



Traditional knowledge identifies causes of bycatch on bottlenose dolphins (*Tursiops truncatus* Montagu 1821): An ethnobiological approach



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ABSTRACT

Studies have documented the importance of understanding the traditional knowledge of artisanal fishermen regarding fishery-cetacean interactions. In this paper, we identified the effects of artisanal fisheries on bottlenose dolphins (*Tursiops truncatus*) in southern Brazil (~30°S – 32°S) and searched for alternatives to decrease the possible negative effects based on fishermen's knowledge. In November and December 2009, 44 interviews were conducted with fishermen who worked in the Barra de Imbé/Tramandaí (n = 22) and in the southern part of the Lagoa dos Patos in Rio Grande (n = 22). There is an overlap between bottlenose dolphin distribution and fishery activities, which could cause an increase in bycatch frequency. According to local fishermen, more rigorous laws must be enacted to prevent entanglement. The employment of acoustic alarms in gillnets to reduce the frequency of bycatch is not well accepted because there is a widespread fear of causing a decrease in fishing efficiency.

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1. Introduction

Interactions between artisanal fisheries and cetaceans have been reported worldwide and may be characterized as both positive (Pryor et al., 1990; Zappes et al., 2011a; D'Lima et al., 2013) and negative (Jefferson et al., 1993; Bordino et al., 2002; Prajith et al., 2014). The negative interactions of cetaceans and fishing activities involves collisions with fishing boats (Laist et al., 2001; Van Waerebeek et al., 2007; Neilson et al., 2012); use of dolphins carcasses as bait during fishery activities (Da Silva and Best, 1996; Da Silva et al., 2011; Alves et al., 2012); and bycatch by fishing gear (Au and Jones, 1991; Barlow and Cameron, 2003; Read et al., 2006).

The main interaction with fishing refers to mortality due to accidental involvement with gillnets (Bertozzi and Zerbini, 2002; Bearzi et al., 2011). This interaction can affect the size of populations of whales and dolphins and interfere in the maintenance of the species (Secchi et al., 2004; Natoli et al., 2008). Interactions with dolphins are more common because some species of delphinids have coastal habits and gillnets are placed next to the coast (Di Beneditto, 2003).

1.1. Interactions between bottlenose dolphins and artisanal fisheries

The bottlenose dolphin, *Tursiops truncatus* Montagu 1821 (Cetacea, Delphinidae) has a wide distribution, ranging from tropical to temperate oceans worldwide (Wells and Scott, 1999; Connor et al., 2000). The species presents coastal and oceanic ecotypes, with coastal individuals sighted in smaller groups formed of females with offspring, juveniles of both sexes, and isolated

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subgroups of males. Pelagic groups tend to have larger group sizes and more heterogeneous populations (Wells and Scott, 1999).

Conflicts between artisanal fishing and bottlenose dolphins have also been described in various parts of world, and involves injure to dolphins, as they can be injured or killed; and to fishermen, who may lose artifacts or fishing effort in coast of Florida in North America (Zollet and Read, 2006), the Uruguay (Praderi, 1985; Franco-Trecu et al., 2009), the Mediterranean Sea (Bearzi et al., 2011), Asinara Island National Park, Sardinia (Lauriano et al., 2004; Díaz López and Shirai, 2007), South Australia (Kemper et al., 2005), the Balearic Islands (Brotons et al., 2008), and the east coast of South Africa (Natoli et al., 2008). Despite these conflicts, positive interactions too are described, as the human-dolphin cooperative fisheries, where dolphins drive schools of fishes from deeper waters against the coastline, in this moment fishermen place gill nets or cast net in direction of fish and the dolphins feed at same time. These interactions occur between bottlenose dolphin and nomads named Imragen in Mauritana, Africa (Busnel, 1973), aboriginal Australians, eastern Australia (Neil, 2002) and fishermen in Myanmar (Smith et al., 2009) and Chilica Lagoon, India (D'Lima et al., 2013).

Investigations into the interactions between small cetaceans and artisanal fisheries in Brazil began in the 1990s (Lodi and Capistrano, 1990; Simões-Lopes, 1991; Pinedo, 1994; Siciliano, 1994; Monteiro-Filho, 1995; Simões-Lopes et al., 1998), and have shown that dolphins and artisanal fishermen share the same physical space. On the coast of the state of Rio Grande do Sul in southern Brazil (~30°S – 32°S), fishermen share their fishing grounds with small cetaceans, such as bottlenose dolphins. Positive interactions involving this species and human fishing activities — such as rounding up schools of fish and indicating their positions to the fishermen — has been described by Pryor et al. (1990), Simões-Lopes (1991), Simões-Lopes et al. (1998) and Zappes et al. (2011a) in the northern coast of Rio Grande do Sul (29°58'S, 50°07'W), by Simões-Lopes et al. (1998) in the state of Santa Catarina (28°29'S, 48°45'W), and by Przybylski and Monteiro-Filho (2001) in the state of Paraná (25°12'S, 38°45'W). However, interactions involving conflict, such as the accidental capture of bottlenose dolphins in fishing equipment, collision with boats and harpooning, are reported along the entire Brazilian coastline (Siciliano, 1994; Zerbini and Kotas, 1998; Di Benedetto, 2003; Freitas Netto and Di Benedetto, 2008; Zappes et al., 2011b, 2013a; Fruet et al., 2010).

