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Fisher's perceptions on shark fisheries in Sao Tome Island (Gulf of Guinea, West Africa)

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ABSTRACT

Sao Tome and Principe (STP) is a small island developing state in the Gulf of Guinea (West Africa) and is considered a global hotspot of marine biodiversity. Still, detailed information on sharks' diversity, abundance, and respective fisheries is mainly absent. Here, we interviewed fishers from different local communities of the island of Sao Tome to characterize: i) local knowledge on shark fisheries, ii) those reliant upon these resources, and iii) their perceptions about shark populations and their importance on Sao Tome Island. A total of 111 semi-structured interviews were conducted between May 6 and June 15, 2019, in 11 fishing communities. Ninety-seven percent of fishers mentioned that sharks are present in their fishing grounds, and 98 % reported that they catch sharks. The species most identified by fishers (77 %) was the scalloped hammerhead shark (*Sphyrna lewini*), followed by the bluntnose sixgill shark (*Hexanchus griseus*; 33 %), white shark (*Carcharodon carcharias*; 31 %), longfin mako shark (*Isurus paucus*; 29 %), pigeye shark (*Carcharhinus amboinensis*; 27 %), and other six species (under 20 % each). Sixty-two percent of interviewees perceived sharks as a threat to their safety and livelihoods. When asked if sharks should be protected, 59 % of fishers agreed, while 40 % did not consider it necessary. Common reasons in support of protection were that sharks were disappearing (23 %), important for ocean health (9 %), and overfished (5 %). Most fishers (89 %) noticed shark abundance changes, decreasing over the past 15 years. Regarding the underlying causes, the most common response was the increase in the fishing pressure from international fishing fleets (72 %). We argue that raising awareness and building capacity close to local communities on sharks' essential role and importance will be fundamental to supporting future conservation measures, as misinformation and prejudice against sharks are widespread.

1. Introduction

Shark populations have been declining over the past few decades, driven by overfishing, habitat degradation, and climate change (Dulvy et al., 2021; Pacoureau et al., 2021; Queiroz et al., 2019; Santos et al., 2021). Sharks tend to occupy high trophic levels in marine ecosystems,

where they exert a crucial role in their structure and functioning. Shark population declines have put them in the international conservation spotlight (Davis and Worm, 2013; Dulvy et al., 2014; Pacoureau et al., 2023). As a key threat to shark populations pertains to fishery exploitation, international and national regulations on the topic have increased over the past few decades (Jorgensen et al., 2022). However, a significant challenge for conserving shark species worldwide is the limited data for small-scale fisheries, which in some countries contribute considerably to elasmobranch catch (Davis and Worm, 2013; Di Lorenzo et al., 2022; Mason et al., 2019, 2020). In small island developing states (SIDS) — or large ocean states — where human dependence on marine goods and services for well-being and livelihood is extreme (Baldwin et al., 2013; Sherman et al., 2018; Teelucksingh and Watson, 2013), ensuring sharks' conservation is fundamental.

Sao Tome and Principe (STP) is a SIDS composed of two oceanic islands — the island of Sao Tome and the island of Principe — located on the Cameroon Vulcanic Line in the Gulf of Guinea, slightly north to the equator and off the western coast of central Africa (Maia et al., 2018b). It has an exclusive economic zone (EEZ) of 160,000 km^2 and a population of 215,000 inhabitants, the majority of which (96 %) live on the island of Sao Tome (FAO, 2021; World Bank, 2021). Sao Tome has a land area of 857 km^2 and is characterized by a narrow shelf with shallow waters (<25 m depth) up to 1.2 km from shore and an abrupt change in depth (100–1000 m) from 3 to 7 km offshore (Hachich et al., 2015; Porriños et al., 2021). Together with the surrounding oceanic tropical islands, the country has long been described as part of a global hotspot of marine biodiversity (Roberts et al., 2002).

The rapid growth of the human population in the country over the past decades has led to increased anthropogenic pressure over marine ecosystems, such as increased fishing effort (Maia et al., 2018b; Nuno et al., 2021a). In fact, with 16 % of the population living below the poverty line (i.e., with less than $2.5 per day; World Bank, 2023) and a Human Development Index of 0.618 (ranked 138 out of 191 countries; UNDP, 2023), Sao Tome and Principe is highly dependent on its marine resources. Fish is the primary source of protein for most of its population (average consumption of 29.3 kg per capita per year; De Labra et al., 2023; Serkovic and Million, 2019), and the fisheries sector represents the second most important source of revenue for low-income families (after cocoa), providing jobs for thousands of people (De Labra et al., 2023). Fisheries in STP are largely artisanal and focused on coastal pelagics, such as flying fish and frigate tuna (De Labra et al., 2023; Porriños et al., 2023), with 4.3 thousand fishers and 2.4 thousand fishmongers (of which 3.8 and 2.2, respectively, are in Sao Tome Island; Porriños et al., 2023).

As for sharks, while a variety of species is assumed to be present in STP, based on distribution maps (Costa et al., 2022; Ebert et al., 2021; IUCN, 2023, Porriños et al., 2021)., detailed information on sharks' diversity and abundance is mainly absent (Porriños et al., 2021). A recognized valuable way to fill data gaps for poorly understood fisheries is by interviewing fishers (Damasio et al., 2015; Mason et al., 2020). Indeed, evaluating community perceptions can provide valuable insights into the status of marine living resources while also giving social and cultural contexts (Glaus et al., 2019; Marin-Monroy et al., 2020; Mason et al., 2019, 2020; Nuno et al., 2021). This approach is critical to implementing effective conservation measures and ensuring fair fisheries management. Gaining insight into the beliefs and values of fishing communities concerning their activities and resource use can further assist policymakers in designing management systems that will be more widely accepted and respected by these communities. Ultimately, perceptions are significant as they influence compliance with the regulations integrated into the management system (Marin-Monroy et al., 2020).

Currently, national legislation on fishing activities and fishery resources does not outline any specific regulations on sharks (e.g., Law no. 09/2001 and Decree no. 28/2012), other than a recent ruling (Decree no. 19/2020) that establishes a temporary halting on the export and import of shark fins of any species due to the identified need for studies that can determine the health of shark stocks. STP is also a signatory to international and regional conventions and agreements, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2024), the Convention on the Conservation of Migratory Species of Wild Animals (CMS, 2024), the International Commission for the Conservation of Atlantic Tunas (ICAAT, 2024) and the Fisheries Committee for the Eastern Central Atlantic (FAO, 2024), who set restrictions and guidelines on the international trade of endangered species, including sharks, and promote sustainable fishing practices.

