



## 'Human-dolphin (*Tursiops truncatus* Montagu, 1821) cooperative fishery' and its influence on cast net fishing activities in Barra de Imbé/Tramandaí, Southern Brazil

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### ABSTRACT

'Human-dolphin (*Tursiops truncatus* Montagu, 1821) cooperative fishery' and its influence on cast net fishing activities in Barra de Imbé/Tramandaí, Southern Brazil – aims to describe 'fishing with dolphins' or 'botos' (*Tursiops truncatus* Montagu, 1821), its importance in mullet fishing in conjunction with the traditional knowledge of artisanal fishermen, and the negative economic impact that tourism has had on mullet fishing in Barra de Imbé/Tramandaí (29°58'S 50°07'W). In November and December of 2009, 22 artisanal fishermen associated with the Tramandaí Fishermen's Union were interviewed. During these interviews, questionnaires were employed utilizing both open and closed questions that dealt with behavioral ecology, biological and interactional issues related to bottlenose dolphins, and small-scale fishing in the region. All those interviewed described "boto fishing," in which bottlenose dolphins "helped out the fishermen." According to these interviews, this kind of fishing, marked by close interaction between humans and 'botos,' allows nets to be cast fewer times and with captured fish yields that are greater than, when there is no dolphin is present. The fishermen maintain that this increased productivity results from 'botos' showing them exactly where the schools of fish are located below the water surface. This has made it possible to observe the impact that dolphin fishing has on the monthly incomes of these fishermen, and there is concern among fishermen, that the intense tourism may one day contribute to the disappearance of the 'boto,' a situation, they believe would negatively affect their fishing activities.

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### 1. Introduction

Artisanal fishermen are classified as a traditional community group that provide practical and theoretical information based on their observations of the ecology of a species, and pass this knowledge on to the community (Diegues, 2000).

Ethnobiological studies conducted with fishery communities are important because, they may justify the inclusion of local fishermen in management decisions in conservation hotspots, such as the Atlantic Forest coast of Brazil (Paz and Begossi, 1996). This

local knowledge must be recognized as a source of valuable information for the management of aquatic mammals (Chilvers et al., 2005; Fisher and Young, 2007; Souza and Begossi, 2007; Zappes et al., 2009) and for artisanal fishing. It is also suggested that co-management schemes in marine areas might benefit from the adoption of a 'knowledge-building' approach to management, in conjunction with local knowledge, instead of one that uses 'knowledge-using' during this process (Gerhardinger et al., 2008).

Interactions between fisheries and dolphins have been reported worldwide and may be characterized as both positive (Busnel, 1973; Neil, 2002; Wise et al., 2005; Smith et al., 2009) and negative (Lauriano et al., 2004; McFee et al., 2006; Brotons et al., 2008). In Brazil, various studies have described the interaction of dolphins and fishermen (Pryor et al., 1990; Simões-Lopes, 1991; Peterson et al., 2008; Zappes et al., 2009). Yet few studies carried out in Brazil have deeply probed questions of conservation involving

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traditional knowledge of artisanal fishermen and the bottlenose dolphin, *Tursiops truncatus* Montagu, 1821 (Cetacea, Delphinidae) (Simões-Lopes, 1991; Peterson et al., 2008).

In Barra de Imbé/Tramandaí, situated in Rio Grande do Sul State (29°58'S 50°07'W), Southern Brazil, there is a peculiar interaction between dolphins, which are known as 'botos' in this region, and artisanal cast net fishermen known as 'tarrafeiros.' Fishermen there share their fishing waters with the 'botos' in a symbiotic relationship whereby both groups are interested in catching mullet fish (*Mugil* spp.). This interaction was described by Pryor et al. (1990), Simões-Lopes (1991), Tabajara (1993) and Simões-Lopes et al. (1998) and was found to occur throughout the year in this region. The presence of these 'botos' bears socio-economic importance in fishing activities and has encouraged the unbridled growth of tourism there (Tabajara, 1993).

