheries (Cortés et al. 2010; ICCAT 2013a), since this species is more productive and may sustain heavier exploitation rates compared to the other shark species. The results of these assessments, however, were strongly dependent on the assumptions made and may be considered highly uncertain. All uncertainties related to the assessment of the conservation condition of this species, together with its high catches, led the IUCN to classify it as Near Threatened (Stevens 2009). The fragility of the blue shark stock assessment, however, is not a problem exclusive to the species, being, much on the contrary, shared by almost all shark species exploited in the Atlantic Ocean. Any management measure stemming from these models, therefore, should be interpreted with considerable caution. In an attempt to improve their management, spatial biodiversity patterns could be particularly useful to identify areas of high conservation value, not only for a particular group, but also for the entire ecosystem (Lucifora et al. 2012).

According to Hazin and Lessa (2005), blue sharks caught by the Brazilian tuna longline fleet ranged from 71 to 398 cm TL, with juveniles and adults being well represented. These patterns were also observed in this study. In the Caribbean Sea and the Guyana-Amazon, blue shark catches were also composed of individuals with a wide range of lengths (79–355 cm FL), with approximately 40 % of the total catch corresponding of immature females (Tavares et al. 2012). The general sex ratio found in the present work slightly favored males, similarly to the Caribbean Sea (0.9:1) and the Guyana-Amazon (0.8:1) (Tavares et al. 2012). According to Carvalho et al. (2010), female blue sharks caught in the northern part of the fishing ground were predominantly adults and large-adults throughout the year, while in the southern part, juveniles and large-juveniles were much more abundant. No discernible trend in male blue shark lengths could be observed (Carvalho et al. 2010). In this study, although blue sharks of all sizes were caught in the fishing area, as already observed by Montealegre-Quijano et al. (2014), most specimens from the south were smaller than 170 cm TL, while larger individuals (>260 cm TL) were mainly found near the northeast Brazilian coast, in accordance with Carvalho et al. (2011). Similar spatial segregation by size was found in the North Pacific Ocean, with a greater proportion of juvenile blue shark at higher latitudes (Nakano 1994) and also in the North Atlantic Ocean (Vandeperre et al. 2014). The higher abundance of smaller blue sharks off the southern coast of Brazil might be explained by a variety of oceanographic characteristics of this area, which promotes the increase in the amount of potential prey (e.g. squid *Illex argentines*) for blue sharks (Carvalho et al. 2011). According to their study, mating occurs in southern Brazilian waters, primarily from December to February, and ovulation and fertilization follows about 3–4 months later from April to June while off northeast Brazil. Pregnant female sharks are hypothesized to select warmer waters, such as off the northeast of Brazil, to reduce gestation and development time of embryos (Hight and Lowe 2007; Jirik and Lowe 2012).

The oceanic whitetip sharks caught in the southwestern and equatorial Atlantic Ocean are mainly juveniles, with 78 % having less than 180 cm (Lessa et al. 1999). Lessa et al. (1999) suggested a size at birth around 70 cm TL, based on a small individual caught with fresh umbilical scars. Coelho et al. (2009) found near-term embryos measuring 52 cm TL and estimated that the size at birth should be around 55 and 65 cm TL, as proposed by Compagno (1984). Individuals measuring around 50 cm TL found in the present work, however, indicate that the size at birth might be even smaller than previously reported and that the study area may be a nursery ground. Geographical segregation by sex was not observed in the study area (Tolotti et al. 2013). In this study, the oceanic whitetip shark was mostly caught within tropical waters. Other studies detected the same patterns (Domingo et al. 2007) and reported no clear pattern of seasonal change (Tolotti et al. 2013). In the South Atlantic, Tolotti et al. (2013) observed a drop of the CPUE values for this species from 2008. Cortés et al. (2010) classified this species as one of the most vulnerable in the Atlantic, while the IUCN also categorized it as Vulnerable (Baum et al. 2006). The well acknowledged critical situation of the whitetip shark prompted ICCAT to adopt a regulation (Rec 10-07) which prohibits fishermen to "retain onboard, transship, land, store, sell, or offer for sale any part or the whole carcass of oceanic whitetip sharks". Also, in 2013, this species was added to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora—Appendix II), which prompts permits to ensure exports are sustainable and legal. Oceanic whitetip sharks are mainly caught by fleets characterized by the deployment of hooks at shallower depths, indicating that the use of deep longline hooks (> 100 m) may help to mitigate the bycatch of this species (Tolotti et al. 2013).