In this study, we interview fishers from different local communities in STP to characterize the local knowledge concerning shark fisheries, the people dependent on these resources, and their perspectives regarding shark populations and their significance on Sao Tome Island. We further discuss how fishers' attitudes and knowledge might contribute to more effective conservation measures and the management of small-scale elasmobranch fisheries in STP. This first dedicated assessment of artisanal shark fisheries was conducted on the island of Sao Tome, where, as noted previously, most of the population lives.

2. Methods

2.1. Survey design and implementation

A survey protocol was developed to conduct semi-structured interviews with fishers (English and Portuguese templates available in Appendix I). This incorporated questions to characterize local knowledge of shark fisheries, those reliant upon these resources, and their perceptions about shark populations and their importance on Sao Tome Island. The interview included sections on: a) socio-demographic characteristics (e.g., age, main occupation, education level, income); b) general fishing practices (e.g., fishing experience, fishing frequency, gear types, fishing methods, fishing times, expenditure); c) sharks' fisheries (e.g., species, number, size, seasonality, type of gear); d) importance and use of sharks; e) perceived changes in shark abundance; and f) identification of fishing grounds where sharks were present. Fishers were also asked to identify species present in their catch from a poster illustrating 51 shark species (ID board), selected based on the distribution maps according to Ebert et al., (2013), and provide local names for these species.

A total of 111 semi-structured interviews were conducted between May 6th and June 15th, 2019, in 11 fishing communities around the island of Sao Tome (Fig. 1). These communities were selected through previous consultation with local NGOs (Oikos, Marapa, and Alisei) based on their perceived importance on fisheries, particularly shark catches, and to achieve geographical representation around the island. Interviews were targeted at fishers (ideally with knowledge of sharks) as experts who are directly dependent on marine resources and make decisions on where, when, and what to fish. Within each fishing community, permission to conduct interviews was asked *a priori* from community leaders ("*chefe de comunidade*" and/or "*chefe de praia*") and presidents of local fisheries associations who identified active fishers that could be interviewed, based on their availability and likely knowledge of sharks. Sampling was then targeted, with an average of 10 fishers (SD = 1.4) being interviewed per community (Fig. 1).

Interviews took place in the morning, from 9 am to 12 pm, while fishers were either preparing to go out or returning from a fishing night, at the most convenient location (most commonly at the beach). All interviews were conducted by the same three authors (VP, AS, MP) in Portuguese (the official language of STP) and, in rare cases, in Creole (local language), which was later translated into Portuguese by AS or a community representative.

The conditions of the interviews, with regards to i) the presence and interference of other people, ii) the attention, and iii) the respondent's comprehension, were registered at the end of the survey. If the
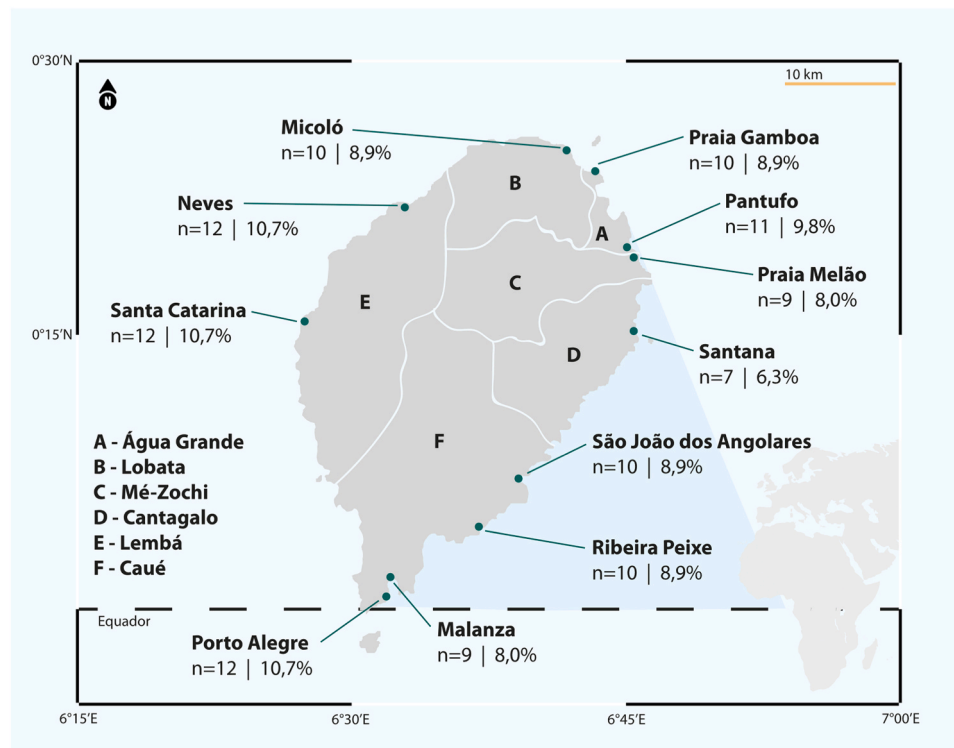
Fig. 1. Map of the study area, showing the location of the eleven fishing communities along the six districts (identified by letters A to F) of Sao Tome Island. The number of interviews and percentual value (referring to a total of 111 responses) are presented for each community.

respondent had time and space to answer, and bystanders were watching without commenting or only providing minor reactions, the interview was labeled as "with the presence of others." If bystanders reacted before the respondent, the interview was labeled as "*with interferences.*" Similarly, respondents' attention was registered at the end of the survey on a scale of "weak" to "very good" based on the overall attention and responsiveness of the interviewee.

Permission to undertake the interviews was requested from relevant national entities, namely the Directorate for Fisheries and the Directorate General for the Environment of Sao Tome and Principe, who gave oral and written consents, respectively. International best practices on ethics were also followed: before each interview, respondents were informed about the scope and objectives of the study and the relevance of their contribution; they were further informed they could decline to answer any question, leave the interview at any time, there were no right or wrong answers, and their participation was voluntary and anonymous. All participants verbally consented to both survey participation and the use of their anonymous responses.

2.2. Data analysis

Descriptive summaries and proportions were used for closed-ended and categorical responses (e.g., levels of perceptions) and for open-ended, qualitative interview responses (e.g., reasons for not targeting sharks), data was categorized using an inductive approach to seek emergent themes (Elo and Kyngäs, 2008).

For the categorization of socioeconomic groups, monthly income was divided into four categories to differentiate among low, middle, and high income, based on the World Bank's definition of the poverty line ($2.15 per day using 2017 prices; World Bank, 2023). Exchange rates from Santomean dobras (STN) to euros (EUR) were based on the official rate of STN24.53 = EUR1.00 (Banco Central de São Tomé e Príncipe, 2023).

The condition of the interviews was used to exclude one interview from the analysis, where the attention and comprehension of the

respondent were very low. Two other interviews, where attention and comprehension were also low, were still included because answers were only registered for the questions the respondents seemed to understand. Two other interviews, labeled as "*with interferences,*" were also included, knowing that the answers were not the personal perception of the respondent only but of a group of people.