A current problem in the Barra de Imbé/Tramandaí occurs mainly during the months from January to February and June to July (the latter being the best time to fish for mullet), the summer and winter breaks, respectively, in Brazil. During these periods, the 'tarrafeiro' and the 'boto' compete with intense tourist boat traffic for space on the bar, as well as the large numbers of tourists who engage in sport fishing. The region has no regulatory measure that would give preferential rights to cooperative fishing in 'tarrafeiro' locations. On the contrary, the law in Brazil allows any citizen in possession of a professional fishing license to practice traditional fishing in any area of the country (Peterson et al., 2008).

Scientific knowledge about the relationship between fishermen and the 'boto' population at Barra de Imbé/Tramandaí and on the increasing tourist activities in the region is still incipient, while local knowledge on these issues has been shown in detail. Analyzed

through an ethnobiological framework, the testimony of fishermen shed great light on the issues, surrounding the positive and negative aspects of cooperative fishing on the Barra de Imbé/Tramandaí.

Though local fishermen have demonstrated the importance of 'botos' in the fishing economy, no studies to date have carried out an in-depth investigation into the local knowledge issues of the 'tarrafeiros', describing their perception of 'boto fishing' or their perceptions on the interference of tourism in the economics of mullet fishing. Thus, this study aims to describe 'boto fishing' in terms of the perceptions of artisanal fishermen who make their living at the Barra de Imbé/Tramandaí, the importance of this species of dolphin to cast net mullet fishing, as well as the negative influence of tourism on cooperative fishing.

## 2. Material and methods

### 2.1. Study area

The lagoon-estuarine system of Tramandaí is made up of two lagoons (Tramandaí and Armazém) that receive freshwater from the Tramandaí River and the Camarão Channel, and are connected to the Atlantic Ocean by an estuary known as Barra de Imbé/Tramandaí (Fig. 1). The Tramandaí Lagoon (29°57'S - 050°11'W), which is situated in the north of the Rio Grande do Sul State, covers an area of 12.86 km<sup>2</sup> with an average depth of 1.1 m (Guadagnin and Beckcer, 2002) and is the principal artisanal fishing area of the entire Tramandaí River drainage basin. This lagoon borders the municipalities of Tramandaí (29° 59'S, 50° 09'W) and Imbé (29° 57'S, 50° 07'W), two urban centers on the northern coast. 'Botos' are present in the Barra de Imbé/Tramandaí, distributed mainly in the

