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Employing Local Ecological Knowledge to reveal interactions between artisanal fishers and Guiana Dolphins (*Sotalia guianensis*) along the Maranhão coast, northern Brazil

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ABSTRACT

The Guiana dolphin (*Sotalia guianensis*) is a cetacean found in tropical coastal waters of the Western Atlantic, distributed from Honduras to northern Santa Catarina, Brazil. Its restricted distribution and interaction with human activities, such as artisanal fishing and pollution, make it highly vulnerable to anthropogenic threats, being classified as near threatened by the International Union for Conservation of Nature (IUCN) and vulnerable by the Brazilian Chico Mendes Institute for Biodiversity Conservation (ICMBio), the Brazilian Ministry of the Environment's administrative arm. Local Ecological Knowledge (LEK) is essential to understand interactions between fishing communities and this species. In this sense, this study aimed to identify the interactions between artisanal fishers and Guiana dolphins on the coast of Maranhão, aiming to provide relevant information on Guiana dolphins, essential to support conservation efforts for the species. A total of 88 semi-structured questionnaires were applied to fishers from the Tubarão Bay Extractive Reserve and São Marcos Bay, in Maranhão, northern Brazil. The calculated Smith's Salience Index revealed that the most valued ethnospecies are mullet, hake and croaker. Although overlaps between ethnospecies and the Guiana dolphin diet are noted, no direct conflicts were recorded. Some fishers perceive the presence of dolphins in a positive light, associating them with helping them locate fish, while others view the interaction negatively, considering that dolphins feed on fish caught in nets. Most fishers (56.8%) are not bothered by the presence of dolphins during fishing, and 82.95% stated that they do not interfere. Although 45.4% of fishers believe that dolphins can get entangled in fishing gear, there were no records of intentional captures. The importance of conservation and environmental education strategies is highlighted to ensure harmonious coexistence between fishers and Guiana dolphins.

Keywords: Ethnoecology, Artisanal fishing, Cetacean, Conservation.

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SIGNIFICANCE STATEMENT

This study provides insights into the interactions between artisanal fishers and the Guiana dolphin (*Sotalia guianensis*) along the coast of Maranhão, Brazil. This species faces increasing pressures due to its restricted distribution and interactions with human activities, such as artisanal fishing and pollution. By incorporating Local Ecological Knowledge (LEK) through interviews with fishers, this research fills gaps in how fishers perceive and interact with dolphins in northern Brazil. The results indicate the absence of direct conflicts, with most fishers reporting neutral or positive perceptions towards dolphins. However, concerns about accidental entanglement in fishing gear reinforce the need for continued monitoring. This study highlights the importance of conservation and environmental education strategies to promote a harmonious coexistence between fishers and Guiana dolphins, contributing to this species conservation and the sustainability of local fisheries.

INTRODUCTION

The Guiana dolphin (*Sotalia guianensis*) is a small cetacean, member of the Delphinidae family, endemic to the Eastern Atlantic Ocean, distributed from Honduras, in Central America, to the north of Santa Catarina, in southern Brazil (Barreto et al. 2011; Batista et al. 2014; Silva and Best 1996). This species is characterized as a habitat specialist with a potential clinal geographic distribution, concentrated in shallow and coastal tropical waters of the continental shelf of the western Atlantic Ocean (Lobo et al. 2021).

Due to its restricted distribution and strong overlap with human activities, the Guiana dolphin is vulnerable to artisanal fishing activities, chronic effects of pollution, and other anthropogenic actions, including heavy vessel traffic and marine seismic research (Barreto et al. 2011). In a recent assessment, the International Union for Conservation of Nature (IUCN) classified this species as near threatened (NT) (Secchi et al. 2018). In Brazil, is fully protected by law, and its capture, transport, and any processing and commercialization activity are prohibited (ICMBio 2018) due to its national classification as a vulnerable species (VU) (Brasil 2022).

The application of ethnographic tools, such as Local Ecological Knowledge (LEK) (Begossi et al. 2000; Hanazaki 2003), helps complement scientific knowledge through the traditional knowledge of local communities, especially in places that are difficult to access or where there is a lack of financial resources (Huntington 2000). This type of knowledge is acquired over years of experience and transmitted to generations who, by living with nature, learn about local species and the use of natural resources in the communities where they live (Diegues 2001). Understanding the types of interactions between fishing communities and target species, as well as the ecology and behavior of Guiana dolphins from a fisher perspective (Manzan and Lopes 2016; Siciliano 1994; Zappes et al. 2010) are essential for the development of action plans aimed at mapping priority areas for conservation, in addition to environmental awareness actions, both inside and outside legally protected areas (Zappes et al. 2013a).

Along the coast of the state of Maranhão, northern Brazil, fishing production is mostly carried out artisanally, representing about 92% of the total production carried out in this state (Almeida et al., 2006). Approximately 200 artisanal fishing communities are located in this state, carrying out their activities with low technological levels and basic methods, such as fixed traps (*currais*), drift nets (gill nets), longlines, and handlines (Monteles et al. 2010; Santos et al. 2011). In addition, the state's fishing fleet is characterized by small, low-power vessels, thus limiting the productive capacity of this sector when compared to industrial fishing (Carvalho et al. 2020). Therefore, each fishing net, trap, and vessel comprise potentially a source of interaction between the Guiana dolphins and artisanal fishing communities. Because of this, these associations need to be understood in order to build healthy human-wildlife relationships.

Although some studies report on the occurrence, habitat use, meat consumption, and traditional knowledge of Guiana dolphins (Filgueira et al. 2021; Garri et al. 2008; Moura et al. 2019; Pivari et al. 2020; Siciliano et al. 2018) along the coast of the state of Maranhão, the area still lacks much information concerning ecology, behavior, population size, bioacoustics, the presence of contaminants, and water quality, especially in areas influenced by port activities (Pivari et al. 2020). Given these threats, this study identifies the types of interactions between artisanal fishers and Guiana dolphins along the coast of Maranhão, in order to contribute with relevant information on this species, essential to support conservation actions.