For this study, the terms offshore and near-shore were used to refer to "far from the coast" and "close to the coast," respectively.

3. Results

3.1. Study participants

Eighty-six percent of respondents showed a high level of attention and 85 % of comprehension (good/very good categories; Supplementary Table 3). Forty percent of fishers were alone during their interview, and 58 % had the presence of other community members (Supplementary Table 3). In the latter case, interferences were limited, with only two fishers being unable to respond appropriately due to a lack of time or space caused by other people's interventions. Response rates per topic were all very high (over 89 %), except for the section on sharks' fishing grounds, which collected replies from 62 % of respondents (Supplementary Table 4).

Respondents were all male, averaging 43.5 years old (SD =14.1) and 26.9 years of fishing experience (SD = 14.0). Fishing was the main occupation of 90 % of respondents, with 72 % fishing every day and 19 %5–6 days a week. About half (54 %) of respondents had primary education level (grade 1st to 4th), 34 % basic (grade 5th to 9th) or 3 % secondary (grade 10th to 12th), and 7 % did not have any formal education. Forty percent of respondents earned less than 2000 Santomean dobras per month (equivalent to €81.6) and 28 % between 2000 and 5000 dobras (€81.6-€204) (Supplementary Table 1).

A total of 99 % of fishers used a fishing vessel to fish (primarily dominated by dugout canoes and other smaller boats with a median size of 5 m), both offshore 90 % and near-shore 39 % (Supplementary

Table 2). Seventy-three percent fished during daytime and nighttime (depending on ocean conditions and tides), 25 % only during the day, and 2 % at night. Thirty-nine percent of respondents reported fishing alone, and 41 % were accompanied by 1–2 other fishers (Supplementary Table 2). On average, respondents reported the presence of another 14 fishers in the same fishing area (SD = 8.4). As for gear type, 96 % of fishers used handlines (e.g., jiggling lines, longlines, trolling), 43 % used nets (e.g., gillnets, "voador panhá" nets, "maxipombo" nets, or purse seine nets; cf. Porriños et al., 2021), 5 % handheld harpoons, and 1 % spearguns. Most respondents targeted bony fish (57 %), and 42 % did not target any other fish or types of seafood (Supplementary Table 2). A small number of fishers reported actively targeting sharks (8 %), rays (7 %), and resources such as sea snails, octopuses, or cuttlefish (4 %). As for usual catches, 98 % of respondents reported catching bony fishes, 32 % sharks, and 18 % rays. Fishers spent, on average, 25,000 Santomean dobras (c. €1020) per year on fishing-related expenses (SD = 61, 036) – median value of 10,000 Santomean dobras (c. €408) – with reported annual values ranging from 490 dobras (€20) to 500 196 dobras (€20 408) (Supplementary Table 2).
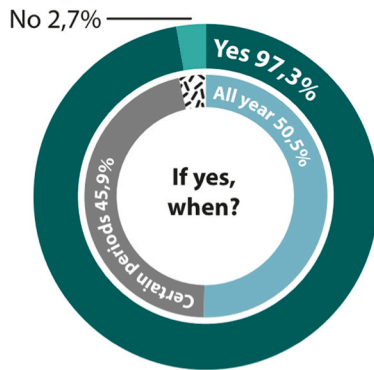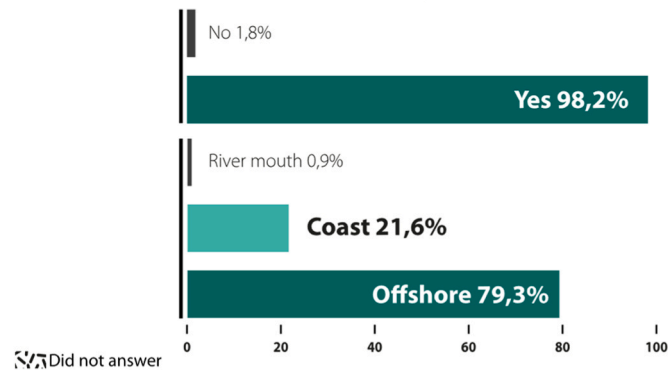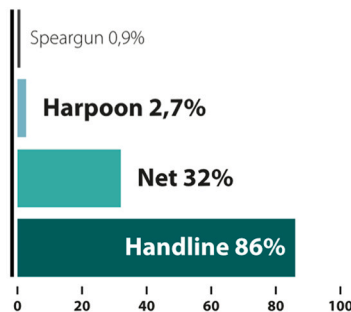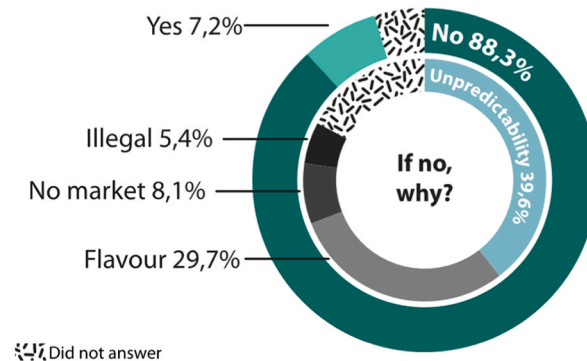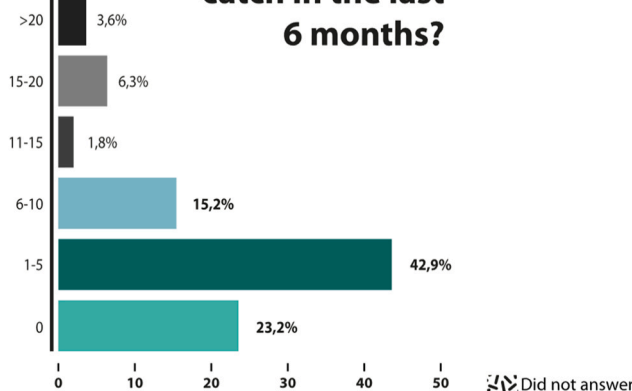

Fig. 2. Answers of respondents to questions related to shark fisheries. Questions with only one possible answer are represented by a circle (A, D), whereas bar graphs can represent questions with more than one possible answer per respondent, as in B, C, E, and F. Percentual values refer to a total of 111 responses.
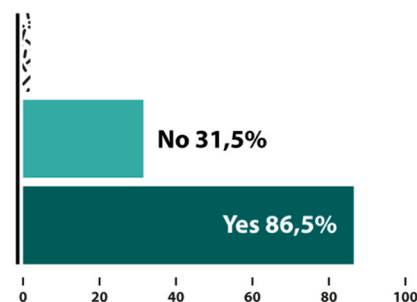
3.2. Sharks' fisheries

Ninety-seven percent of fishers mentioned that sharks are present in their fishing grounds (Fig. 2A) – 51 % said they can be found all year round, while 46 % found them only in specific periods – and 98 % reported catching sharks (Fig. 2B). Eighty-six percent of respondents caught them using handlines, 32 % using nets, 3 % harpoons, and 1 % spearguns (Fig. 2C). While a small number of fishers target sharks (8 %), in most cases (88 %), sharks are caught by chance (Fig. 2D). Several reasons were appointed for such opportunistic behavior, namely sharks' unpredictable occurrence (40 %), their flavor (30 %), lack of a specific market (8 %), or the perception that sharks' fishing is illegal (5 %; Fig. 2D). Seventy percent of respondents reported catching sharks in the six months prior to the interview (Fig. 2E), with 43 % catching up to 5 sharks, 15 % between 6 and 10, and 11 % reporting higher numbers, including four respondents mentioning catches of 30–65 sharks; Fig. 2E). Most respondents (90 %) reported that sharks were alive when caught (Table 1), and 87 % monitored their equipment regularly while fishing (Fig. 2F).