1.2. Local laws to protect cetaceans

In Brazil, the direct catch, bycatch and molestation of cetaceans is prohibited within 200 nautical miles from shore (Federal Law n° 7.643/87). Since 1997, major changes have occurred in an effort toward improving the conservation of cetaceans in the country, including the development of the Centro Nacional de Pesquisa e Conservação de Manejo de Mamíferos Aquáticos (National Research Center for the Conservation and Management of Aquatic Mammals) (CMA/IBAMA – Portaria IBAMA n° 143-N/98), the Rede de Ecalhes de Mamíferos Aquáticos do Nordeste (Net of Strandings of Aquatic Mammals of Northeast) (REMANE – Portaria IBAMA n° 39/2000) and the implementation of regulations for the captivity of marine mammals (Portaria MMA n°98/2000). In this context, it is important to discuss the current interactions between cetaceans and fishery activities in Brazil.

1.3. The importance of ethnobiological studies

Ethnobiological studies involving the traditional knowledge of communities are embedded in the area of ethnology and are related to the various cultural manifestations and spiritual

development of man in different societies (MacNeill, 1990). Ethnology was constructed through ethnography, in which writing enabled the publication of information by different people (Hammersley and Atkinson, 2007). Ethnographic research is related to the observed fact and analysis of human groups considered in its particularity, where the researcher reconstructs the life of each community and try to understand the social rules and cultural patterns and not only describe the daily life of a group (Mauss, 1967; Malinowski, 1978). In this sense, ethnobiological studies of fishing communities are important because the daily contact that these communities maintain with cetaceans represents an opportunity to monitor fishing activities while evaluating their impact on these populations. The need for the participation of local fishermen in the management of coastal fauna along the Brazilian Atlantic Ocean has been identified and recommended by several authors (Paz and Begossi, 1996; Begossi et al., 2002; Souza and Begossi, 2007; Zappes et al., 2013a, 2013b). Unfortunately, the public policy in the country disregards the importance of traditional knowledge during the preparation of strategies and rules for the management and conservation although researchers have suggested the use of this knowledge.

The bottlenose dolphin is the only dolphin species present in the Barra de Imbé/Tramandaí and the Lagoa dos Patos (southern Brazil), permitting easy recognition by fishermen in these areas. Studies to date on the traditional knowledge of artisanal fishermen with respect to bottlenose dolphins are limited and have not represented in-depth investigations into the issues concerning the conservation of this species (Simões-Lopes et al., 1998; Peterson et al., 2008; Zappes et al., 2011a). The objectives of the present study are therefore as follows: 1) to identify the potential effects of artisanal fisheries on the local status and conservation of bottlenose dolphins based on traditional knowledge; 2) to suggest alternatives to decrease the bycatch based on traditional knowledge. The following fundamental question was addressed:

Based on traditional knowledge, is it possible to identify the potential causes of capture accidental caused by artisanal fisheries on dolphin populations and suggest management alternatives?

2. Materials and methods

2.1. Study area

The estuary-lagoon complex of Tramandaí is located north of the state of Rio Grande do Sul (29°57'S, 050°11'W); it receives freshwater from the Tramandaí River and the Camarão Canal and is connected to the Atlantic Ocean by the Barra de Imbé/Tramandaí estuary (Fig. 1). Bottlenose dolphins are present in the Barra de Imbé/Tramandaí estuary and are mainly distributed at the mouth of the estuary. A small population of nine individuals has been estimated for the area (Simões-Lopes et al., 1998; Giacomo and Ott, 2010). The mullet fishery (*Mugil* sp.) that uses cast nets is an important local activity, and interactions between these artisanal fisheries and bottlenose dolphins have been recorded (Simões-Lopes et al., 1998). A total of 583 artisanal fishermen are registered with the Tramandaí Fishermen's Union, of which 40 use cast nets and other types of fishing gear, such as gillnets. Normally, fishermen and their family process and sell their own captured fish directly to consumers (Cotrim, 2008).

The Lagoa dos Patos (32°09'S, 52°05'W; Fig. 2) is located 320 km south of the Barra de Imbé/Tramandaí. In this area, the estuary is connected to the Atlantic Ocean by a narrow canal (0.5–3 km in width) formed by two rock breakwaters that extend approximately 4 km into the ocean (Vooren et al., 2005). Bottlenose dolphins are distributed in this canal and in the adjacent coastal areas throughout the year (Mattos et al., 2007; Di Tullio, 2009), with an