MATERIAL AND METHODS

Study area

This research was conducted at the Tubarão Bay Extractive Reserve, a legally protected area, and in the São Marcos Bay region, a non-legally protected area. Both are located along the Maranhão coast, which exhibits wide tidal variations, which can reach 7.1 m, averaging 3.4 m variations (Furtado 2007). The Maranhão coast is highly diverse, presenting several

mangroves, bays, inlets and dunes. This coast contains important Conservation Units, with Extractive Reserves (RESEX) comprising a relevant category for the conservation of marine and coastal environments and the culture of traditional communities (Figure 1).

The Tubarão Bay RESEX, a conservation area created by Decree 9,340 of April 5th, 2018 (Brazil 2018), is located east of São Luís Island and covers part of the municipalities of Icatu and Humberto de Campos. This conservation area covers about 223 thousand hectares (Soares 2017). Local seasonality is marked by dry and rainy periods, temperatures are usually above 27 °C and the average annual rainfall rate is of 1,719 mm (Monteles et al. 2010). Thirteen human communities that live basically from artisanal fishing, shellfish gathering, small plantations and raising small animals for their own consumption are located within this conservation area (Soares 2017). Three artisanal fishing communities were selected for this study, namely Gato Island (2°31.8'S, 43°38.4'W), Grande Island (2°28.5'S, 43°34.4'W) and Carrapatal (2°22.1'S, 43°40.5'W).

The other sites, namely the municipalities of São Luís (2°31.8'S, 44°18.5'W), Raposa (2°25'S, 44°06.1'W) and Alcântara (2°24.5'S, 44°25'W), are located in the São Marcos Bay, bordered to the west by the municipality of Alcântara, to the south by the mouth of the Mearim River and to the east by the Ilha do Maranhão (DHN, 2013). This bay exhibits wide tidal variations, with maximums of up to 7.2 m, but, mostly, with a maximum amplitude not exceeding 5.5 m. In addition, this bay displays high commercial importance due to local port facilities responsible for the flow of a large part of the production and activities that move the population to the Baixada Maranhense region (Amaral and Alfredini 2010).

Data collection

Interviewees were selected according to the following criteria: (i) the individual should work as a fisher in the study area, (ii) be over 18 years old, and (iii) be available to participate in the interview and agree to a Free and Informed Consent Form (FICF). The snowball technique was used to select interviewees, so that, interviewed fishers indicated other experienced informants to contribute to the research at the end of each interview (Bailey 1982). This method favors obtaining important informants for the research. However, in order to avoid interview biases, researchers can interrupt the snowball technique and conduct opportunistic meetings with other fishers on the beaches and fishing ranches (Zappes et al. 2016b).

Interviews were conducted with local fishers using a semi-structured questionnaire containing open and closed questions. The first part of the questionnaire addressed socioeconomic information and local fishing activities, while the second part addressed ecology and recognition of the Guiana dolphin and interactions between fishers and the species. During the interviews, a photographic board with 10 aquatic mammal species of that occur along the coast of Maranhão was also presented. The fishers had to indicate which species they recognized as the Guiana dolphin and whether they recognized other species for the coast of Maranhão.

Data analysis

Smith's Salience Index is widely employed analysis for open lists, when the aim is to understand which items are most important in a list provided by the interviewee (Sutrop 2001). This index was used to identify which fish ethnospecies are considered most important by the interviewees, through citation frequencies and the position of the items during the interviewees' speech (Chaves et al. 2019). This analysis was performed using Anthropac software (Analytic Technologies, Kentucky) version 1.0.1.36, designed for open list analyses (Borgatti 1998).

The nonparametric Kruskal-Wallis test was used to identify possible differences in the perception of artisanal fishers from inside and outside the RESEX regarding types of Guiana dolphin interactions (positive, negative or neutral). Fisher's exact test was used to assess whether the degree of fishing experience (years of fishing) influenced the interviewees' perception of the possible interference of Guiana dolphins while they were performing their duties.

Based on the interviewees' reports on Guiana dolphin diets, a Venn diagram was created to compare this information with data described in the scientific literature on the subject along the Brazilian coast (Daura-Jorge et al. 2011; Cremer et al. 2012; Di Beneditto and Ramos 2004; Lopes et al. 2012; Pansard et al. 2011; Rosas et al. 2010; Godoy et al. 2020). All statistical procedures were performed in RStudio software (version 2024.04.0), using the *ggplot2* package (Wickham 2016) to create the graphs, and the *VennDiagram* (Chen et al. 2022) and *circlize* (Gu 2014) packages to create the Venn diagram.

Ethical aspects

Considering the direct participation of humans in this study, the research was approved by a Research Ethics Committee (CAAE 61284422.8.0000.5244). Furthermore, because it was partially conducted in a Conservation Unit, a Chico Mendes Institute for Biodiversity Conservation authorization was also obtained (SISBIO-ICMBio: 81349-2).