While respondents reported catching almost all shark species presented in the identification board (47 out of 51), eleven species were identified more frequently (i.e., more than 15 times; Fig. 3). From those, the species most identified (77 %, n=85) was by far the scalloped hammerhead shark (*Sphyrna lewini*) followed by 33 % (n=37) of fishers reporting catches of bluntnose sixgill shark (*Hexanchus griseus*), 31 % (n=34) white shark (*Carcharodon carcharias*), 29 % (n=32) longfin mako shark (*Isurus paucus*), 27 % (n=30) pigeye shark (*Carcharhinus amboinensis*), and other six species under 20 % each (Fig. 3). Six of the most identified species are classified by the International Union for the Conservation of Nature (IUCN) as "vulnerable," "endangered," and "critically endangered," the three categories with the highest risk of extinction (IUCN, 2023). The mean diversity of identified species across communities was 47 (SD =18,6), with a minimum of 22 species identified by fishers from *Ribeira Peixe* and a maximum of 85 identified by fishers from *Porto Alegre* (Supplementary Table 5).

Ninety-eight percent of respondents sold the sharks that were caught to fishmongers (known as "*palaiês*" in Creole) either from their
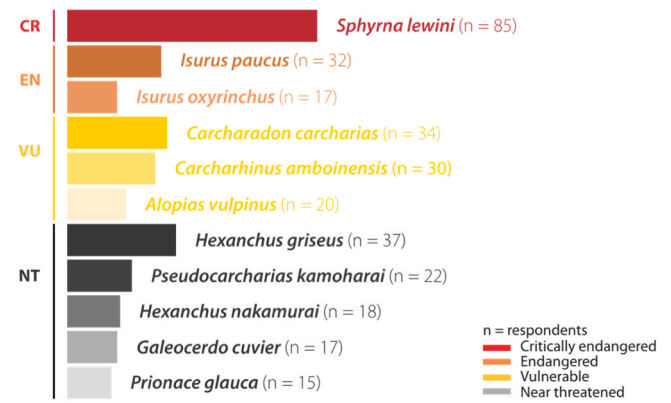

Fig. 3. Santomean fishers' most identified shark species organized by their respective International Union for the Conservation of Nature (IUCN) categories. Here are considered species with greater than or equal to 15 identifications. A list of the remaining species and number of identifications can be found in Supplementary Table 5.

community (91 %) or from other communities (21 %; Table 1). Few fishers sold sharks directly to restaurants (2 %) or outsiders (1 %). The latter is neither a fish dealer nor a restaurant owner and is not from the community. In most cases (96 %), respondents said sharks were sold as a whole, with only two fishers reporting they sold the fins and meat separately. Prices varied not only with size but also with species caught. On average, the price of a small shark (one meter long) corresponded to 399 dobras (€16) (SD = 281.3) and a large shark (3–4 m) to 2324 dobras (€95) (SD = 1030.6) (Table 1). On the higher end, the price of a shark can go up to 5000 STN/ 204,1 EUR. Fifty-seven percent of respondents reported also eating the caught sharks, and 7 % shared them with their extended families and community (Table 1).

3.3. Fishing grounds

Sharks were identified in the fishing grounds of almost all interviewed fishers (97 %, Fig. 1). Most fishers reported catching sharks in offshore areas (79 %) and a smaller number along the coast (22 %; Fig. 2B). When asked about specific areas where they catch sharks, fishers identified 20 different locations. Of those, *Ilhéu das Rolas* (11 %), *São Miguel* (8 %), *Sete Pedras* (8 %), the area of the south from *Porto Alegre* to *Santa Catarina* (6 %), and *Praia Grande* (5 %; Fig. 4) were most frequently mentioned. For the scalloped hammerheads that were consistently identified throughout all communities (Supplementary Table 5), areas of higher abundance are assumingly found in the southern part of Sao Tome Island, namely at *Sete Pedras*, *Ilhéu das Rolas*, and on the southeastern coastal area from *Porto Alegre* to *Santa Catarina* (Fig. 4). While fishers mainly reported the presence of adults, they also mentioned the occurrence of pregnant females and juveniles – particularly in the previously mentioned area from Porto Alegre to Santa Catarina, more precisely in São Miguel and Quijá river.

3.4. Fishers' perceptions of sharks

Although most respondents (87 %) never had any negative experience with sharks, 62 % of respondents perceived sharks as a threat to their safety (Fig. 5A), and, for some, even their way of living, since some would argue that "*sharks eat all the fish, leaving nothing for the people.*" Nevertheless, 35 % of respondents saw sharks as a business opportunity. In fact, when asked why sharks were important, most respondents (91 %) said it was because of their contribution to income. Others highlighted their role as a food source (33 %), environmental reasons (16 %), and cultural purposes (10 %) (Fig. 5B). When asked if sharks should be protected, 59 % of fishers agreed, while 40 % did not see it as necessary (Fig. 5C). Common reasons in support of protection were that

Table 1
Use of sharks by fishers on the island of São Tomé. Questions allow for multiple answers. Percentual values refer to a total of 111 responses.