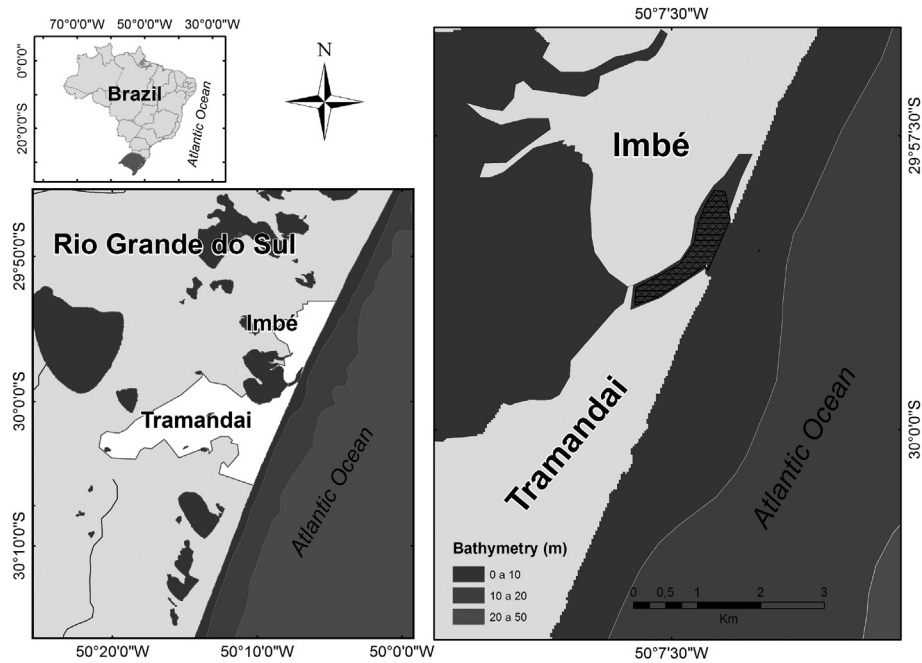


Fig. 1. Study area in the Barra de Imbé/Tramandaí, Rio Grande do Sul State, southern Brazil. Inset: shaded area – Barra de Imbé/Tramandaí; area where cast net fishing is practiced and frequently visited by dolphins.

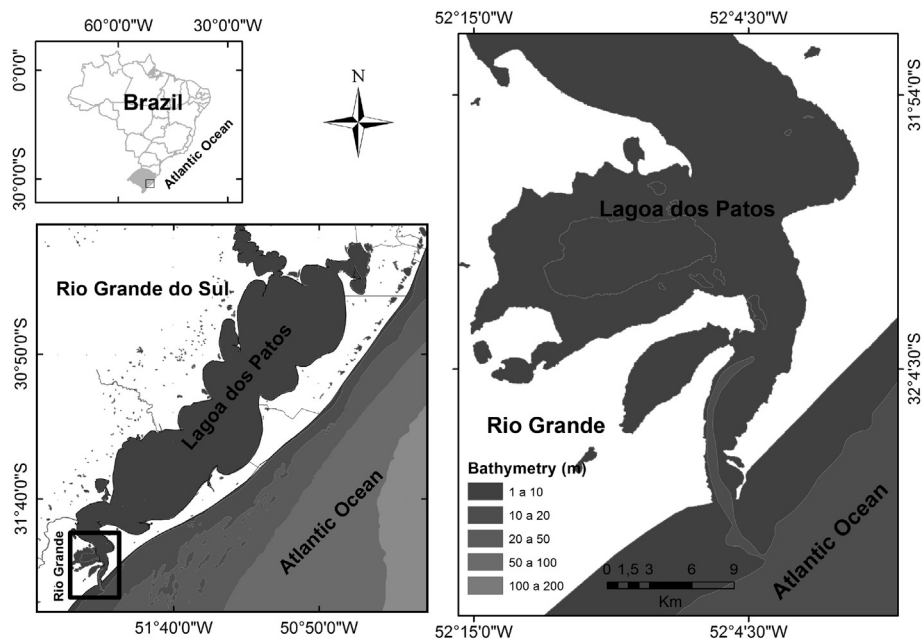


Fig. 2. Study area located in the southern portion of the Lagoa dos Patos, in Rio Grande, Rio Grande do Sul State, southern Brazil.

estimated population of 89 individuals (Dalla-Rosa, 1999). The Fishermen's Colony of Rio Grande (Z-01) registers 285 artisanal fishermen, but only 80 work in the southern region of the Lagoa dos Patos. Fishermen operate longlines, traps, trawls, gillnets, cast nets, and beach seines (Garcez and Sánchez Botero, 2005; Vooren et al., 2005).

2.2. Data collection

Data were collected during November and December 2009 in 44 ethnographic interviews with artisanal fishermen from the two

locations. Twenty-two fishermen of the Tramandaí Fishermen's Union were interviewed (55% of the working fishermen in the area), and the same number from the Fishermen's Colony of Rio Grande (Z-01) (representing 27.5% of the working fishermen in the area). All fishermen interviewed conduct their activities in waters inhabited by bottlenose dolphins.

The number of fishermen interviewed was determined based on two considerations: 1) fishing vessels are operated by two to four fishermen, and each of these men may work on more than one craft and 2) after the tenth interview the same pattern of responses was observed among those interviewed. The qualitative approach, in

which reports are obtained from local members, was shown to be appropriate for studies related to cultural perception because although it does not quantify, it still allows the approach between subject and object. In these studies, if the sample is too large, new data do not introduce new information related to the objectives of the research, which can become repetitive (Mason, 2010). In this research, the frequencies are rarely important because these studies are concerned with meaning and not with generalized hypothesis statements (Crouch and McKenzie, 2006).