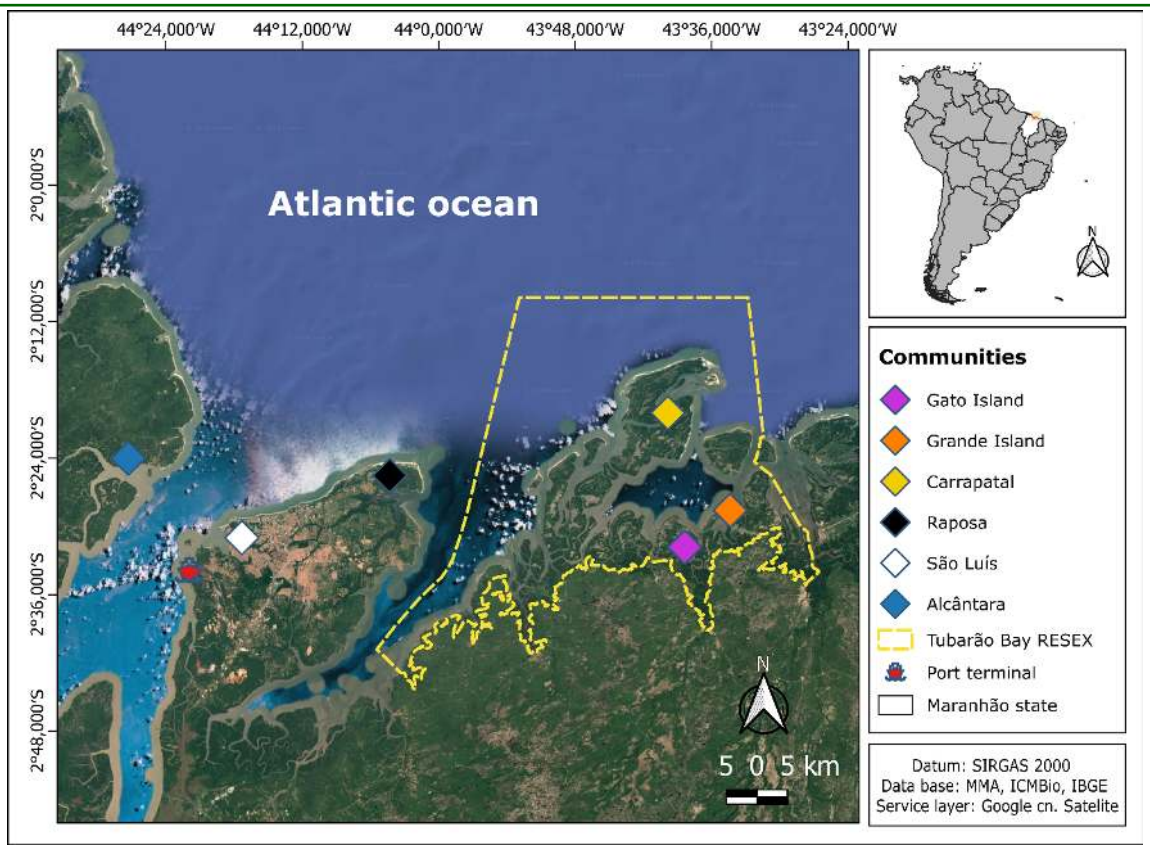

Figure 1. Map of communities visited inside and outside the Tubarão Bay Extractive Reserve, Maranhão, northern Brazil.

RESULTS

Fisher and artisanal fishing characterization

A total of 88 artisanal fishers were interviewed between July 2022 and November 2023, all male, ranging from 28 to 82 years old (± 12.4), most (n= 38; 43.2%) between 43 and 57 years of age. Most interviewees had between 27 and 41 years of fishing experience (n= 43; 48.9%), and did not complete elementary school (n= 72; 81.8%), dropping out between the fourth and fifth grades. Most interviewees fish daily (n= 48; 54.5%), leaving the ports at high tide and returning after 12 hours. Due to the proximity between the community and their fishing grounds, most of the vessels are small, with engine powers between 5 and 12 HP (n= 50; 56.8%). The fishers reported using 12 types of fishing gear, of which the three most cited were gillnets (malhadeira – 13.6%, caçoeira – 12.5% and serreira – 12.5%). Description concerning fishing characteristics, type of vessel and type of net are depicted in Table 1.

Species importance for fishers

Literature reviews and expert consultations identified 27 fish and two shrimp species. However, elasmobranch species were not differentiated, as interviewees employed generic names for this group. However, the identified species were distributed among six orders, with the most abundant comprising Perciformes representatives (Table 2).

Smith's Salience Index indicated that the most important (salient) fish ethnospecies considered by the interviewees were: mullet (0.209), hake (0.187) and croaker (0.154) (Figure 2). A breaking point was observed at the shrimp ethnospecies level, with an index below 0.1. However, the ethnospecies white shrimp (0.142), uritinga (0.132), cangatã (0.123) and stonefish (0.119) were noted between 0.1 and 0.15. From this point on, less frequent ethnospecies were observed, with less than five reports. The ethnospecies classified as salient are valued in the local market and are consumed by Guiana dolphins.

Table 1. Artisanal fishing activity characterization studied communities on the coast of Maranhão, northern Brazil. **Legend:** Alcântara (ALC), São Luís (SLZ), Raposa (RAP), Gato Island (GIT), Grande Island (GID), Carrapatal (CAR).

Characteristics		ALC	SLZ	RAP	GIT	GID	CAR	Total
Fishing time (Autonomy)	1 day	5	12	3	18	6	4	48
	2 – 4 days	8	8	8	0	6	5	35
	8 – 12 days	0	0	4	0	0	1	5
Type of vessel	Motorboat	12	14	15	15	10	8	74
	Canoe	1	5	0	0	1	1	8
	Sailboat	0	1	0	3	1	1	6
Type of net	**Gillnets**							
Fixed or drifting gillnets with cork or styrofoam floats on the upper part and lead weights on the lower part to keep them vertical in the water, with mesh sizes ranging from 20 to 30 cm between opposite knots. Made of monofilament nylon, they vary in length from 100 to 800 meters and in width from 4 to 6 meters.	Malhadeira	0	1	1	2	8	0	12
Drift nets that operate at the surface, midwater, and bottom, similar to other gillnets. They are handwoven with monofilament nylon of 1.0 to 1.2 mm and, at the surface, are fixed to styrofoam floats.	Caçoeira	1	0	1	7	0	2	11
	Sajubeira	0	0	1	2	0	0	3
	Tainheira	2	3	0	0	0	1	6
Gillnet with a mesh opening between opposite knots of 9.5 to 10 cm and a height of 4 meters. Ranges from 800 to 1,600 meters in length.	Serreira	2	2	5	2	0	0	11
Drift net attached to the vessel by a nylon cable, with a length of 350 to 700 meters and a mesh opening of 18 cm between opposite knots.	Gozeira	1	2	3	2	0	1	9
Conical net with a rectangular mouth, kept open by wooden spacers and extended horizontally by two fishermen in shallow waters. It uses monofilament nylon thread with a 0.25 mm diameter.	Puçá	1	0	0	3	1	2	7
	Beach seines							
Used for white shrimp fishing, as it is highly selective regarding size. Has two mesh sizes to capture only adult shrimp.	Camaroeira	0	8	0	0	1	0	9
Used for shrimp fishing, up to 100 meters long with 24 mm mesh sizes, also capturing surrounding fauna.	Lanço	2	0	0	0	0	2	4
	Longlines							
Fixed fishing gear over 1,400 meters long, with hooks placed every 1.0 to 1.6 meters along nylon cables.	Espinhel	1	4	4	0	0	0	9
	Net barriers							
Semi-fixed fishing gear, similar to a fence, where a net is attached to stakes at the bottom of waterways. Is not standardized and is used in river channels.	Tapagem	3	0	0	0	0	2	5
	Zangaria	0	0	0	0	2	0	2

Table 2. Identification of ethnospecies cited by artisanal fishers as the target of their fishing activities and frequency and salience values obtained by the Smith Index.