|		%
When you catch sharks, they are...	Alive	90.1
	Dead	5.4
	No answer	4.5
How do you use the sharks you catch?	To sell	98.2
	To eat	57.7
	To share	7.2
	No answer	2.7
To whom do you sell sharks?	Fish dealers from my community	91.0
	Fish dealers from other communities	20.7
	Restaurants	1.8
	Outsiders	0.9
How do you sell sharks?	Entire shark	95.5
	Fins	2.7
	Meat	2.7
	Teeth	0.0
		Dobras / €
For how much you sell a small shark (about 1 m long)?	Min	50/2.04
	Max	1000/40.82
	Average	398.78/ 16.28
For how much you sell a large shark (about 3 m long)?	Min	400/16.33
	Max	5000/ 204.08
	Average	2324.07/ 94.86
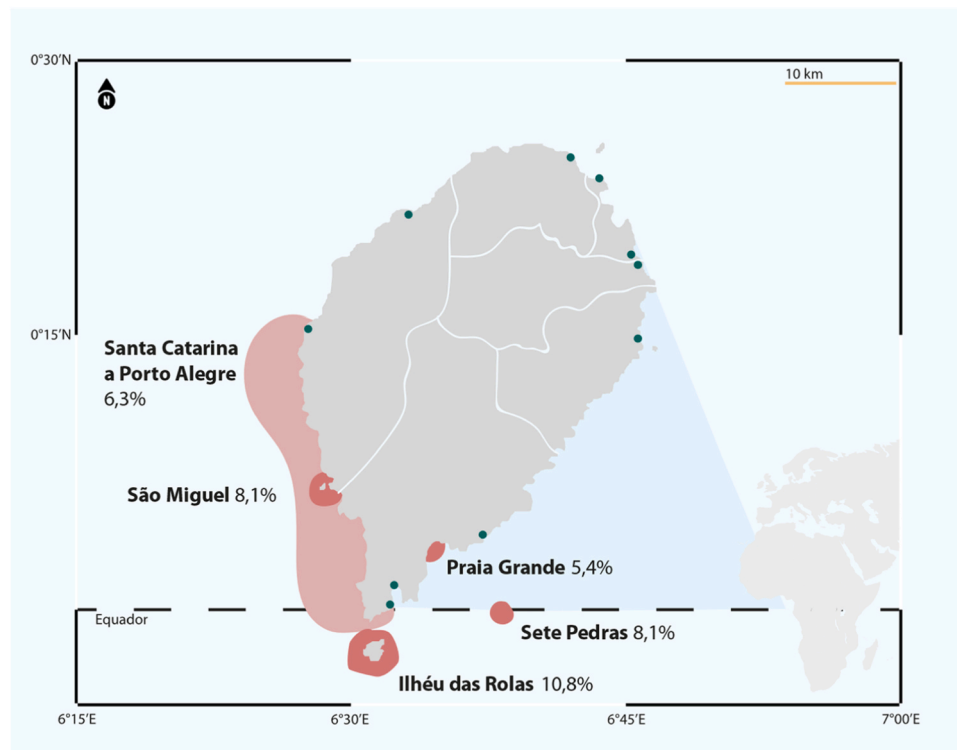
Fig. 4. Areas of the Island of Sao Tome highlighted by fishers as areas of higher abundance of sharks. Percentual values refer to a total of 111 responses.

sharks were disappearing (23 %), were impacted by international fishing fleets (16 %), were important for ocean health (9 %), and were overfished (5 %).

When asked if they could (or would) avoid catching fish in areas with a high abundance of sharks, opinions were divided, with 48 % of respondents saying no and 46 % saying yes (Fig. 5D). A high number of fishers further expressed they would potentially stop catching sharks (Fig. 5E) if they had alternative catches (45 %) or alternative businesses (27 %), or if there was a legal obligation to do so (8 %). On the contrary, 14 % of respondents saw no significant reason for ceasing their shark-catching activities (Fig. 5E). When asked about sharks' protection status in Sao Tome and Principe, most fishers (96 %) agreed sharks were not protected anywhere except for two respondents from Porto Alegre.

3.5. Changes in abundance

Most fishers (89 %) have noticed changes in the abundance of sharks in Sao Tome over the past 15 years, with 82 % mentioning a reduction in their populations (Fig. 6A). Respondents identified several underlying causes, the most common being an increase in the fishing pressure, especially from international fishing fleets (74 % (Figs. 6B and 6C). Only a small number of respondents identified national fleets (5 %) or the use of less traditional fishing methods such as nets (1 %) as the primary cause (Fig. 6C). Other reasons cited were the lack of food, changes in water temperature, and water pollution. Only eight fishers perceived an increase in the abundance of sharks, with two also stating that sharks were reproducing more (2 %). When asked about future trends, 69 % of respondents believe sharks will be less abundant in the upcoming decades, and 14 % believe that their abundance will increase (Fig. 6D).

4. Discussion

4.1. Santomean fishers

Santomean fishers play a fundamental role in society, as fish is the main source of protein for human consumption, and the fisheries sector represents the second most important source of revenue for low-income families (Belhabib, 2015; Belhabib et al., 2015; De Labra et al., 2023; FAO, 2021; INE, 2017; Porriños et al., 2023; Serkovic and Million, 2019). National statistics, however, show that artisanal fishers have the lowest mean monthly income at the national level (1100 dobras, €45; INE, 2017), being in a highly unstable and precarious socioeconomic position. This is further exacerbated by the high cost of essential goods that must be imported (e.g., rice, flour, and beans cost from €0.6-€2 per kg; INE, 2017), and to the fact that artisanal fishers' households tend to be numerous, which significantly increases expenses (52 % with up to 3 children, 31 % with 4–6 children; D'Almeida et al., 2019). Collected data is in line with national statistics, with almost half of respondents living below the poverty line (less than $2.5 per day). Although the mean cost of maintaining fishing gear (e.g., lines, hooks) is €85 per month (Supplementary Table 2), this value is greatly influenced by a smaller number of responses from fishers that use motorized boats and long trawling nets. The median value – €34 per month – is likely more representative. Still, even so, it is almost half of the monthly budget of low-income fishers, thus significantly reducing their economic capacity. In general, gear types identified in this study are in line with national statistics on artisanal fisheries (Direção das Pescas, 2019; Porriños et al., 2023), with almost all respondents fishing with handlines (e.g., jigging lines, longlines, trolling).

Although the interviewing process in each community started with fishers with likely knowledge of sharks, the process ended up being more inclusive for fishers in general since i) it does not seem to exist much targeting on sharks, and ii) the poll of fishers was limited to the people available at the time of the team's visit. As such, we can assume that these replies represent not only the experience of shark experts, but also of regular fishers.