In studies related to ethno-science, an ideal sample size between 30 and 60 interviews has been recommended (Morse, 1994; Bernard, 2000). As in this study, other ethnobiological studies on the traditional knowledge of fishermen regarding marine mammals in southeastern and southern Brazil also used sampling rates equivalent to less than 50% of the fishermen registered in local fishing institutions (Table 1). Based on these studies of similar communities, our sample size of 44 respondents is sufficient for obtaining ethnobiological information.

Interviews were conducted with standard pre-written questionnaires containing semi-structured open and limited-response questions (Costa-Neto and Oliveira, 2000). The questionnaire was composed of questions divided into the following categories: (1) characteristics of the populations of *T. truncatus* that occur in each area (size, color, areas of sighting); (2) effects of the artisanal fishery on bottlenose dolphins – incidents in which dolphins got entangled in fishing nets, causes and locations of entanglement and suggestions of alternatives to prevent bycatch (Box 1). Questions initially dealt with adult animals before covering information about calves (newborns). This methodology allowed the fishermen to clearly describe each age group they have encountered. Some questions elicited closed responses which were followed by open justifications or explanations so that interviewees could express their reasoning. After the use of questionnaires, fishermen created a drawing (Barra de Imbê/Tramandaí $n = 16$; Lagoa dos Patos $n = 13$) where they indicated the specific location of entanglement in the Barra de Imbê/Tramandaí and Lagoa dos Patos. Some interviewees did not want to indicate the area of bycatch because could reveal the fishing area. All interviews were conducted by means of dialog, and the terms employed in the questionnaires maintained the regular vocabulary used by fishermen and were based on a study published by Zappes et al. (2009). The interviewer (C. A. Zappes) introduced herself as a member of a teaching institution to avoid associations with environmental regulatory agencies or authorities.

Box 1

Topics of the issues of the semi-structured questionnaire.

1. Characteristics of *Tursiops truncatus*

Size

Color

Areas of sighting

2. Effects of artisanal fisheries on bottlenose dolphins

Occurrence of bycatch

Causes of bycatch

Local of bycatch

Suggestions of alternatives to prevent the bycatch

Three methods for selecting interviewees were employed as follows: i) indicated by the community leader (Sanches, 2004), ii) a snowball method in which new candidates were suggested by those already interviewed (Bailey, 1982), and iii) aleatory encounters. The first fisherman to be interviewed was chosen by their

Table 1

Ethnobiological studies and sampling rates in southeastern and southern Brazil.

Reference	Sampling rates	Local
Souza and Begossi (2007)	average of five respondents in each community	São Sebastião, São Paulo State
Peterson et al. (2008)	51 respondents	Laguna, Santa Catarina State
Zappes et al. (2011a)	22 respondents	Barra de Imbê/Tramandaí, Rio Grande do Sul State
Alves et al. (2012)	16 respondents	Central Amazon
Zappes et al. (2013a)	between 16 and 44 respondents	Central Amazon and along the Brazilian coast
Zappes et al. (2013b)	33 respondents	Southern Right Whale Environmental Preservation Area (EPA), Santa Catarina State

community leader, as the community leader has intimate knowledge of community members (Sanches, 2004). This leader indicated only the first respondent to avoid a direction in the choice of local actors that could participate in the research. The snowball method was employed from the first interview onward, where after each interview the interviewee was asked to indicate other fishermen who could participate in the study; the process was repeated with new respondents to form a network (Biernacki and Waldorf, 1981; Bailey, 1982; Patton, 1990). The indications of new members allowed the addition of varied insertion points (Goodman, 1961). Each interviewee was a new insertion point that allowed the construction and understanding of this network of relationships. By utilizing the knowledge of the community leader and social networks of the local community, the researcher's ability to identify fishermen was enhanced because a local person can provide better information about the community than someone who is an outsider. To minimize the possible selection of respondents (induction reports), the snowball method was sometimes interrupted, and the selection of the next fishermen to be interviewed occurred randomly.

2.3. Data analysis

To select fishermen with knowledge of bottlenose dolphins, the characteristics of the species data (size, color, areas of sighting) were analyzed. Fishermen whose responses included body lengths between 1.5 and 4 m, dorsum coloration ranging from gray to dark blue to black, white abdomen coloration, and distribution areas including coasts (marine areas adjacent to the Barra de Imbê/Tramandaí and the Lagoa dos Patos), bars, breakwaters, and inner area of the Lagoa dos Patos were selected based on the known information for the species in the area (Jefferson et al., 1993; Castello and Pinedo, 1977; Simões-Lopes, 1991; Flores and Fontoura, 2006; Fruet et al., 2010).

3. Results

All 44 interviewees recognized the dolphins at the Barra de Imbê/Tramandaí and the Lagoa dos Patos as bottlenose dolphins and were able to identify and distinguish calves and adults. Adult individuals were identified by descriptions of coloration and body size, whereas calves were identified by the description of body size and behavior, such as following adult individuals. Fishermen were not able to differentiate juveniles from the other two categories.