Class and order	Scientific name	Popular name (English)	Local name	Frequency	Salience
TELEOSTEI					
Siluriformes	*Sciades* spp.	Catfish	Bagre	10	0,051
	Aspistor quadriscutis	Bressou sea catfish	Cangatã	20	0,123
	Sciades herzbergii	Pemecou sea catfish	Guribu	14	0,075
	Sciades proops	Crucifix sea catfish	Uritinga	20	0,132
	Bagre bagre	Coco sea catfish	Bandeirado	10	0,062
	Notarius grandicassis	Thomas sea catfish	Cambeu	2	0,008
	Aspistor parkeri	Gillbacker sea catfish	Gurijuba	6	0,033
	Notarius bonillai	Cazon sea catfish	Uriacica	2	0,017
Perciformes	*Micropogonias furnieri*	Whitemouth croaker	Cururuca	1	0,009
	Macrodon ancylodon	King weakfish	Pescadinha	8	0,08
	Plagioscion squamosissimus	Silver croaker	Corvina	22	0,154
	Cynoscion spp.	Hake	Pescada	21	0,187
	Cynoscion acoupa	Acoupa weakfish	Pescada amarela	2	0,023
	Cynoscion jamaicensis	Jamaica weakfish	Pescada gó	9	0,056
	Mugil gaimardianus	Redeye mullet	Tainha-pitiu	5	0,03
	Mugil curema	White mullet	Tainha-Sajuba	10	0,055
	Mugil trichodon	Fantail mullet	Tainha	28	0,209
	Genyatremus luteus	Torroto grunt	Peixe-pedra	16	0,119
	Oligoplites spp.	Leatherjacket	Tibiro	2	0,013
	Caranx hippos	Crevalle jack	Xareu	1	0,005
	Centropomus parallelus	Fat snook	Robalo	1	0,003
	Centropomus pectinatus	Tarpon snook	Camurim	4	0,028
	Lutjanus spp.	Snapper	Carapitanga	1	0,005
	Trichiurus lepturus	Largehead hairtail	Guaravira	1	0,009
Elopiformes	*Megalops atlanticus*	Atlantic tarpon	Camurupim	1	0,002
Batrachoidiformes	*Batrachoides surinamensis*	Pacuma toadfish	Pacamão	1	0,006
Scombriformes	*Scomberomorus brasiliensis*	Thazard serra	Serra	3	0,011
CRUSTACEA					
Decapoda	*Litopenaeus schmitti*	White shrimp	Camarão branco	15	0,142
	Xiphopenaeus kroyeri	Seabob shrimp	Camarão piticaia	6	0,032
ELASMOBRANCHII	———————	Stingray	Arraia	10	0,054
		Shark	Cação	1	0,009

Guiana dolphin recognition

When presented with the photographic board, only 30 (34%) interviewees correctly identified the Guiana dolphin as the one they find in their communities or fishing spots. However, 23 (26.1%) interviewees confused the target species with the common dolphin (*Delphinus delphis*) and 15 (17%), with the rough-toothed dolphin (*Steno bredanensis*).

The artisanal fishers were divided in determining the type of group to which the Guiana dolphin belongs. Thus, 43 (48.8%) interviewees reported that the Guiana dolphin belongs to fish group, mainly because it is an animal that lives in water. Another 42 (47.7%) fishers responded that it is a mammal, justifying this answer by the fact that the dolphin has some similarity to humans and because it is not an aggressive animal that can attack fishers, as we can see in the reports below:

"He's a fish. He's in the sea, right? He's just different from the others. He has to have a sigh on top so he can go up..." (60 years old – IGD)

"He's a fish because he lives in the water and what lives in the water is a fish." (81 years old – SLZ)

"A mammal because he has breasts, right? They say they suckle, the young ones." (54 years old – IGD)

"A mammal because, like, he's not an aggressive fish. He's not like a shark, he doesn't attack anyone." (38 years old – IGD)

"A mammal because it doesn't have gills like fish. They spend 5 to 10 minutes underwater and then come up to breathe" (70 years – RAP)

Interactions between artisanal fishers and Guiana dolphins

Most fishers reported that they were not bothered by the presence of dolphins during fishing activities (n= 50; 56.8%). Among those who mentioned positive interactions (n= 32; 36.4%), they highlighted that dolphins can help in locating the fish. In contrast, the fishers who reported a negative interaction (n= 6; 6.8%) justified that the dolphins feed on the fish caught in the fishing nets, generating competition for the fishing resource. The artisanal fishers also described their perceptions about the interactions with the dolphins, emphasizing that both groups depend on fishing for their subsistence. In addition, they reported that the dolphins help to keep away larger predators, such as sharks, dogfish and swordfish. Above all, a relationship of mutual respect was evidenced, in which the fishers recognize the effectiveness and versatility of the fishing strategies of Guiana dolphins (Table 3).

The Kruskal-Wallis test did not indicate any significance (p= 0.130; H= 8.5) when comparing the perception of fishers from different communities and the types of interactions (positive, negative or neutral). Fisher's exact test indicated no difference in fisher perceptions regarding the interference of dolphins in fishing activities (p= 0.217), considering the degree of interviewee experience. Furthermore, most of the interviewees (n= 73; 82.95%) indicated that Guiana dolphins do not interfere with their fishing.