4.2. Sharks in Sao Tome Island

Knowledge gathered through this interviewing process indicates the presence of sharks around the island of Sao Tome, and it seems that most Santomean fishers catch sharks. As most fishers use active fishing
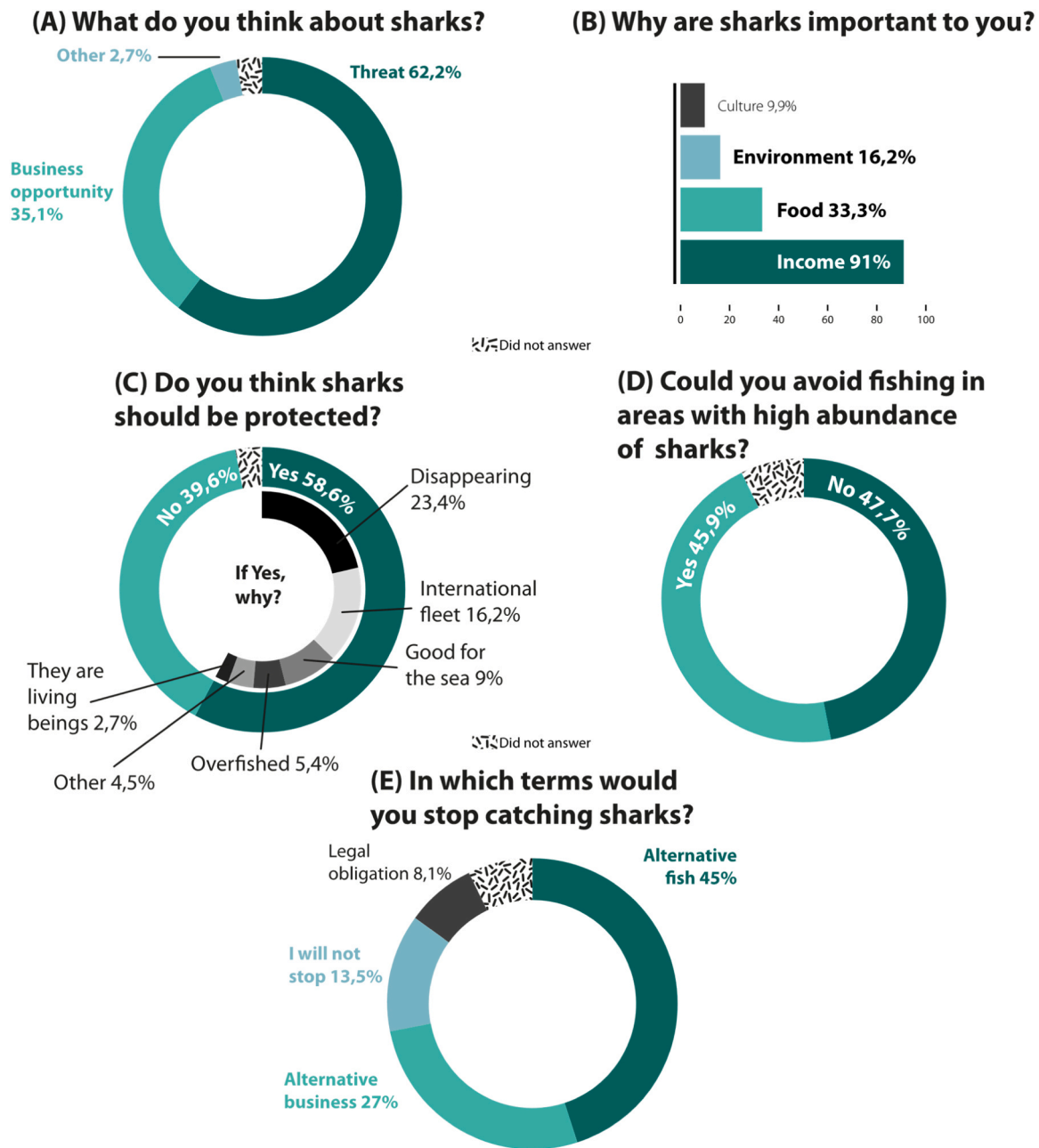
Fig. 5. Fisher's perceptions towards sharks. Questions with only one possible answer are represented by a circle, whereas the bar graph B represents a question with more than one possible answer per respondent. Percentual values refer to a total of 111 responses.

methods (mostly handlines), sharks are often alive when caught. It is then up to the fisher to decide whether to keep or release them. Fishers usually keep sharks once they are hooked. Still, it seems that several factors may influence their release, such as: i) fishing alone - sharks may be too large for a single fisher to pull them into the boat; however, if other fishers are nearby, they can help with the catch; ii) the amount of fish already caught (not leaving space for extra catches of a large dimension); iii) the shark species - some species are more aggressive and thus more feared by fishers, as for the case of the mako shark that is described to "*attack fast and jump over the canoe.*"

Shark prices seem to vary depending on the size and species caught – the scalloped hammerhead being among the most valuable ones, seemingly due to its taste, and the blue shark the least due to its meat with a distinctive "urine" smell and taste. This highlights that sharks can be of great importance to Santomean fishers' income, particularly adult sharks – that can be worth more than the mean monthly income for a

fisher –and thus, a high level of targeting and intentional catches would be expected. This is, however, not the case. Potential reasons for such non-targeted fishing are that sharks are not predictable catches nor are found in great numbers on the island. This is in line with the i) overall low number of sharks caught, as reported by fishers for the six months prior to the interviews, ii) studies on fish and benthic reef communities of the island – that show a low abundance of coastal large predators, in general, and no record of sharks during sampling (Maia et al., 2018b) – and iii) reports on artisanal fisheries – where very few records of sharks were obtained (Porriños et al., 2021). Nonetheless, sharks are part of the catch of demersal gillnets (Porriños et al., 2021) – which can be more effective at catching larger quantities of fish, thus explaining the four highest reported catches (over 30 sharks during the last six months), particularly when used overnight, as these fishers reported doing – and of Santomeans diet (Nuno et al., 2021).

