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ECOSYSTEMS

# Local ecological knowledge of fishers from southern and southeastern Brazil about the franciscana dolphin *Pontoporia blainvillei*: Strategies for conservation

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**Abstract:** This study compares local ecological knowledge (LEK) of fishers from the Southwest Atlantic Ocean (SWAO), Brazil, related to the franciscana dolphin (*Pontoporia blainvillei*). We conducted 330 ethnographic interviews in ten fishing communities in southern and southeastern Brazil between 2012 and 2018. Boolean or Classic Logic was used to identify 95 fishers who were able to recognize the franciscana dolphin accordingly to the taxonomic entity *P. blainvillei*: 23 in northern Espírito Santo state, one in southern Espírito Santo, 20 in northern Rio de Janeiro state, and 51 in northern Paraná state. Among these 95 fishers, 87.4% (n = 83) reported incidental captures in fishing nets. Among these, 52 (54.7%) did not know any solution to this problem. Interviews revealed that the fishers usually discard carcasses in the sea after fat and muscle tissue are removed so that they can be used as bait for shark fishing or as food. In Southeastern Brazil, fishers LEK related to their ability to identify franciscana dolphin varied from 'no identification' and 'extremely low identification' to 'partial' and 'good identification,' while in southern Brazil, fishers mainly presented a 'good identification' of the dolphins. We propose comanagement actions to conserve the franciscana dolphin in the SWAO.

**Key words:** dolphin, local ecological knowledge, incidental capture, Southwest Atlantic Ocean.

## INTRODUCTION

The franciscana dolphin, *Pontoporia blainvillei* (Gervais & d'Orbigny, 1844) is a small coastal marine mammal found in shallow waters up to 50 meters in depth between the northern Espírito Santo state (ES) (18°25'S-39°42'W, southeastern Brazil) and the San Matías Gulf (43°18'S-65°06'W, Argentina) (Praderi et al. 1989, Siciliano 1994, Crespo et al. 2010, Danilewicz et al. 2010). There are distribution gaps in southeastern Brazil, with very few records in recent decades (Cunha et al. 2014, Amaral et al. 2018, Mayorga et al. 2020). The first record includes the coastal area between the Piraquê-Açu River mouth, ES (19°57'S-40º08'W), and Barra de Itabapoana, Rio de Janeiro state (RJ) (21°18'S-40°54'W). The second gap extends from Armação dos Búzios (22°44'S-41°53'W) to Piraquara de Dentro (22°59'S-44°26'W), both of which are located in RJ (Siciliano et al. 2002, Amaral et al. 2018). The absence of the species in these gaps is likely due to water temperature and transparency, the width of the continental shelf, and/or the presence of predators (Siciliano et al. 2002, Cunha et al. 2014).

The franciscana dolphin is mainly threatened by incidental capture in artisanal fishing

nets, reducing the number of individuals in populations over time (Rocha-Campo et al. 2010, Siciliano et al. 2019). Interactions between these dolphins and artisanal fisheries are described on the coasts of ES and RJ, southeastern Brazil, and in Paraná state (PR), southern Brazil (Secchi et al. 1997, Di Beneditto et al. 2001, Rosas et al. 2002, Di Beneditto 2003, Santos et al. 2009, Siciliano et al. 2019, Mayorga et al. 2020). The conservation status of this species is considered 'vulnerable' by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species and 'critically endangered' by the national list of Brazilian fauna threatened by extinction with a risk of extinction (Zerbini et al. 2017, ICMBio 2018).

In Brazil, an artisanal fishery was defined by Federal Law 11 959 on June 29, 2009, as an activity practiced autonomously by professional fishers or in the form of a family economy, without any employment relationship (Brasil 2009). Due to the daily practice of the activity, fishers maintain regular contact with the marine environment, which enables the development of local ecological knowledge (LEK). In fishing communities, LEK is developed for years and increases in each new generation with cultural data transmitted orally from the elders to the younger generation (Peterson et al. 2008). Ethnoecology studies are important in combining LEK and scientific knowledge, and these studies help in the development of fishing management and conservation actions (Silvano & Begossi 2002, Zappes et al. 2016, Abreu et al. 2017).