The Venn diagram demonstrates the overlap between fish species caught by artisanal fishers and those that make up the Guiana dolphin diet. Among the 26 ethnospecies mentioned by the interviewees, six were also reported as Guiana dolphin prey, both by the interviewees and in literature reports, while four others were cited only by fishers. *Oligoplites* sp., *Cynoscion* sp. and *C. undecimalis* are local fishing targets and considered prey for Guiana dolphins. Furthermore, according to the literature, another 25 species are included in Guiana dolphin diet although the studies that identified these species were extended to other Brazilian regions, so some of them may not occur in our study area. Finally, *C. agassizii* and *A. anableps* were mentioned by fishers only as Guiana dolphin prey, but without any correspondence with the bibliographic references employed herein (Figure 3).

Incidental Guiana dolphin catches

Although most artisanal fishers reported no conflicts and mention that Guiana dolphins do not interfere with their fishing activities, 45.4% (n= 40) of those interviewed believe that this species can get caught in fishing gear, especially gillnets type "malhadeira" (n= 20; 22.7%) and "serreira" (n= 16; 18.1%) and net barriers type "zangaria" (n= 1; 1.1%). There were no reports of intentional Guiana dolphin captures dolphin, but some interviewees reported that the dolphins can die in these gears due to the difficulty in freeing themselves on their own.

Given this scenario, the fishers were asked about their actions when they come across a Guiana dolphin trapped in a net. If the animal is found alive, 52 (60.4%) interviewees said that they release the animal, while the others did not want to or did not know how to answer. However, if the animal is already dead, fishers reported the following actions: discard (n= 33; 37.5%), consumption (n= 12; 13.6%), release directly into the sea (n= 3; 3.4%), use as bait (n= 4; 4.5%) and most did not know or did not want to answer (n= 36; 40.9%).

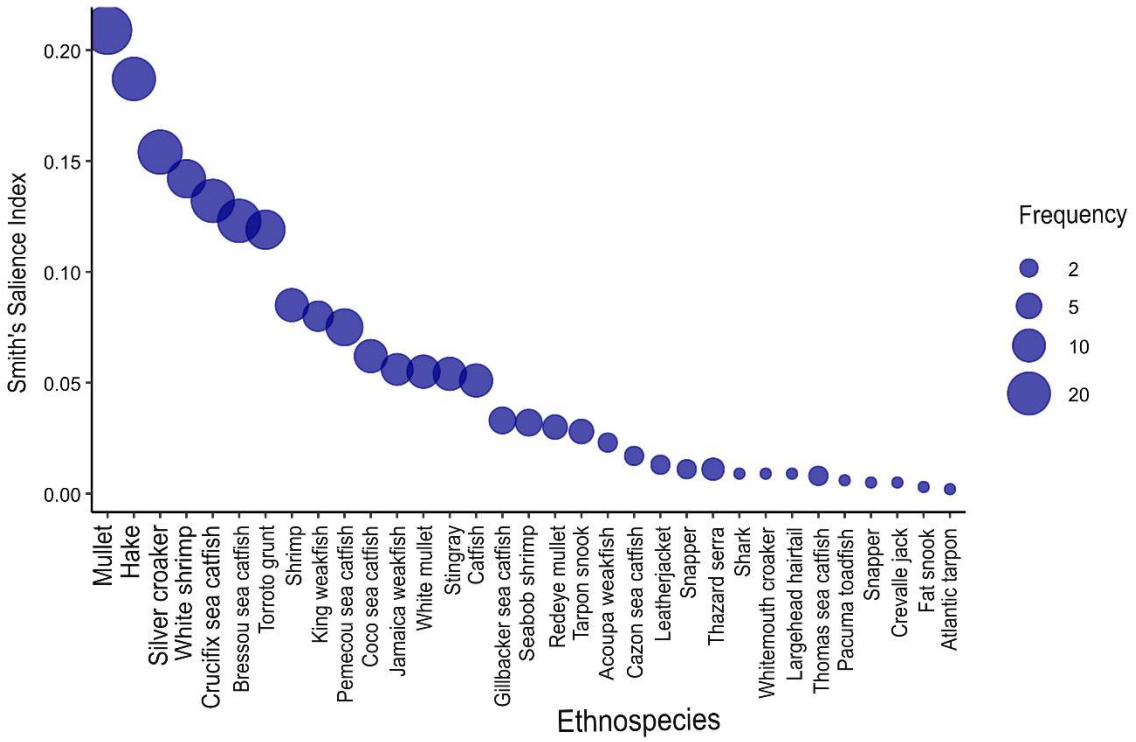

Figure 2. Fish ethnospecies important to the interviewees according to Smith's Salience Index.

DISCUSSION

Fisher and fishing characterization

Fishing activities on the coast of Maranhão, are mostly carried out in an artisanal manner, and are almost exclusively carried out by men. Women, in turn, have other jobs or dedicate themselves to domestic activities, collecting shellfish on sandbanks (croas) and, in some communities, are responsible for selling the resource caught by their husbands (Monteles et al. 2010; Vidigal et al. 2022).

Most of the interviewees in this research were between 43 and 57 years old. This may be related to the fact that older fishers do not yet recognize younger fishers as reference people in fishing activities, and thus do not recommend them to participate in interviews. Generally, younger fishers become recognized as good fishers when they start fishing alone, knowing how to properly use gear and bait according to the target species of the fisheries (Vidal et al. 2019a).

Most of the interviewees did not finish elementary school due to the need to start working as fishers while still in childhood. Due to the demanding routine of fishing, many claim that they are unable to study after working long hours. Similarly, Santos et al. (2011) identified a higher percentage of artisanal fishers with incomplete elementary education in the municipality of Raposa, in addition to associating low levels of education with fishers belonging to the older age group. There are no schools in many more isolated communities, or, when there are, many do not offer secondary education, thus requiring students, upon completing elementary school, to leave their communities to study in municipal headquarters or in hub communities (Vidal et al. 2019a).

Faced with the challenges and devaluation of fishing activities, many young people are not interested in this activity, thus leading to the progressive aging of artisanal fishers. This is a problem, since this is an activity that depends on the transmission of knowledge, fishing techniques, experiences and the location of fishing grounds, so that artisanal fishing can continue, without losing its essence and keeping local traditions alive (Berkes and Turner 2006; Musiello-Fernandes et al. 2021).