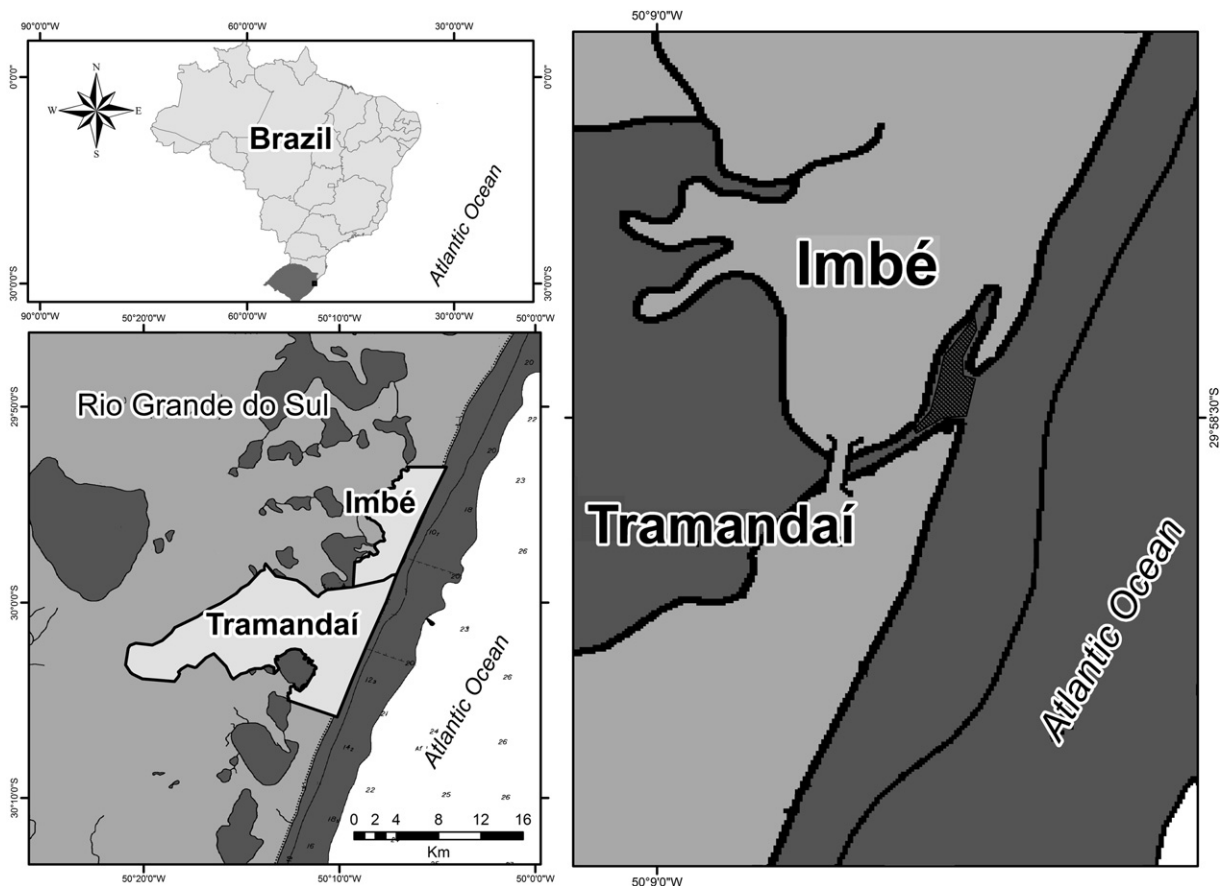


Fig. 1. Barra de Imbé/Tramandaí, RS (29°58'S 50°07'W), Brazil. Inset: shaded area in which cast net fishing is practiced and area frequently visited by dolphins.

mouth of the estuary. This location has been chosen for cooperative mullet fishing with cast nets for the precise reason that it is a place that increases the contact of fishermen with the 'botos' (Simões-Lopes et al., 1998).

The Tramandaí Fishermen's Union has 481 professional artisan fishermen registered in Tramandaí and 102 registered in Imbé. These men use different fishing equipment in the estuary, lagoon, and the lakes, according to the Tramandaí Regional Office. The number that work with cast nets in the capture of mullet is approximately 40, and these men generally process and sell their fish directly to the consumer, often with the aid of family members (Tramandaí Fishermen's Union-unpublished data). Artisanal fishermen associated with the aforementioned union were interviewed for this study. As the focus was on cast net fishermen in the Barra de Imbé/Tramandaí, only fishermen who met this criteria were interviewed.

## 2.2. Procedures

Data was collected during the months of november and december of 2009 through 22 ethnographic interviews with artisanal fishermen from the region. The data collection occurred in three stages. The first phase of work involved exploratory research (participant observation) (Schensul et al., 1999) to identify potential informants (interviewees). The second meeting with the fishermen was so that the researcher could explain and clarify the objectives of this work and to obtain their permission to be interviewed as informants. During the third and final contact, interviews were conducted. All informants met the following criteria (Peterson et al., 2008): (1) they were artisanal fishermen; (2) fishing was their primary economic activity; and (3) they fished cooperatively with dolphins. All potential interviewees were men, as only men engage in this activity. To avoid possible interference from other informants, all fishermen were interviewed individually. The interviews were conducted according to the availability of each fisherman, thus taking place either in the informant's residence after working hours or, when possible, at fishery locations.

Interviews were guided by a standard semi-structured questionnaire (Schensul et al., 1999) containing 40 open and 17 closed questions that functioned as a roadmap for the interview. The interview was conducted in an informal manner using this questionnaire (Araújo et al., 2005). The questionnaire itself was divided into categories with: (1) socio-economic questions about the fisherman's age, address (neighborhood), times of year fishing activities were engaged in; (2) questions about descriptions of the fishing activity (artifacts, boats, fish) (Begossi, 2001); (3) questions about dolphin ecology; (4) questions about cooperative fishing dynamics, the importance of the dolphin in artisanal fishing, and local institutions' roles in cooperative fishing; (5) questions about environmental conflict that dealt with possible interference from human activities such as tourism and other types of fishing (Box 1).