Previous studies about artisanal fishers' LEK related to the franciscana dolphin have been specific to some areas and usually have not proposed any management actions that could contribute to the conservation of the species (Pinheiro & Cremer 2003, Rosa et al. 2012, Zappes et al. 2016). Thus, the aim of the present study is to describe and compare the LEK, including the gaps, held by fishers from small ports in the SWAO, which encompasses the species distribution area to evaluate the species' interactions with artisanal fishery. Based on LEK descriptions and comparisons, we presented levels of educational actions that are needed within the studied communities.

## MATERIALS AND METHODS

### Study area

This study was developed with ten artisanal fishing communities that were selected to conduct the LEK comparison, and the communities are distributed in the Southwest Atlantic Ocean (SWAO), along the coast of three Brazilian states: Espírito Santo (ES), Rio de Janeiro (RJ), and Paraná (PR) (Figure 1, Table I). Six of these communities (Conceição da Barra, Regência, Barra do Riacho, Atafona, Peças Island, and Superagui Island) have records of the franciscana dolphin, and four of the communities are located in a record distribution gap (Piúma, Anchieta, Arraial do Cabo, and Cabo Frio). The state of ES has approximately 411 km of coastline, and the coastal municipalities of Conceição da Barra; Regência, a district of the municipality of Linhares; and Barra do Riacho, a district of the municipality of Aracruz are located in the northern region; and the coastal municipalities of Anchieta and Piúma, which is one of the ports with the largest volume of fish, are located in the southern portion of the state (Martins et al. 2009). One of the most representative ports in terms of gillnet fishing effort is located in the north of RJ state in the district of Atafona (Di Beneditto et al. 2001). The east coast of RJ is characterized by a region of great lakes and by industrial fishing in both Arraial do Cabo and Cabo Frio, with mainly hand lines, longlines and octopus traps being used in Arraial do Cabo (Silva et al. 2014). In the state of