Artisanal fishing is characterized as an activity carried out on a small scale, with small vessels and low fishing time autonomy, due to their low capacity to move and store the collected fishery resources (Filgueira et al. 2021). In Maranhão, the tidal range can reach more than 6 m. Because of this, nautical activities (port activities, movement and fishing) are governed by the rise and fall of the tide (Vidigal et al. 2022).

About 300 fish species, grouped into 23 orders, are

Table 3. Reports from artisanal fishers regarding positive, negative and neutral relationships with Guiana dolphins on the coast of the state of Maranhão.

Type of association	Artisanal fisher reports
Neutral	"He doesn't get in the way. He doesn't help either because when it's fishing, when it's fishing, it's dry and no one can go there. Usually, there's very little mullet fishing here, but it's mostly nets out there..." (60 years old – IGD)
	"Everyone lives in their own place... We're on our side and they are there surviving... There's no dolphin fishing here." (64 years old – IGD)
Positive	"A fisher who is intelligent thinks like this: when we are in the sand banks and there are dolphins there, they say there are fish; where there are dolphins, big fish don't touch them, they say that the dolphin defends its territory; it doesn't do any harm, it doesn't influence the fishers in any way. We human beings are the ones who 'are in' the fish's habitat and sometimes the guy doesn't want to understand" (38 years old – IGT)
	"The dolphin doesn't get in the way. Wherever you see a dolphin, you don't see a ferocious/devouring animal nearby, it is a respected animal, it doesn't have a spur, nothing. Even the swordfish respect it" (57 years old – SLZ)
Negative	"We say that he gets in the way like this: he hits the fish, but it's his duty to catch them so he can eat them too; when we want to fish, we stay quiet to catch the others, right? They arrive quietly, when the fish arrive, they strike... whoever gets there first is the winner, right?" (49 years old – IGT)
	"Sometimes he drives the fish away because if there's a fish and he comes to eat, the fish moves away... one time we were fishing in the lower part of the river, when a dolphin came out, man... the fish came and swarmed the shore, running, leaving in fear of the dolphin..." (57 years old – IGT)

estimated as occurring in the estuarine waters of the northern Brazilian coast (Camargo and Isaac 2001), while an approximate richness of 303 species of bony fish has been estimated for the coast of Maranhão (Cardoso et al. 2018; Neta et al. 2011). According to a survey carried out by the Maranhão Institute of Socioeconomic and Cartographic Studies (IMESC), about 168 species of fish, distributed among freshwater, estuarine and marine ecosystems, exhibit some commercial importance (Guimarães et al. 2021). This diversity of fishing resources leads to the use of different fishing gear, allowing fishers to optimize fish catches, especially fish presenting the greatest economic importance (Moraes and Ferreira Darnet 2022; Silva et al. 2020).

Smith's Salience Index

A total of 33 ethnospecies were identified, but only three were considered salient, with an index above 0.15 and a frequency of occurrence of 10 to 20 reports. According to Guimarães et al. (2021), the ethnospecies considered the most important by the interviewees (mullet, hake, silver croaker, white shrimp, crucifix sea catfish, bressou sea catfish, and torroto grunt) are a fishing resource of moderate to great commercial importance on the coast of the state of Maranhão. Competition for food resources and space is the main cause of conflicts between species. However, even with apparent resource overlap noted herein, no conflicts between humans and Guiana dolphins were reported.

The attribution of importance and value to items through open list, reflects how much that item (fishery resource) is valued by each individual, whether for personal consumption or in the local market (Chaves et al. 2019). The ethnospecies mullet, hake, silver croaker, catfish, torroto grunt and shrimp are appreciated by many people in the region; therefore, the price of these resources stands out from the others.

The most valued ethnospecies by the local market is the acoupa weakfish (*C. acoupa)*, costing on average R$29.00/kg. However, the swim bladder of this species is as valued as its meat, costing up to R$237.00/kg. Torroto grunt (*G. luteus*) and tarpon snook (*C. pectinatus*) cost on average R$16.00/kg, silver croaker (*P. squamosissimus*) costs R$14.00/kg and mullet, R$13.00/kg, while bressou sea catfish (*A. quadriscutis*) costs R$7.00/kg. Thus, the more eth-