3.1. Bycatch

When 44 fishermen were asked about the occurrence of bycatch of bottlenose dolphins, most of interviewees affirmed its occurrence: Barra de Imbé/Tramandaí ($n = 16$; 72.7%) and Lagoa dos Patos ($n = 13$; 59.1%) and did not identify the incidental capture as negative. In the Barra de Imbé/Tramandaí, 6 (27.3%) fishermen did not describe bycatch and in the Lagoa dos Patos, 9 (40.9%). From here, the number of respondents and the percentages are based on fishermen that described the bycatch to each area.

According to these fishermen there is no competition between themselves and dolphins. Six causes for accidental capture of bottlenose dolphins were cited by 15 fishermen in the Barra de Imbé/Tramandaí (93.7%) and by 12 fishermen in the Lagoa dos Patos (92.3%), as follows 'Many nets, disorientation', 'Unable to see net', 'Attempt to steal fish from net', 'Dolphin carelessness', 'Scared by net', 'Chasing fish' (Fig. 3). Two fishermen did not know to identify the causes of bycatch: Barra de Imbé/Tramandaí ($n = 1$; 6.2%) and Lagoa dos Patos ($n = 1$; 7.6%). Fishermen blamed the dolphins for five of these six causes.

Coastal marine waters that were 1–3 km from shore were cited by all fishermen ($n = 16$) at the Barra de Imbé/Tramandaí who reported the accidental capture of bottlenose dolphins and by 46.2% ($n = 6$) of fishermen working within the southern areas of the Lagoa dos Patos, supporting mostly coastal interactions. Some interviewees of Lagoa dos Patos ($n = 7$; 53.8%) did not want to indicate the area of bycatch because could reveal the fishing area whose location is considered a secret in community. Fishermen indicated specific areas of accidental capture by drawings the areas (Figs. 4 and 5).

3.2. Mitigation of bycatch

When questioned about suggestions to prevent the accidental capture of dolphins in nets, fifteen (93.7%) fishermen from the Barra de Imbé/Tramandaí that described the bycatch and 10 fishermen of Lagoa dos Patos (77%) suggested a more rigorous enforcement of existing laws as a solution to the problem. Those interviewed were asked to comment specifically on the possible employment of acoustic alarms in gillnets. All interviewees maintained that because of the costs incurred and a fear that emitted sounds would interfere with the ability to capture fish, the use of alarms in nets would be highly impractical for these artisanal fisheries. Fishermen clearly expressed concern about the suggested alternative because

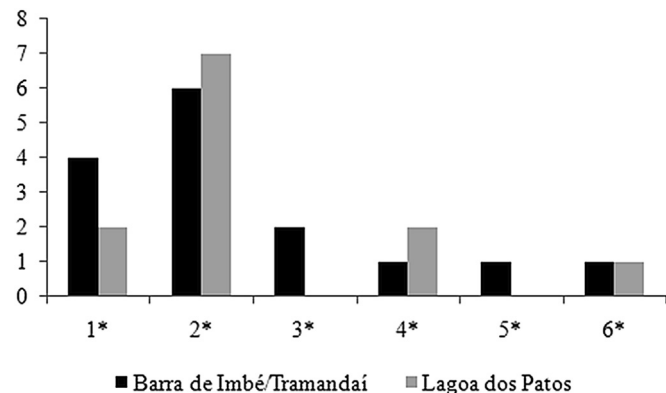


Fig. 3. Causes of bycatch of bottlenose dolphins, *Tursiops truncatus*, by gillnets and seines according to the traditional knowledge of the Barra de Imbé/Tramandaí and Lagoa dos Patos fishermen. Legend: 1* – 'Many nets, disorientation'; 2* – 'Unable to see net'; 3* – 'Attempt to steal fish from net'; 4* – 'Dolphin carelessness'; 5* – 'Scared by net'; 6* – 'Chasing fish'.

they believe that the method would reduce the efficiency of their fishery.

4. Discussion

In Brazil, studies related to the perception of artisanal fishermen demonstrate the existence of traditional knowledge regarding bottlenose dolphins (Souza and Begossi, 2007; Simões-Lopes et al., 1998; Peterson et al., 2008; Zappes et al., 2011a, 2011b, 2014). The daily practice of artisanal fishery allows the elaboration of this knowledge about the encountered species. The regular contact of fishermen with bottlenose dolphins allows individual recognition of *T. truncatus*. In southern Brazil, the observation of marks or scars on dolphins can allow for individual identification (Simões-Lopes, 1991; Zappes et al., 2011a). In certain situations, each dolphin may receive a name given by fishermen (Zappes et al., 2011a). This indicates a degree of detail during the elaboration of traditional knowledge about dolphins.