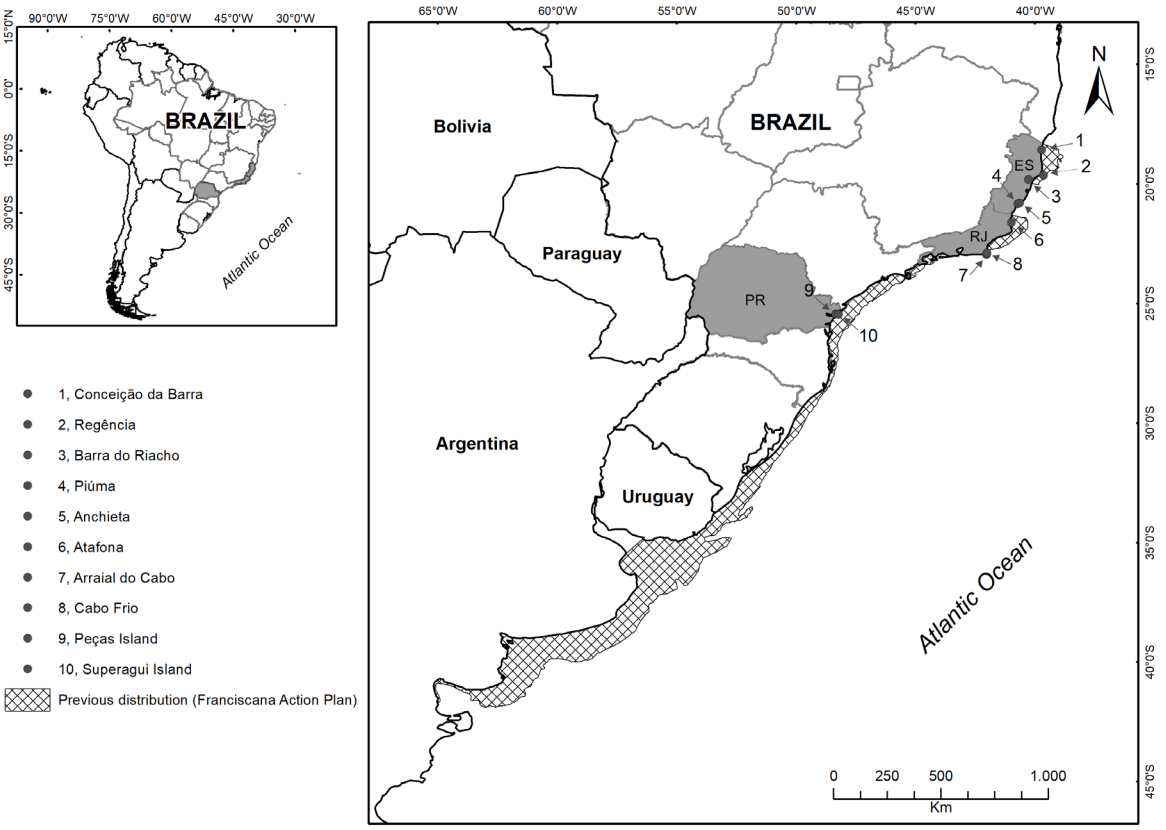


**Figure 1. Location of the fishing communities along the Southwest Atlantic Ocean (SWAO), with gaps and *Pontoporia blainvillei* occurrence areas. Image: Sérgio Carvalho Moreira.**

PR, more specifically in the Paranaguá Estuarine Complex (PEC), the preferred areas for fishing are mainly on the coasts of Superagui Island and Peças Island (Zappes et al. 2016). The coasts of Conceição da Barra, Regência, and Barra do Riacho were impacted in 2015 by a dam that released millions of iron mining waste into the Atlantic Ocean. This impact is considered a threat to franciscana dolphin (Pinheiro et al. 2019). The communities were selected according to the guidelines of the franciscana dolphin National Action Plan (NAP), which indicates priority areas for its conservation on the Brazilian coast (Rocha-Campo et al. 2010). Fishers located in the distribution gap of the franciscana dolphin were also interviewed to confirm the absence of the species.

## Procedures

We conducted 330 ethnographic interviews between 2012 and 2018 with artisanal fishers living within the study area (Table I). Considering that the number of interviews in studies that use traditional knowledge usually varies from 30 to 60 (Mason 2010), this study presents an appropriate sample size to obtain data related to LEK. However, in qualitative studies involving cultural data, when the sample size is very large, new data does not necessarily present new information related to the research objectives but only repeat the information (Mason 2010, Zappes et al. 2013a). Therefore, studies must consider the real meanings of the reports of cultural and traditional knowledge that cannot be reduced only to quantitative variables (Mason

**Table I.** Study areas and representation of interviewed artisanal fishermen.

| Brazilian region | State* | Fishing community | Geographic coordinates | Fishing institution | No. of fishermen registered with the fishing institution# | Study period and no. of interviews |
|---|---|---|---|---|---|---|
| Southeastern Brazil | ES | Conceição da Barra | 18º35'S, 39º43'O | Fishermen Colony Comandante Ferreira da Silva Z-1 | 2,500 | Jan/2016 (n = 30) |
| | ES | Regência | 19º38'S, 39º38'O | Fishermen Association of Regência | 60 | Mar/2016 (n = 30) |
| | ES | Barra do Riacho | 19º49'S, 40º16'O | Fishermen Colony Manoel Miranda Z-7 and Fishermen Association of Barra do Riacho | 900<br>150 | Feb/2016 (n = 30) |
| | ES | Anchieta | 20º48'S, 40º38'O | Fishermen Colony Marcílio Dias Z-4 | 199 | Nov/2018 (n = 30) |
| | ES | Piúma | 20º50'S, 40º43'O | Fishermen Colony Z-9 | 220 | Aug/2018 (n = 30) |
| | RJ | Atafona | 21°37'S, 40°59'O | Fishermen Colony Z-2 | 12 | Jul/2017 (n = 30) |
| | RJ | Cabo Frio | 22º52'S, 42º01'O | Fishermen Colony Z-4 | 1,470 | Jul/2018 (n = 30) |
| | RJ | Arraial do Cabo | 23º00'S, 42º00'O | Fishermen Colony Z-5 | 1,200 | Jul/2018 (n = 30) |
| Southern Brazil | PR | Superagui Island | 25°28'S, 48°13'O | Fishermen Colony Z-2 | 130 | Aug-Sep/2012 (n = 50) |
| | PR | Peças Island | 25°27'S,48°20'O | Fishermen Colony Z-2 | 62 | Mar-Apr/2012 (n = 40) |

***Captions: ES - Espírito Santo; RJ – Rio de Janeiro; and PR – Paraná. #- Values represent all fishermen registered with the fishing institutions during the study period, regardless of marine or fluvial activity.**

2010, Alves et al. 2019). Thus, our sample size is sufficient for this type of study.