The questions related to dolphin ecology described features pertaining to size, color, occurrence area, resident population size, behavior, and trophic interactions. Questions were initially related to adult individuals while subsequently dealing with young and infant calves. In this way, fishermen could clearly describe each of the two age groups interacted with. Some questions elicited closed responses which were followed by questions stimulating open explanations, while others induced justifications that allowed fishermen to express their reasoning. To test the reliability, collate and verify the validity of the information contained in the reports, and to avoid sampling errors, we used the technique of information repeated in synchronic situation by applying the same questionnaire to all respondents (Araújo et al., 2005).

### Box 1. Topics of the issues of semi-structured questionnaire.

1. Social Economic Aspects
  - Age
  - Address (neighborhood)
  - Period in which works with fishing in the region
2. Description of the Fishing Activity
  - Technology artifacts
  - Boats (length, engine)
  - Fish species
3. Ecology of dolphins
  - Size
  - Color
  - Occurrence area
  - Resident population size
  - Behavioral ecology
  - Trophic interactions
4. Cooperative Fishing Dynamics
  - Interaction with fishing activities
  - Importance of the dolphin in artisanal fishing
  - Local institutions in cooperative fishing
5. Environmental Conflicts
  - Tourism
  - Other activities

All interviews were conducted through dialogs which facilitated interaction and the establishment of trust between the interviewer and the fishermen. The terms utilized in the questionnaire were in keeping with the usual vocabulary employed by the fishermen and were based on a study carried out by Zappes et al. (2009). This researcher (C. A. Zappes) presented herself as a member of a teaching institution to avoid associations on the part of the fishermen with authorities or environmental regulatory agencies. In order to preserve important information, some reports were digitally recorded with the permission of those interviewed, to later be transcribed and analyzed (Freitas Netto et al., 2002). This was not possible with all interviews, however, because some respondents did not feel comfortable with the recording equipment.

Two methods for choosing interviewees were employed. The selection of the first fishermen was made with the aid of the president of the union cited above, who is generally the person who best knows its members (Sanchez, 2004). From the second interview on, a "snowball method" was used whereby potential interviewees were contacted based on information gathered from members who had already answered the questionnaire (Bailey, 1982). Reports about fishing expeditions and the so-called 'cooperative fishing' ('boto' fishing) were analyzed to gauge the degree of influence these animals had on cast net fishing.

After transcribing the interviews, a table was created to organize the data according to categories related to the initial research questions of the questionnaire (Ryan and Bernard, 2000), i.e., social economic aspects, description of the fishing activity, behavioral ecology of dolphins, cooperative fishing dynamics, and environmental conflicts. With this table it was possible to group the information by categories of themes as a means to classify the reports so that the material contained on a particular topic could be easily identified, thus facilitating interpretation of the interviews (Bogdan and Biklen, 1994).

These categories clarified the relationship between language (materiality of reports) and social interaction through the application of discourse analysis for the development of the perception of fishermen on cooperative fishing, helping to build this system of scientific thought (Rocha and Deusdara, 2005).

### 3. Results and discussion

#### 3.1. Human-dolphin cooperative fishery

Estuarine mullet fishing requires a net, called a 'cast net,' with a circumference of between 30 and 36 m and small pieces of lead, called *chumbada*, placed on its outer edge. Upon being cast, this net opens up in the air and is therefore characterized as a piece of equipment with horizontal action to capture the fish. This net is fully extended when it hits the water, but quickly closes due to the weight of the *chumbada*.

By locating schools of fish below the waters of the Barra de Imbé/Tramandaí, dolphins aid in this endeavor. All fishermen interviewed ( $n = 22$ ; 100%) describe this practice as '*boto fishing*,' cited in the literature as cooperative fishing (Pryor et al., 1990; Simões-Lopes, 1991; Smith et al., 2009). In this type of activity, dolphin 'help the fishermen' with their cast net fishing. The fishermen stand knee or waist-deep in the waters off the Barra de Imbé/Tramandaí beach. There is no rule about how the cast nets are thrown, and the first fisherman to arrive at the location begins to fish and only ceases his activities when his Styrofoam cooler is full of fish, which will subsequently be sold. In Imbé/Tramandaí relatively few fishermen—around 40 individuals—participate in cooperative fishing with '*botos*'.