4.1. Bycatch

Accidental capture of dolphins is cited worldwide and generally is caused by nets of artisanal and industrial fisheries. Studies described this kind of accident to various species, but mainly to bottlenose dolphin, there are reports in different areas as, Galician waters, Spain (López et al., 2003); Sardinia in Mediterranean Sea, Italy (Lauriano et al., 2004; Díaz López and Shirai, 2007; Bearzi et al., 2008); Biscay Bay and English Channel, United Kingdom (Morizur et al., 1999); Mauritania, North Africa (Zeeberg et al., 2006); coast of South Africa (Natoli et al., 2008); Southern North Carolina, South Carolina, Florida, United State of America (Palka and Rossman, 2001; Burdett and McFee, 2004; McFee et al., 2006; Wells et al., 2008); Cabo Polonio, Punta del Diablo and La Paloma, Uruguay (Laporta, 2009); coast of Peru (Van Waerebeek et al., 1990; Mangel et al., 2010) and coast of New Zealand (Fertl and Leatherwood, 1997).

Along the Brazilian coast the bycatch of bottlenose dolphins in gillnets has been identified by fishery communities (Simões-Lopes, 1991; Peterson et al., 2008; Zappes et al., 2011b; Lodi et al., 2013). In the Barra de Imbé/Tramandaí and Lagoa dos Patos, these nets are positioned outside the estuary near the coast and tend to capture bottlenose dolphins. Along other parts of the Brazilian coastline, this type of net has been identified to be highly responsible for the accidental capture of small coastal and oceanic cetaceans (Siciliano, 1994; Zerbini and Kotas, 1998; Bertozzi and Zerbini, 2002; Rosas et al., 2002; Di Benedetto, 2003; Secchi et al., 2004; Danilewicz et al., 2010; Marigo and Giffoni, 2010).

Accidental capture affects fisheries because there is the economic loss of the artifact, the fishing efforts of the entire crew, the resources invested in fuel for the fishing boat and food for the crew while at sea (Zappes et al., 2013b). The traditional knowledge related to the causes of bottlenose dolphin entanglement in fishery equipment indicates a need for educational programs to raise awareness in the fishing communities. Because understanding the traditional knowledge was possible identified that artisanal fishermen did not identify the incidental capture as a negative interaction on bottlenose dolphin. In this sense, these programs can help these communities with technical support to find solutions for bycatch and change structures of equipments in order to decrease entanglement. In this regard, there is need of intervention on the part of researchers and non-governmental organizations that can interfere in order to decrease the entanglement through of partnership with stakeholders and government. First, when fishermen understand that they—and not the dolphins—bear the responsibility for accidental capture, the implementation of effective measures for the conservation of these two dolphin populations

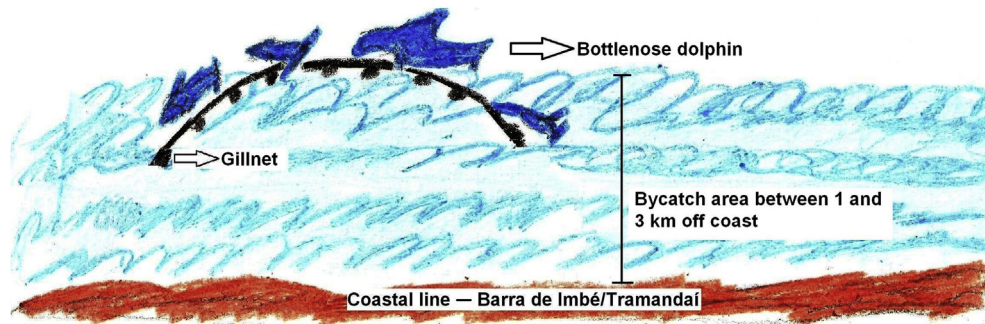


Fig. 4. Areas of accidental capture (between 1 and 3 km off the coast); drawings made by fishermen of the Barra de Imbé/Tramandaí, Rio Grande do Sul State, southern Brazil.