The first stage of the field work was an exploratory investigation through participant observation to comprehend the daily fishing activities in each community (Malinowski 2014). This followed a pre-established but flexible standard, allowing the interviewer to make adaptations during the process (Kendall 2008); however, after the period of the exploratory investigation the questions were defined and the same questionnaire was used in all the communities. The present study was submitted to the Plataforma Brasil (Brazilian database for registering research involving humans) and to the Sistema de Gestão Nacional do Patrimônio Genético e do Conhecimento Tradicional Associado (SISGEN) and approved by the Ethics Committee (CAAE 07863218.7.0000.5542). Previous consent was requested from the interviewees' legal representatives, according to the Brazilian law that adresses this type of data collection (Federal Law 13123 from May 20, 2015). Each fisher was informed about the aims of the study, and asked if he or she agreed to participate (Librett & Perrone 2010), with an assurance of their anonymity. The vessel name of each fisher was recorded to avoid interviewing workers from the same boat.

The interviews were performed through dialogues, favoring interaction and establishing trust between interviewer and interviewee (Schensul et al. 1999, Opdenakker 2006). All fishers were interviewed individually to avoid interference from others. Following Sanches (2004), the first interviewee was selected made

with the help of a local guide. From that point on, we used the snowball method (Bailey 1982), as well as random meetings with fishers in the studied communities.

The questionnaire was divided into categories: (1) fisher's profile (age and fishing practice time), (2) identification of franciscana dolphin by him/her, (3) occurrence of incidental capture of franciscana dolphin, (4) carcass destination, and (5) causes and solutions to incidental captures. A standard semistructured questionnaire was used during the interviews and was composed of open and closed questions (n = 56 and n = 12 respectively) (Schensul et al. 1999). The same questionnaire was used with different interviewees at different periods of time (technique of repeated synchronous information) (Melo 2004). The criteria used to select the subjects were (1) being an artisanal fisher, (2) having fishing activity as the main source of income and (3) participating in artisanal fishery in one of the studied communities. At the end of each interview, we showed the fisher an illustrative board containing photographs of small cetacean species that occur within the study area, among which there was a picture of a franciscana dolphin. Visual stimulation helped with analyzing the data collected from the interviews (Miranda et al. 2007) because the use of the image made it easier for the fisher to indicate which the animals occurred in the region.

## Data analysis

Reports were organized into categories related to the questions (Ryan & Bernard 2000). This allowed us to group data by subjects (categories of the questionnaire described previously) for the classification of the reports and the interpretation of the interviews. We used the triangulation method to compare the reports, aiming to cross and filter collected data based on the methods that were used (participant observations, interviews, and illustrative boards) (Heale & Forbes 2013). Thus, it was possible to obtain maximum veracity from the reports and to establish connections through oral information.

Boolean or Classical Logic (Cockett & Manes 2009) was used to identify the fishers who could recognize the franciscana dolphin accordingly to the taxonomic entity "*P. blainvillei*", comparing the reports with the literature on body size, coloration and distribution patterns as well as identification on the illustrative board. As the last two features are linguistic variables, Boolean or Classical Logic helps with their transformation into numeric values with 0 (zero) for 'incorrect answer' and 1 (one) for 'correct answer' (Table II). The fishers who correctly indicated three or more of the species' features, including visual recognition on the illustrative board, were classified as those who recognize the franciscana dolphin.