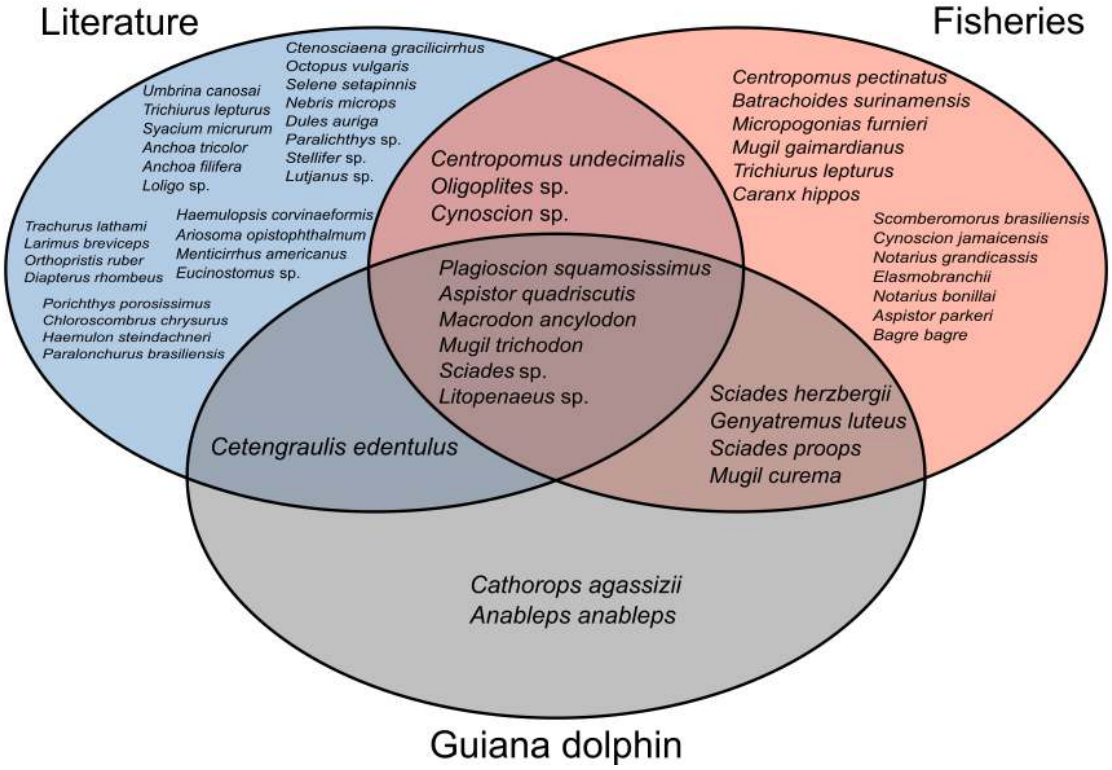

Figure 3. Venn diagram with the species of fish caught by artisanal fishermen and those preyed upon by gray dolphins according to interviewees and scientific literature.

nospecies that fishers capture that are most valued by the local market, the higher their income will be on each fishing trip (Filgueira et al. 2022). However, excessive search for fishing resources can overload local fish stocks, reducing species abundance of species and indirectly impacting the food resource of Guiana dolphins.

Guiana dolphin recognition

When identifying dolphin species using an photographic board, most of the interviewees did not point to the Guiana dolphin image. Some interviewees attributed the name Guiana dolphin to other small cetaceans (*D. delphis, S. bredanensis* and *T. truncatus*). The Guiana dolphin occurs in estuarine and river environments, while *S. bredanensis* (known locally as toninha) occurs in waters further from the coast and has the habit of following fishing boats. In addition, the interviewees described the physical characteristics of this species, reporting a darker coloration and a larger physical size than the Guiana dolphin. The perception of artisanal fishers on the coast of Maranhão regarding the existence of other species of cetaceans was recorded in the research by Filgueira et al. (2021), with fishers living in Farol de Santana, who carry out their fishing activities in a marine environment, did not recognize the Guiana dolphins, but rather the bottlenose dolphin (*T. truncatus*). Manzan and Lopes (2015) observed something similar with fishers from Rio Grande do Norte, who pointed out *T. truncatus*, due to morphological similarities with Guiana dolphins, since some characters are difficult to distinguish through photos.

The Guiana dolphin is a discreet species, rarely coming to the surface to breathe and most of its visible behaviors are related to feeding (Azevedo et al. 2009). Furthermore, the color of the water, for most of the year, is brown in several places along the coast of Maranhão, due to the influence of large rivers, inputting high amounts of suspended sediments, making it even more difficult to observe this species in its natural environment (Filgueira et al. 2021).

Guiana dolphin ethnotaxonomy

The interviewees demonstrated some degree of difficulty in answering which group the Guiana dolphin belongs to. The fishers who identified this species as a type of fish have this conviction based on the premise that everything that lives in the water is a fish. This finding had already been reported by Souza and Begossi (2007) in São Sebastião and Oliveira et al. (2008) in *caiçara* communities. Hunn (1982) sug-

gests that the definition of the category "fish" is not based on morphological similarities with other forms of life but is determined by the habitat in which they live. On the other hand, the interviewees who identified the dolphin as a mammal indicated morphological characteristics, such as the presence of genitalia and mammary glands, similar to those of human beings.

Furthermore, the fishers attributed human qualities to Guiana dolphins (courage, docility, intelligence), as well as the performance of playful behaviors and a feeling of protection on the part of fishers in shipwreck situations. Similarly, the *caiçaras* of Cananéia attributed intelligence to the Guiana dolphin, considering its ability to see fishing nets and the care shown with the carcass of an individual of the same species (Oliveira et al. 2008). Zappes et al. (2016a), when researching the franciscana dolphin (*Pontoporia blainvillei*) in the state of Paraná, Brazil, reported that the species was seen as "calm" and "indifferent". Finally, the attribution of these human qualities to cetaceans by fishers can reduce possible conflicts between humans and wildlife (Zappes et al. 2020).

Interactions between artisanal fishers and Guiana dolphins

Several reports of positive and negative interactions between humans and cetaceans, especially Guiana dolphins, are available along the Brazilian coast (Seminara et al. 2019; Silva et al. 2024). However, most reports are positive, with artisanal fishers benefitting from a partnership with the dolphins. Cooperative fishing between Lahille's dolphin *Tursiops gephyreus*, at Barra de Tramandaí, and artisanal fishers who join forces to fish for mullet using cast nets is well known (Silva et al. 2021). Some of these local dolphins have improved their fishing strategy, directing schools of mullet from deeper areas to the coast, where fishers wait for the signal to cast their fishing nets. After the signal, the fishers cast the nets and the escaping fish are captured by the dolphins (Valle-Pereira et al. 2022).

Other strategies are based on the use of fishing nets, corrals and other anthropogenic structures such as barriers, driving fish into these traps and feeding on those that try to escape (Louzada 2013; Simões-Lopes et al. 1998). Relationships of this nature are defined as non-cooperative mutualism between humans and wildlife, because the structures facilitate the capture of prey by dolphins and increase the number of fish in the nets of artisanal fishers (Cram et al. 2022).

However, negative interactions are observed when dolphins capture fish directly from fishing gear, especially gillnets, causing fisher losses, which increases conflicts and exposes cetaceans to retaliation. Damage caused to fish caught in fishing nets can result in fish devaluation of the fish, affecting fish marketing (Read 2008). Furthermore, by damaging fishing nets, dolphins cause economic losses to fishers, since these nets need to be repaired or replaced (Vidal et al. 2019b). In some regions of the Amazon, dolphins belonging to the Inia genus are injured or even killed to prevent them from preying on commercially valuable fish species and/or damaging fishing gear (Alves et al. 2012; Loch et al. 2009; Vidal et al. 2017). Under this perspective, Alves et al. (2012), observed that artisanal fishers in the Central Amazon believe that protecting dolphins is not important, justifying their responses by the financial losses caused to their fishing nets and the large population, with some fishers suggesting the extermination or control of the dolphin population.