The silky shark is commonly found near shelf breaks, island shelves, and deep reefs, at depths around 50 m (Bass et al. 1973). In the southwestern and equatorial Atlantic Ocean, silky sharks represent only 0.2–1.1 % of total catches. However, it should be taken into account that the data used in this study is for only a part of the longline fishery in operation in the Atlantic Ocean and catches of this species are mainly composed of juveniles. This species has been categorized according to IUCN as Near Threatened (Bonfil et al. 2009). Likewise, ICCAT has also adopted a regulation (Rec 11-08) which prohibits fishermen to "retain onboard, transshipping or land any part or the whole carcass of silky sharks".

The first attempts to assess the impact of high sea fisheries on South Atlantic shortfin mako sharks was made by Costa et al. (1996) and the authors were unable to determine any trends. Also, studies on the shortfin mako shark have reported, in the past, declines in abundance rates (Scott 1997; Takeuchi et al. 2005). However, in 2012, ICCAT conducted the stock assessment of Atlantic shortfin mako, for both North and South stocks, and the available CPUE series showed increasing or flat trends for the more recent years. Hence, indications of potential overfishing shown in the previous stock assessment have diminished (ICCAT 2013a). However, this increase in the CPUE series could be due to an increase in abundance, an increase in catchability, or changes in the fishing strategy or in data reporting for this species (ICCAT 2013a). Increasing catch trends were observed for makos in this study. This high uncertainty in past catch estimates and deficiency of some important biological parameters, particularly for the southern stock, were obstacles for obtaining reliable estimates of the current status of the stocks (ICCAT 2013a). Moreover, the ERA conducted in both 2009 and 2012 showed that shortfin makos were amongst the most vulnerable stocks in Atlantic (Cortés et al. 2010; ICCAT 2013b) and was assigned as Vulnerable by IUCN (Cailliet et al. 2009). The contrasting results imply that the status of the South Atlantic stock should be considered with caution.

There is little information on the catches of thresher sharks in the South Atlantic Ocean. Some countries still fail to collect shark data while others collect it but fail to report (ICCAT 2013b). However, significant reductions in thresher CPUE have been reported in pelagic longline fisheries in the northwest Atlantic and declines are also suspected to have occurred in other areas (Amorim et al. 2009). Also, in this study, catches of this species were not reported after 2006. This species is categorized as Vulnerable by IUCN (Amorim et al. 2009). In 2009, this species was the 4th most vulnerable elasmobranch species in the Atlantic Ocean (Cortés et al. 2010) and, in 2012, this species was considered the most vulnerable shark species also in the Atlantic (ICCAT 2013a).

There is a growing concern amongst the diverse sectors of society, Regional Fisheries Management Organizations (RFMOs), Non-governmental Organizations (NGOs), and stakeholders in relation to shark population declines and what the subsequent impacts on ecosystem health will mean from ecological, economic, and public health perspectives, as well as how a changing climate may exacerbate the situation (White and Kyne 2010; Gallagher and Hammerschlag 2011; Simpfendorfer et al. 2011). Recently, diverse initiatives concerning the evaluation of the stocks and management have emerged, given the fragile situation of world shark stocks. However, despite the various initiatives, as commercial fisheries struggle to apply regulatory and legal mechanisms that depend on reliable species-specific data (Pauly et al. 2013), the shark industry faces an even greater obstacle to transparency: sellers change product names to overcome consumer resistance (Bornatowski et al. 2013).

This study has contributed to improve the knowledge on the spatial distribution of southwestern and equatorial Atlantic Ocean shark stocks, which is essential for the implementation of Marine Protected Areas. In this region, areas of high fishing effort overlap significantly with some nursery areas (as for the oceanic whitetip shark) suggesting that these areas are at a direct risk from the industrial longline fishery. In this study, it is evident that high values of CPUE of South Atlantic sharks ares heterogeneously distributed in the southwestern and equatorial Atlantic Ocean, as previously observed by Lucifora et al. (2012) in terms of biodiversity. Designing protected area-based conservation strategies for a taxonomic group requires basic knowledge of spatial patterns of biodiversity (Primack 2006). Protecting hotspots of Chondrichthyan diversity may be a cost-effective strategy to conserve many individual species at once and the communities in which they live (Lucifora et al. 2012).

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Appendix

See Table 2.

Table 2 Linear relationship

	a	b	r^2
OCS			
TL × FL	13.083	0.7,202	0.9783
TL × ID	−0.6282	0.2481	0.9046
BSH			
TL × FL	8.126	0.7909	0.9736
TL × ID	18.099	0.1454	0.7988
FAL			
TL × FL	−4.8375	0.8627	0.9978
TL × ID	−0.5801	0.2859	0.9396

a and *b* are the parameters of the relationship

r^2 determination coefficient, *TL* total length, *FL* fork length, *ID* interdorsal length. *BSH* blue shark, *FAL* silky shark, *OCS* oceanic whitetip

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