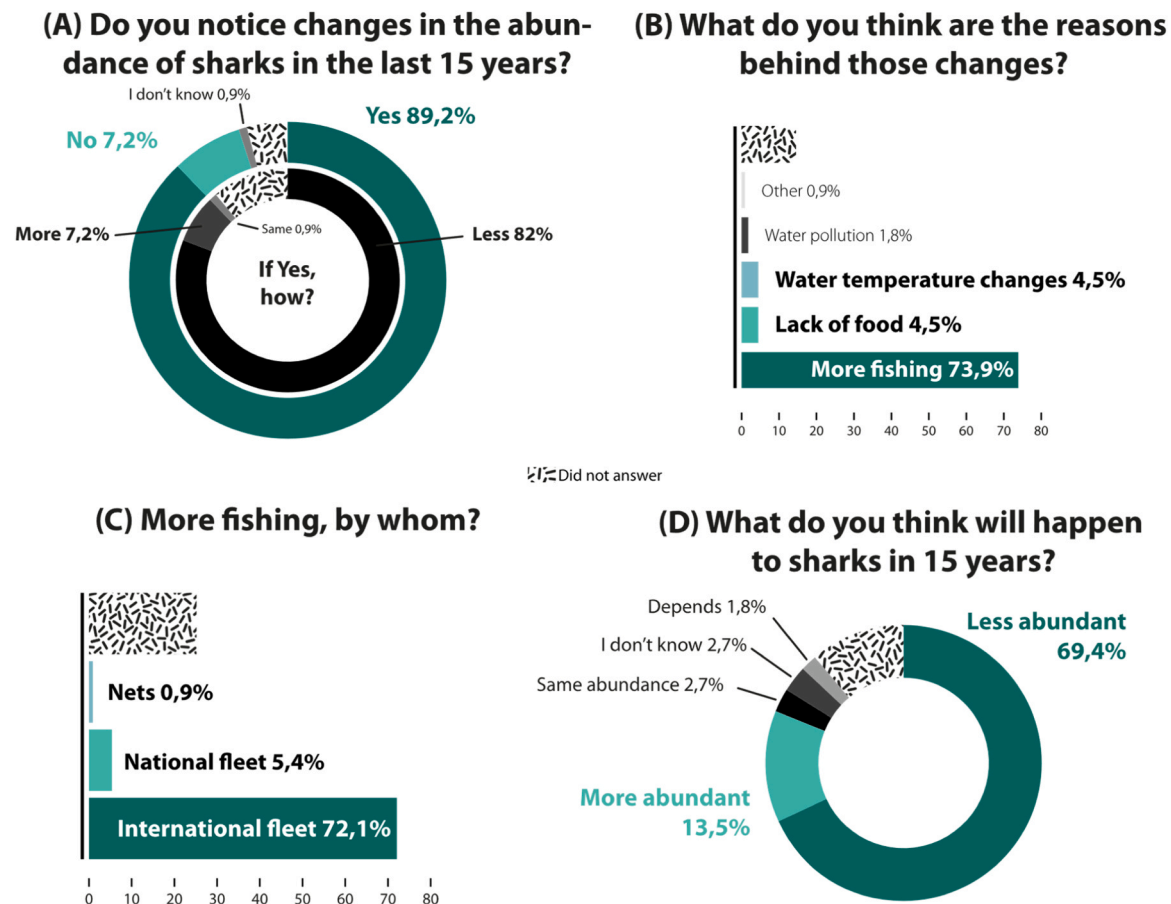As for seasonality, sharks seem to be present in Sao Tome all year

Fig. 6. Perceptions of fishers regarding changes in abundance of sharks in a 15-year period. Questions with only one possible answer are represented by a circle, whereas the bar graphs B and C represent questions with more than one possible answer, per respondent. Percentual values refer to a total of 111 responses.

round. Several respondents reported catching sharks in specific periods only — namely in the "*gravana*", the dry season, from May to September. However, the same respondents said they had fished sharks during the six months prior to the interview — which corresponds to the wet season, from October to April. Such inconsistency is likely due to misinterpretation, as fishers generally perceive sharks as present all year round, although their abundance and/or availability seem to be much higher in the *gravana*. The end of the rainy season comes with consistent winds that, together with the good weather, allow fishers to travel further offshore, where most likely they will encounter oceanic shark species such as blue and mako sharks. Seasonality of catches might then be an indicator of low shark abundance in coastal areas – where fishers are forced to stay during the rainy season (in other words, changes in fishing grounds), and changes associated with wide-spread horizontal migrations, such as those found in the scalloped hammerhead (a coastal-pelagic, semi-oceanic species; e.g., Coiraton et al., 2020; López et al., 2023).

Although almost all shark species in the ID board were identified by at least one fisher, most were surprised by the number and variety of the shark species presented, which, together with some recurring comments, such as "*we fish all of these*" – while pointing to the whole page –, indicates that a lot of these species are probably not fished or known by Santomean fishers but were still pointed at. Therefore, the interpretation of these results should be careful and done with a critical eye. For example, respondents were fast and accurate at distinguishing the scalloped (*S. lewini*) from the smooth hammerhead (*S. zygaena*) by pointing at the details of the shape of their head, in this case to the scalloped hammerhead, thus indicating that respondents are familiarized and are capable of correctly identifying this species and possibly

others that are usually seen or caught. On the other hand, they appeared confused while identifying other similar species, such as longfin (*I. paucus*) and shortfin mako (*I. oxyrinchus*). This case is particularly difficult, even to the trained eye, and thus, confusion and misidentifications were expected. By looking at the topmost identified species, we tried to dilute these identification errors and let broad patterns arise. In addition, and even though the ID board was presented with the question of whether the respondents catch these species, it was apparent that responses were based on whether or not fishers knew the species, so the interpretation of these results should not be indicative of their representativeness on fishers' catches, but rather of potential presence in national waters.

The critically endangered scalloped hammerhead, or '*toto*' in Santomean creole, is likely present all around the island, given the consistent identification across all communities. The distinctive features of the bluntnose sixgill shark (*H. griseus*), with its dorsal fin at a particular lower end of the body, the large gills, and the unique body shape, make the presence of this species highly probable. It is worth noting that the bigeye sixgill shark (*H. nakamorai*), a species often mistaken for the bluntnose sixgill shark, is also present in the top 15 list but with less than half of the identifications. Realizing that, apart from general species distribution maps (Ebert et al., 2021; IUCN, 2023), there are no scientific records or official reports of their presence on the island, so either one or the two may be present here. The same applies to the vulnerable white shark (*C. carcharias*), with no scientific or official records but probable distribution – as identified in the Sharks of the World guidebook (Ebert et al., 2021). The distinctive characteristics of *C. carcharias*, together with respondents' descriptions of its aggressiveness and size, make its presence highly probable, even though it is rarely seen, as pointed out by

respondents. *C. carcharias* is also known, in some Portuguese-speaking countries, like Portugal and Angola, as the shark of Sao Tome ('*tubarão de São Tomé*'; Froese and Pauly, 2023), thus supporting the idea that this species is likely found here. As for the two endangered species of mako sharks – longfin (*I. caucus* and shortfin (*I. oxyrinchus*) – *locally known as "tunhã,"* it is challenging to distinguish between the two. While their presence is reported in the area by Carranza et al. (2006), they also do not indicate which species. Photographic evidence collected among fishers (Supplementary Figure 2 A) indicates the presence of shortfin makos alone. If this proves to be true, then the species would have been marked by 37 fishers, making it the second most identified shark, together with the bluntnose sixgill. Nonetheless, we cannot refute the possibility that both could be present, especially when considering that most of these respondents only pointed to one of the two.