According to the interviews, the '*botos*' recognize certain fishermen and show a kind of preference for 'showing the schools of fish' to these particular men. They associate this ability to recognize certain fishermen with the clothes worn or equipment used. The men 'most favored by the *botos*' are those that wear large straw hats and rain ponchos while fishing, which interviewees maintain allows '*botos*' to recognize them from the shadows cast on the water. Even when other fishermen imitate the clothes worn by 'those most favored,' dolphin continue 'showing more fish' to the original men. They say this is due to the *botos*' preference.

'*Boto fishing*' begins when the '*botos*' drive schools of fish from deeper waters against the coastline. Next dolphins surround the fish near the beach while the fishermen await the dolphin 'head signal' in order to cast their nets. This 'signal' is a nodding movement on the part of the dolphin accompanied by a pointing gesture made with their noses (rostrum) to show the exact location of the school. This behavior is interpreted as the signal for fishermen to cast their nets.

This interaction between *T. truncatus* and cast net fishing activities is also described in Laguna, Santa Catarina State (28°29'S 48°45'W) (Pryor et al., 1990; Simões-Lopes, 1991; Simões-Lopes et al., 1998; Peterson et al., 2008) and occurs in a similar manner. The perception of Barra de Imbé/Tramandaí fishermen is that of a cooperative relationship that takes place, since with the aid of '*botos*' the amount of time invested in mullet fishing is reduced and yield efficiency is increased. The casting of the net may serve to reverse the direction of escaping mullet, causing the school to lose cohesion and thus facilitating the capture of fish by '*botos*' themselves (Simões-Lopes et al., 1998). The cast net is the only fishing artifact that upon release disrupts the cohesion of the schools and facilitates the cooperative fishing.

The cooperative fishery that occurs between dolphins and the cast net fishermen is only described in areas in which animals approach the beach. For Monteiro-Filho (1995), the animals use the sand as a barrier that serves to corral the schools. The fishermen have come to value this technique because it can facilitate the capture of fish while reducing the amount of effort invested due to improved accessibility of the schools of fish. This capture, however, is only efficient when the fisherman throws his nets in the exact spot indicated by the animal with the 'head signal' because the turbidity of the waters limits visibility and prevents the fisherman from seeing the school.

There is no record in the literature of when this human-dolphin interaction in the Barra de Imbé/Tramandaí began. The fact is that the transmission of such knowledge occurs between generations of fishermen and dolphin. *T. truncatus* individuals in captivity (Mercado et al., 1999) and in the wild (Simões-Lopes, 2005) have demonstrated the ability to repeat the observed actions of other individuals of their group, which explains the continued presence of this behavior in association with cast net fishing practices.

#### 3.2. Good and bad '*botos*'

To the fishermen, there are '*botos*' that are 'good' and 'bad' for fishing. A good '*boto*' is one that shows the exact location of the school, facilitating capture by cast net. It is an animal that is never wrong; a '*showing boto*.' A bad '*boto*,' however, is one that indicates the wrong place and fools fishermen. Consequently, the fisherman 'wastes time' when he fishes with such a dolphin, because his fishing will be unsuccessful. Such individual variations in behavior were also observed in Laguna (Pryor et al., 1990; Peterson et al., 2008). This data indicate the degree to which the local fishing community notices the environment around it and understands the behavioral ecology of this cetacean species in the region.

#### 3.3. '*Boto*' names

This *T. truncatus* population is estimated at nine animals (Simões-Lopes and Fábian, 1999). According to the interviewed fishermen, this number has remained steady for several decades. Interviewees have had close daily contact with the animals, allowing them to observe features such as natural marks and/or scars and to identify each individual dolphin without mistaking one for another. The dorsal fin, which is the most exposed bodily feature of animals in motion, is the part of the dolphin's body most noticed by fishermen. In time, blemishes on the body, rostrum shape and pectoral flipper marks are also recognized. The behavior of each dolphin while fishing also facilitates its identification. At birth each dolphin receives a name, but as time goes on this name may be modified when fishermen notice a special individual feature that the animal presents during its development. According to the interviewed fishermen, names are based on 'father *boto*' and 'mother *boto*,' morphological features, sex, and behavior exhibited during the interaction with fishermen. Only after this recognition do fishermen choose the definitive name.