No significant differences in the interviewees' perceptions regarding the type of interaction with the dolphins were observed, even when dealing with communities inside and outside the investigated Extractive Reserve. Thus, a pattern was observed, with relationships between artisanal fishers and Guiana dolphins being defined as neutral or positive. Furthermore, most interviewees reported that Guiana dolphins do not interfere with fishing, despite sharing the same environment and food resources. Hallwass et al. (2024), in a study in the Brazilian state of Pará, concluded that, despite the economic losses arising from negative interactions with the dolphins, artisanal fishers recognized the collective benefits arising from the conservation of these animals, which act as umbrella species, ensuring the healthy maintenance of fish stocks.

Artisanal fishers identified 13 fish ethnospecies preyed on by Guiana dolphins; of these, 10 are also caught by artisanal fishers. The use of the same food resource and the same fishing areas can contribute to conflicts between humans and wildlife (Tixier et al. 2021). However, conflicts are reduced when the environment presents abundance and a high diversity of resources (Cram et al. 2022). Thus, despite the overlap of ethnospecies considered important, such as mullet and bressou sea catfish, fishers did not report aggression or retaliation against Guiana dolphins. However, Silva et al. (2024) cataloged 36 publications related to interactions between cetaceans and fishers on the Brazilian coast, and the types of interactions that involved competition for resources almost always had a negative consequence for cetaceans.

Incidental Guiana dolphin captures

Accidental captures in fishing nets represent one of the greatest threats to cetaceans, especially those that most frequently use the coastal region (Borobia et al. 1991). According to the interviewees, the most dangerous types of nets for Guiana dolphins on the

coast of Maranhão are gillnets ("malhadeira" and "serreira"). Gillnet type "malhadeira" are dangerous because the dolphin cannot see them and, when they touch it, it quickly becomes entangled; while gillnet type "serreira" has the characteristic of floating close to the surface, so that the dolphin cannot escape easily. Pinheiro and Cremer (2003) observed that gillnets (mesh sizes of 17 to 27 cm) aimed at hake and croaker in Babitonga Bay, Santa Catarina, can cause death by drowning in cetaceans. Similarly, fishers from Babitonga attributed a greater risk of fatal accidents for dolphins to nets with larger meshes and more resistant nylon threads, characteristics of the nets mentioned by the fishermen.

Incidental catches in Brazil are routinely reported for other cetacean species, such as the Amazon River dolphin (*Inia geoffrensis*) (Vidal et al. 2017); tucuxi dolphins (*Sotalia fluviatilis*) (Marmontel et al. 2021); the franciscana (*P. blainvillei*) (Secchi et al. 2021); the bottlenose dolphin (*T. truncatus*) (Zappes et al. 2016b); the humpback whale (*Megaptera novaeangliae*) (Meirelles et al. 2009); and the southern right whale (*Eubalaena australis*) (Zappes et al. 2013b). Anthropogenic impacts, especially incidental captures, are even more dangerous when they affect endemic species or species with small and isolated populations, such as the franciscana, a species classified as Vulnerable at the international level (Ceballos and Ehrlich 2002; Zerbini et al. 2017).

It is important to recognize the actions of fishers when they come across a Guiana dolphin trapped in their fishing nets, whether alive or dead. Most of the interviewees reported that they would release the dolphin if they found it trapped in a fishing net. This gesture shows that the fishers understand the importance of this animal for the environment, and that there is no effort to capture this species. Similarly, fishers from Novo Airão reported that there is no targeted fishing for river dolphins, although they understand that this practice exists in other parts of the Amazon (Vidal et al. 2017).

On the other hand, if Guiana dolphins are found dead in fishing nets, the interviewees reported that they discard it, consume it, or use the meat as bait. Barbosa-Filho et al. (2018) reported that fishers from southern Bahia use Guiana dolphin meat as bait for elasmobranchs and consume part of the meat. The use of other parts of aquatic mammals is an ancient practice in the culture of some communities, with mystical accounts attributing healing powers to the oil extracted from the blubber and protection through other cetacean parts, such as teeth and eyes (Siciliano et al. 2018). These illegal practices pose a serious threat to groups at the top of the trophic chain, which perform ecosystem services essential to the balance of the environments they inhabit (Machado et al. 2019).

CONCLUSION

The Local Ecological Knowledge (LEK) of artisanal fishers on the coast of Maranhão reveals the main interactions between fishing communities and Guiana dolphins. This LEK provided us with a valuable perspective on the ecology and behavior of Guiana dolphins through the eyes of artisanal fishers. Furthermore, the reports of the interviewees were in line with consolidated research on the species in different environments on the Brazilian coast. This integration between scientific knowledge and traditional knowledge is essential for the development of effective conservation strategies, which consider not only species ecology, but also local practices and perceptions, favoring participatory management of certain areas, especially Conservation Units.

The analysis of interactions between fishers and Guiana dolphins indicate that, despite overlapping food resources, most fishers maintain a neutral or positive relationship with the dolphins, recognizing that they can help locate fish. Promoting environmental education and raising awareness about the importance of Guiana dolphins is paramount to strengthen peaceful coexistence and reduce the perception of competition between humans and wildlife. Furthermore, the benefits arising from positive relationships with cetaceans are favorable to both groups, since communities can use their traditional knowledge concerning ecology and species distribution in tourism initiatives, promoting activities for observing cetaceans from boats or strategic points on dry land, thus contributing to the conservation of these aquatic mammals and to generating income.

To avoid or mitigate conflicts, strategies that promote harmonious coexistence are essential, such as implementing sustainable fishing practices and reducing the environmental impact of human activities. Cooperation between scientists, natural resource managers and fishing communities is crucial to achieve a balance that benefits both dolphins and fishers, ensuring the preservation of marine biodiversity and the continuation of traditional fishing practices sustainabley.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea: CHMSF.
Carried out the experiment: CHMSF.
Carried out the data analysis: CHMSF.
Wrote the first draft of the manuscript: CHMSF, MDV, SS.
Review and final write of the manuscript: CHMSF, MDV, RAHD, SS.
Supervision: MDV, SS.

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