The thresher shark (*A. vulpinus*), easily identified by its long tail, which also gives its Santomean name '*labulongo*', was differentiated from the bigeye thresher (*A. superciliosus*), also present in the ID board. Both species can potentially be found and fished in Sao Tome, and there is a strong indication that at least one is due to such a differentiating local name. Yet, it is worth noting that there is still no record confirming either one. Some respondents quickly recognized the tiger shark (G. cuvier) due to its pattern, which resembles the one of a land mammal well known by the Santomean, the African civet (*Civettictis civetta*), thus giving it its local name '*lagaia.*' Photographic evidence (Costa et al., 2022) confirms its presence in Santomean waters. Similarly, the blue shark (*P. glauca*) has both photographic records (Supplementary Figure 2B) and a Santomean name, '*maiawa*', given due to its characteristic meat that loses a lot of water during cooking. As for the pigeye (*C. amboinensis*) and the crocodile (*P. kamoharai*) sharks, both without official records, they do not have unique characteristics as some of the species described before. For example, the pigeye shark could easily be mistaken for the sandbar shark (*C. plumbeus*), also identified by 12 respondents, or the opposite. The crocodile shark can also be mistaken for a juvenile of other shark species. As so, we cannot conclude much about these identifications. Finally, it is also worth mentioning photographic evidence of catches that confirm the presence of oceanic whitetip sharks (*C. longimanus*; Supplementary Figure 2 C), possibly of silky sharks (*C. falciformis*; Supplementary Figure 2D), and sightings of whale sharks (*R. typus*, '*mapinta*' or '*pintado*' in santomean), mainly during the dry season.

Among the coastal areas identified as places of higher probability of shark encounters, the southeastern part of the island – from *Porto Alegre* to *Santa Catarina* (in particular, *São Miguel*) – and *Praia Grande*, raise particular interest, since it was also reported the presence of juveniles and pregnant scalloped hammerheads, in both areas. On the latter, photographic evidence – provided by a local fisher that uses gillnets here – identifies it also as a place of frequent catches of juvenile milk sharks (*R. acutus*; Supplementary Figure 2E). These reports, together with the geographic characteristics of these areas, with small bays and river mouths with variable turbidity, lead us to believe that there are areas that could be (or could have been) nursery grounds for scalloped hammerheads and milk sharks, as in Rosa et al., (2023) although the current state of the abundance of sharks in these areas is unknown.

4.3. Human perceptions

The understanding of the sharks' importance for the marine ecosystem and fisheries seems to be limited and recognized only by a small number of fishers. On top of that, there appears to be a feeling of unfairness over shark fisheries since fishers' perceptions indicate that the international fleet might overfish sharks. For that same reason, fishers think sharks should be protected. Not from all fisheries but from international fleets, so these resources can become more readily available to the Santomean. Nonetheless, a few interviewees also mentioned that sharks should be protected because they are "*good for the sea*", "*they*

bring fish with them" or because "*they are living beings*", thus showing a different understanding of their importance.

Marine resources on which Santomean fishers depend are becoming significantly depleted (Maia et al., 2018a; Maia et al., 2018b; Serkovic and Million, 2019). This relates to the increased fishing pressure from national fleets due to population growth over the past few decades (Maia et al., 2018a; Maia et al., 2018b; Serkovic and Million, 2019), as well as the impacts from international fishing fleets, purse seine, and longliners (Hutchinson et al., 2015; Tolotti et al., 2015; Zainudin et al., 2017), operating inside STP's EEZ. Although the latter topic is still under-investigated, it is argued that the activity of international fishing fleets is largely unregulated (Belhabib et al., 2019; Daniels et al., 2016; Doherty et al., 2021; Okafor-Yarwood, 2019; Zoppi, 2019) and contributes to most of the fish being removed from the country's EEZ (Belhabib, 2015; Porriños et al., 2021). Sharks' stocks seem to be no exception to this trend, as virtually all respondents have noticed a decrease in shark abundance since the last 15 years, a perception already reported for other reef fishes on the island (Maia et al., 2018b). Since fishers are sailing further away from shore, seemingly in search of specific catches (such as flying fish; Porriños et al., 2021) or due to the lack of fish inshore, they fish close to international vessels. They describe that these vessels are catching sharks in larger numbers than they are capable, cutting their fins and throwing out the rest of their bodies, as it was already reported on international media, leaving the Santomean fishers with a feeling of injustice, not only because these are their resources but also because of the waste, thus end up attributing the cause of this reduction mainly to international fishing boats. Nevertheless, fishers also recognized the impacts of the national fleet, particularly of less traditional fishing methods, such as demersal gillnets and purse seines, which are particularly relevant closer to shore.

The upcoming challenges that will arise from human pressures on the marine environment are especially relevant due to the importance of fisheries for local communities' livelihoods and wellbeing (Allison et al., 2020). Particularly in what relates to sharks, while there is a generalized perception that they will be less abundant in the near future, there is no consensus on whether fishers are willing to stop fishing in areas of higher sharks' abundance or even stop catching sharks. Because shark encounters tend to be sporadic and take place in areas that correspond to hotspots of other fishing resources, there might be resistance and apprehension from Santomean fishers to comply with species-specific bans, or even with no-fishing zones. This is particularly true when significant economic benefits are present, as highlighted in previous studies (Collins et al., 2020). As the current legal framework in Sao Tome does not encompass any specific shark-related regulations (neither for national fisheries nor for international ones), shark populations might be at an increased risk from human stressors. In effect, the former is why the Convention on International Trade in Endangered Species of Wild Fauna and Flora has recommended the suspension of commercial trade of CITES-listed species in STP (CITES, 2022).

5. Final considerations

Artisanal shark fisheries in Sao Tome seem to be either a result of bycatch from nets and longlines or motivated by the high economic value of adult shark individuals. However, given the socioeconomic context of Santomean fishers, shark fisheries are likely to be used for subsistence only and not for profit (even when sharks are sold, revenues are most likely used to acquire basic goods and compensate for worse fishing days). Still, the low number of sharks being caught and the lack of interest in targeting sharks indicates two larger problems – the low density of top predators in the region, and the lack of marine resources, particularly in coastal areas. This scenario poses risks for ocean health in the long term and, inevitably, for the well-being of local human populations that rely on them. There is, thus, the need for a better understanding of shark populations in STP, together with the impacts of artisanal and industrial fisheries on this key group of organisms.

Identifying sharks' distribution and habitat use is fundamental to design and implement conservation measures properly. Also, raising awareness and building capacity close to local communities on sharks' key role and importance will be fundamental to support future conservation measures and overcome misinformation and existing negative bias against sharks in general.

CRediT authorship contribution statement

Hugulay Maia: Writing – review & editing. **Catarina Pereira Santos:** Writing – review & editing, Resources. **Martina Panisi:** Writing – review & editing, Investigation. **Aristides Santana:** Investigation. **Carina Vieira da Silva:** Conceptualization. **Guillermo Porriños:** Writing – review & editing. **Ana Nuno:** Writing – review & editing. **Lia Vasconcelos:** Writing – review & editing, Supervision. **Catarina Frazão Santos:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization. **Rui Rosa:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Vasco Pissarra:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability

Data will be made available on request.

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Author contributions

VP, RR and CFS conceptualized the study. CFS, CVS and VP designed the survey. VP, AS and MP conducted the interviews. VP, RR and CFS analysed the data. VP and CFS produced the first draft of the manuscript. All authors contributed to and approved the final version of the manuscript.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.rsma.2024.103711.

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