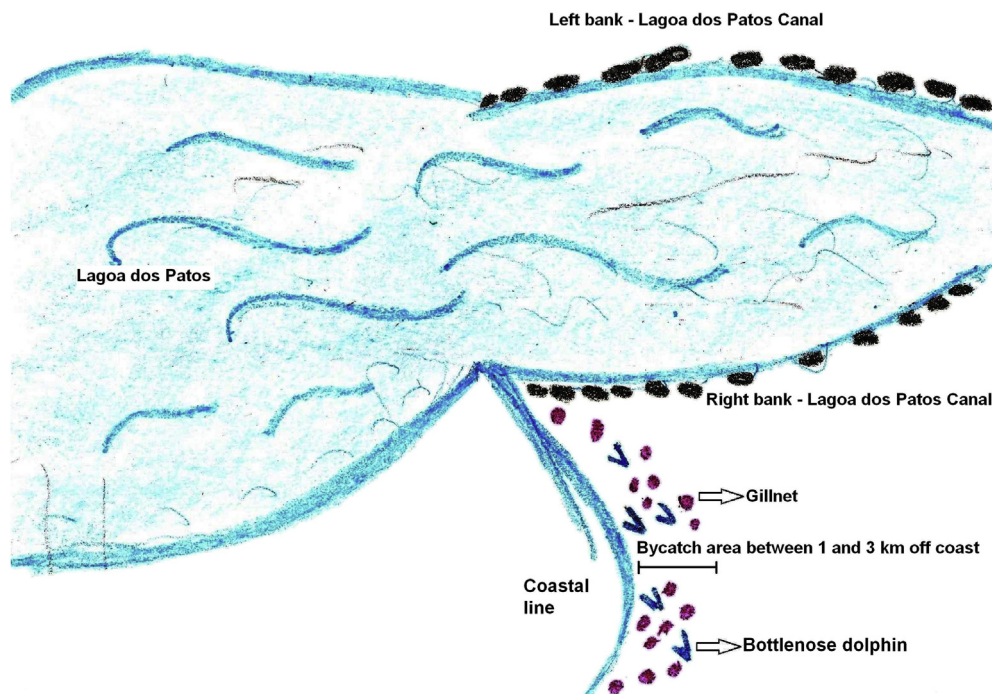


Fig. 5. Areas of accidental capture (between 1 and 3 km off the coast); drawings made by fishermen of the Lagoa dos Patos, in Rio Grande, Rio Grande do Sul State, southern Brazil.

may become possible. Second, the fishermen noted that the bottlenose dolphins cannot perceive the nylon that composes the nets when underwater. In the Cagarras' Archipelago, southwest Brazil, and another study realized in Barra de Imbé/Tramandaí and Lagoa dos Patos, southern Brazil, this same explanation was reported by fishermen (Zappes et al., 2011b, 2014). Tregenza et al. (1997) concluded that the system of echolocation employed by small cetaceans is unable to perceive fishing nets as a barrier, thus leading to their entanglement.

It is known that bycatch occurs mainly in the estuary of the Lagoa dos Patos and in the adjacent coastal areas based on carcasses found on the beach and evidence of net-induced injuries (Fruet et al., 2010). It has been estimated that this is responsible for 42% of the mortality concerning the population of the species in the region. Ideally, it would be desirable to obtain the bycatch numbers based on fishermen reports because is likely that the rate of mortality is underrepresented. However the fishermen cannot feel comfortable in quantifying the total volume of bycatch (Zappes et al., 2014). A number of animals that are not counted have likely died without showing evidence of interactions with fisheries, as many carcasses do not arrive on beaches, and not all that arrive on beaches are quantified (Burdett and McFee, 2004).

An analysis of the population viability of bottlenose dolphin in Lagos dos Patos indicated that the local population will decline under the current levels of bycatch, even with a reduction in current fishing effort (Fruet et al., 2010). This projection is worrisome, not only at a local level. According to Laporta (2009), there is movement of individuals between the coast of Uruguay and the Lagos dos Patos in Brazil. Due to the interchange between these two areas, the incidental capture by gillnets in one location can negatively impact the other location (Laporta, 2009). Apparently, bycatch can have more dramatic consequences in the region of the Barra de Imbé/Tramandaí, where a very low population size of nine to ten individuals has been recorded (Simões-Lopes, 1991; Simões-Lopes et al., 1998; Simões Lopes and Fabian, 1999). However, Fruet et al. (2014) suggested that conservation programs should be urgently implemented in the Lagoa dos Patos and adjacent coastal waters where bottlenose dolphins from different communities show overlapping use areas and where bycatch rates are higher.

4.2. Mitigation of bycatch

When fishermen suggested a more rigorous enforcement of existing laws as a solution to the problem of bycatch they were

describing the laws related to the following: 1) placement of nets and the prohibition of gillnets in areas where bluefish (*Pomatomus saltatrix*) are captured (Portaria MPA/MMA n° 02/09) and; 2) the prohibition of the use of nets when fishing for sea catfish (*Genidens* spp.) from December through March (Portaria MMA n° 17/04) and mullet (*Mugil* sp.) from January through May (Portaria IBAMA n° 171/08). Despite the fishermen describing the necessity of more rigorous law enforcement, they do not obey these laws in all situations.

Studies regarding fishery activity must be linked to the environment management of fishermen activities, involving social rules and technology. Technology is an important item in questions related to fishery and mammal aquatic interactions because of the use of fishery nets (Varjopuro, 2011). Interestingly, no alternative proposed by the fishermen was related to making the nets more obvious to dolphins. Controlled experiments have shown that acoustic alarms may be effective at reducing dolphin and porpoise bycatch in some fisheries (Bordino et al., 2002; Barlow and Cameron, 2003; Leeney et al., 2007; Gönener and Bilgin, 2009). Multifilament nylon webbing nets could also increase echoing from the nets, and the use of alternative methods to attach cork lines, plastic-coated aluminum or steel mesh as measures that could reduce dolphins bycatch have been explored (Dawson, 1991; Jefferson and Curry, 1996; Valdemarsen and Suuronen, 2001). Other measures that could minimize bycatch include fishery in water depths not used by dolphins and the placement of holes in long nets to enable dolphin escape (Au and Jones, 1991; Zappes et al., 2013a). In Kerala, Indian coast, fishermen developed a net called 'dolphin wall net' to avoid the disturbance of dolphin during operation of ring seine fishery activity (Prajith et al., 2014). This is a surrounding type of net, that it creates a barrier to the ring seine and keeps away the cetaceans in a safe distance. The 'dolphin wall net' prevents dolphin's attack toward to the school, also decrease the serious injury of dolphin and damage to the artifact. According to the authors, it is a conservation aspect created by fishermen, which indirectly helps to protect the dolphins.