In order to know if a dolphin is male or female, the fishermen observe whether a particular adult has been seen with a calf. At times a female receives a male name which is later changed after her correct sex is identified. The females that currently inhabit Barra de Imbé/Tramandaí are known as *Geraldona*, *Catatau*, and *Rubinha*, and the males as *Bagrinho*, *Chiquinho*, and *Coquinho*. Three calves have also been reported in the region: *Galhamol* son, *Ligeirinho*, and *Foguetinho*. The first calf received this name because, just as his father, he has a limp or 'soft dorsal fin,' which is what his name means in Portuguese. The second and third calves also have names that in Portuguese refer to their quick speed and rambunctious natures. In the early 1990's, Tabajara (1993) had already documented the presence of the '*botos*' known as *Geraldona*, *Catatau*, *Bagrinho* and *Coquinho* in the region.

#### 3.4. Accidental capture in nets

The accidental capture of '*botos*' in nets has been reported by local fishermen ( $n = 7$ ; 32%). Those interviewed stated that '*botos*' occasionally get caught in their nets, but are released immediately. According to these reports, animals get tangled in the nets because they make a wrong move and find themselves in front of a net at

the moment it is thrown over the school. Calves are generally the ones that get caught, “because they are learning how to hunt and still don’t possess complete mastery of the technique” (report of fisherman J.C.- Barra de Imbé/Tramandaí).

When a dolphin gets captured, the fisherman cuts the net in order to release him. This causes the fisherman a certain amount of anger due to his material loss, but those interviewed maintain that this anger ‘goes away quickly.’ At this moment the fishing activities are interrupted in order to mend the net. Interviewed fishermen affirm that these entanglements do no harm to the animals, merely scaring them temporarily.

In the north of the state monitoring is conducted to quantify the accidental capture of cetaceans by fishing artifacts, but no studies have provided any kind of evidence suggesting that cast net fishing is harmful to dolphins. On the contrary, studies involving the cooperative fishing in the region of Barra de Imbé/Tramandaí indicate that this is a positive relationship for both the dolphins and for the fishermen (Pryor et al., 1990; Simões-Lopes, 1991; Simões-Lopes et al., 1998).

### 3.5. Importance of dolphin fishing behavior for fishermen

According to those interviewed, the influence of *T. truncatus* on cast net fishing has existed since ‘the old days, our grandparents’ time,’ and was always considered a positive interaction between humans and ‘*botos*.’

The exhibitory behavior of these animals in fishing allows for a more efficient capture of fish with cast nets and, consequently, greater yields when compared to fishing without human-dolphin interaction (Smith et al., 2009). All interviewed fishermen described this practice in detail and reported that the presence of the animals in the region guarantees successful fishing.

Through the ethnobiological methodologies employed in this study it was not possible to compare quantities of fish caught using cooperative fishing methods with those caught using more conventional methods of fishery. According Vooren et al. (2005), due to the intense tourist activity in the region and the degree of organization of fishermen, the main mode of marketing is to sell fish directly to consumers; hence there is no estimate of artisanal fisheries production in the region. According to the fishermen in this study, a single working day (morning and afternoon) of cooperative fishing is sufficiently profitable so as to meet his families basic necessities for one week. In this way, the cooperative fishing endeavor is seen as fundamental to the families’ financial security.

In the eyes of the fishermen and their families, the dolphin make it possible for them to maintain housing, food, and studies, for these animals show them the locations of the mullet schools. In Laguna, fishermen also perceived the importance of dolphin participation in cast net fishing (Peterson et al., 2008). A positive influence on the fishermen’s monthly incomes resulting from the behavior shown by the ‘*botos*’ was cited by all those interviewed.

The fishing community of the Barra de Imbé/Tramandaí worries that one day the animals may disappear, which could lead their activity to financial ruin. This concern is based on fishermen observations that report a lack of environmental regulation on the tourism of the region. According to those interviewed, during the summer (January and February) and winter (June and July) the towns of Imbé and Tramandaí receive tourists with sport fishing and nautical sport watercraft that cause intense traffic in the estuary and near the sandbar. These watercraft are generally operated at high velocity and frighten the animals away from the sandbar. Fishermen report that during these periods ‘*botos*’ are seen less often because some of these dolphins tend to leave the area. Other studies have reported that collisions with watercraft can cause injuries or death to dolphins as well as the departure of these

animals from a given region (Monteiro-Filho, 1995; Simões-Lopes and Paula, 1997; Filla and Monteiro-Filho, 2009; Zappes et al., 2010).

Another problem in the perception of fishermen is related to competition for space in the estuary during the cooperative fishing. According to the fishermen, tourists who are licensed to practice fishing occupy many prime fishery locations, which hinders local fishermen. And as the number of tourists is great, they capture large quantities of fish, which in turn dampens sales, because tourists have no need to buy fish. The absence of government measures that could regulate cooperative fishing in the region is a concern for the local fishing community.

The Fishermen’s Union and local authorities have taken no action to manage the uncontrolled tourism in the Barra de Imbé/Tramandaí. The loss of resource control by the community may disrupt their local management system (Peterson et al., 2008), since apparently there is currently balance in the ecosystem with respect to the ratio of *tarrafeiros* to *botos*. For the fishermen, the intense exploitation of mullet during the tourist period in the Barra de Imbé/Tramandaí, in conjunction with the fact that many tourists crowd fishing sites in order to fish themselves or merely to view the dolphins, can lead to a decrease of fish resources. Therefore, the ‘*botos*’ may seek another feeding area, and the cooperative fishing may cease to exist. This chain of unfortunate events is characteristic of the “tragedy of the commons” model (Hardin, 1968; Berkes, 1985). Once these communities become politically organized in order to manage their common space, however, they can mitigate conflicts and decrease pressures on resources (Peterson et al., 2008).

For the effective management of common property resources involving cooperative fishing, some important measures are necessary, such as the delimitation of the area(s) at Barra de Imbé/Tramandaí and/or adjacent areas in which resources are found, the definition of who are entitled to exploit these areas (local fishermen-‘*tarrafeiros*’), and efficient exclusion or control of outsiders (Ostrom, 1990), in this case, the tourists. Existing regulations of this kind that were articulated by a well-organized fishing community are described in Laguna (SC). These pro-cooperative fishing measures are thorough and detailed, making use of shift rotations, partnerships, and first-come rights (Peterson et al., 2008).

The Barra de Imbé/Tramandaí fishermen, in contrast, have little knowledge on how to develop public policies to protect their interests. Although they are organized in a fishing cooperative that represents them, there is no action to control the undesirable presence of outsiders.

The information gathered in this study describes for the first time the perceptions of the Barra de Imbé/Tramandaí fishermen through ethnobiology, offering insight into local perspectives of positive and negative repercussions on cooperative fishing through the interplay of fishermen, dolphin, and tourists. Fishermen reports make clear the sense of respect and dependence that the ‘*tarrafeiros*’ show in relation to the ‘*boto*’ population in this area. The desire to preserve the local human-dolphin cooperative fishing culture is described by the fishermen who reported concern about the possible disappearance of these animals in the region due to uncontrolled tourism.

Many feel a need to define public policy strategies for the conservation of local knowledge by supporting discussion and social strategies to reduce negative tourist impact on the natural population of the species (Chilvers et al., 2005) and on the economics of the cooperative fishing.

## 4. Conclusions

Through the perceptions of fishermen it has been possible to describe and understand the fishing behavior of ‘*botos*,’ the cooperative relationship that exists between these animals and the cast

net fishermen of Barra de Imbé/Tramandaí, to register the socio-economic influence this species has on fishermen income, as well as expose the negative influence of tourism on cooperative fishing. In this region, fishermen have contact with the species and, despite the environmental importance of this area and the presence of these animals there, there have been no studies that show the level of human interference related to tourism on this dolphin population.

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