There is also changes that is not directly related with technology but with alternatives activities. Tourism activities involving 'cetaceans watching' can be an alternative income source to fishing during some season of the year. Apparently these activities are successful in Puerto Lopez at Machalilla National Park, Ecuador, where cetaceans' bycatch rates are decreasing. This fact can be related with the involvement of fishermen in cetacean watching activities (Alava et al., 2012). These changes must be discussed among the fishery community, researchers and local government leaders through policies designed to enhance the environmental and natural resource management (Roué, 2000). This way the local fishermen must play a critical role as allied partners to help in maintenance the ecosystem (Alava et al., 2012).

Researchers, authorities and stakeholders should engage in an in-depth analysis of human ecology in areas with traditional fisheries to suggest alternatives and minimize environmental conflicts (Christie, 2005; Aragón-Noriega et al., 2010). Nevertheless, the community cannot wait for changes based only on research and government institutions (Meek et al., 2011). Stakeholders must expose opinions and look for alternatives based on the laws and empirical knowledge developed over the years, following the co-management approach.

In this study, an important question was whether fishermen identify that there is an overlap of use areas between bottlenose dolphins and artisanal fisheries. Competition between groups of fishermen was described in Rio Grande, the southern region of the Lagoa dos Patos (Castro and Begossi, 1996), but there was no ethnobiological approach that identified competition between artisanal fishermen and fauna, specifically with bottlenose dolphins in

southern Brazil (Peterson et al., 2008; Zappes et al., 2014). The fishermen did not describe a real competition between themselves and dolphins; however, from the moment that bycatch occurs, an overlap of use and competition for space and marine food resources (fish) exist in the Barra de Imbé/Tramandaí and Lagoa dos Patos. Thus, it is important to understand the traditional knowledge of artisanal fishermen to assist management strategies to conserve this coastal population of bottlenose dolphins and to maintain the artisanal fishery in the studied areas (Begossi, 1995).

Initial measures should be realized to minimize the bycatch, such as the following: 1) identify areas of overlap between bottlenose dolphins and artisanal fishery through the regular monitoring of areas frequented by dolphins and areas in which gillnets are used; 2) identify new fishing areas in which fishery resources support fishing in the Barra de Imbé/Tramandaí and Lagoa dos Patos; 3) evaluate the installation viability of artificial reefs to ensure fish stocks in southern Brazil – this evaluation should occur with the participation of local fishermen, and the traditional management of new fishing grounds would occur; 4) maximize the efficiency of reflection of nets and to facilitate the visibility by dolphins without interfere in the efficiency of fish catches (Au and Jones, 1991; Dawson, 1991); 5) change the position of nets (Au and Jones, 1991; Valdemarsen and Suuronen, 2001); 6) install mechanical signs in the nets or electronic signs that emit sound pulses (of high and low frequencies) to make the gear acoustically perceptible to dolphins (Jefferson and Curry, 1996; Bordino et al., 2002; Brotons et al., 2008) and 7) evaluate the promotion of cetacean watching (Alava et al., 2012); however, alternative market studies must be performed with socioeconomic diagnostic and environmental studies beyond the elaboration of protocols for boat approaching bottlenose dolphins in such a way to minimize anthropic interference on animal behavior (Filla and Monteiro-Filho, 2009). In addition, it is necessary to promote the qualification of the community through training courses and the development of local entrepreneurial or administrative skills aimed at generating tourism. These activities of qualification can be realized with the aid of SEBRAE (Serviço Brasileiro de Apoio às Micro e Pequenas empresas – Brazilian Service of Support for Micro and Small Enterprises) located in southern Brazil, which aims to act as a social service for the development of cooperatives, associations and small businesses and thereby encourages entrepreneurship among fishery communities of the Barra de Imbé/Tramandaí and Lagoa dos Patos.

5. Conclusions

Based upon the results of this study, the traditional knowledge of artisanal fishermen who operate at the Barra de Imbé/Tramandaí and the southern part of the Lagoa dos Patos is able to identify the causes of accidental capture caused by artisanal fisheries on bottlenose dolphins. To assess the interference of artisanal fisheries on these dolphins, it is necessary to identify the perception of fishery communities that operate in areas where these dolphins occur, to identify the causes of bycatch, to seek alternatives for fishery techniques in conjunction with the fishermen, and to regularly monitor fishery areas of use and the locations where gillnets are arranged in the Barra de Imbé/Tramandaí and Lagoa dos Patos. Studies that focus on the traditional knowledge of artisanal fishermen may contribute to the establishment of guidelines in natural resource management plans for legally protected areas. The addition of data obtained empirically and traditional scientific methods can become useful from the moment that these two sources provide complementary information. In addition, cooperation among researchers and fishing communities and the participation of social actors through educational activities can be useful in monitoring

fishery activities conducted in coastal areas and the incidental capture of dolphins in fishing gear. In this sense, initial actions that involve the traditional knowledge, scientific knowledge and environmental laws can provide support to elaborate the rules of planning and zoning in future management plans in occurrence areas of coastal populations of *T. truncatus* in Brazil.

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