To compare artisanal fishers' LEK about the franciscana dolphin, the studied communities were grouped in five regions: northern ES (Conceição da Barra, Regência, and Barra do Riacho), with 90 interviews; southern ES (Anchieta and Piúma), with 60 interviews; northern RJ (Atafona), with 30 interviews; the central coast of RJ (central RJ) (Cabo Frio and Arraial do Cabo), with 60 interviews; and PR (Superagui Island and Peças Island), with 90 interviews. From a percentage frequency analysis, we compared the LEK of the fishers who identified franciscana dolphins in each region (Table III).

**Table II. Criteria used for the identification of fishers who recognized franciscana dolphin to the species level (*Pontoporia blainvillei*) (Gervais & D'Orbigny, 1844).**

| Group of Variables | Functions of Pertinence/Proposition | | Linguistic Terms | Literature |
|---|---|---|---|---|
| Body size | Incorrect | Less than 100 cm | 'truly small, not larger than a meter' | Di Beneditto & Ramos 2001, Rosas & Monteiro-Filho 2002, Culik 2011, Jefferson et al. 2015 |
| | Correct | Between 100 and 170 cm | 'up to one meter and sixty centimeters' | |
| | Incorrect | Greater than to 180 cm | 'more than two meters' | |
| Body coloration | Incorrect | Shades of green, black, dark gray on the back with a white abdomen, dark gray, gray, silver, shades of blue, shades of lead | 'it is dark gray on the back with a white belly,' 'greenish gray,' 'it is kind of bluish,' 'looked silver,' 'it is very dark,' 'the porpoise has a color that looks like gunpowder, like lead' | Perrin et al. 2008, Secchi et al. 2002a, Trimble & Praderi 2006, Culik 2011, Jefferson et al. 2015 |
| | Correct | Light brown, shades of pink, light red, light yellow, light gray | 'it is brownish,' 'it is pinkish,' 'it looks like a very light gray,' 'the porpoise has a yellowish color' | |

| Group of Variables | Functions of Pertinence/ Proposition | | Linguistic Terms | Literature |
|---|---|---|---|---|
| Distribution pattern | Correct | Northern coast of Espírito Santo | 'the beach here in the north' | Siciliano et al. 2002, Freitas Netto & Barbosa 2003, Secchi et al. 2003b, Freitas Netto & Di Beneditto 2008, Culik 2011, Cunha et al. 2014, Amaral et al. 2018 |
| | | Rio Doce River mouth | 'exactly in front of the river mouth' | |
| | | Regência coast | 'only close to Regência' | |
| | | Barra do Riacho Coast | 'in front of Barra do Riacho' | |
| | | Northern coast of Rio de Janeiro | 'in the north of Rio de Janeiro, close to the border with Espírito Santo' | Di Beneditto & Ramos 2001, Siciliano et al. 2002, Di Beneditto 2003, Secchi et al. 2003b, Culik 2011, Cunha et al. 2014, Lavandier et al. 2015, Amaral et al. 2018 |
| | | Atafona coast | 'in front of Atafona' | |
| | | Cabo de São Thomé | 'close to Cabo de São Thomé, in the São Thomé Lighthouse' | |
| | | Palmas Island | 'in the surroundings of Palmas' | Rosas & Monteiro-Filho 2002, Secchi & Wang 2002, Secchi et al. 2003b, Culik 2011, Cunha et al. 2014, Amaral et al. 2018 |
| | | Barra da Baía | 'more often at Barra' | |
| | | Inner area of the bay and CEP* | 'in the middle of the canal, near Paranaguá, also between Mel Island and Peças Island' | |
| | | Superagui coast | 'in the coast of the beach and further out, close to Superagui' | |
| | | Lajinha and Coroa beaches | 'at Lajinha Beach, where the tower collapsed' | |
| | | Ponta do Areão beach | 'at Ponta do Areião and further out' | |
| | | Pontal do Paraná boast | 'in the middle of the canal, along the coast, until Mel Island' | |

**Table II.** Continuation.

| Group of Variables | Functions of Pertinence/Proposition | | Linguistic Terms | Literature |
|---|---|---|---|---|
| Distribution pattern | Incorrect | Southern coast of Bahia | 'it appears in southern Bahia, in Abrolhos' | Secchi et al. 2003b, Cunha et al. 2014, Amaral et al. 2018 |
| | | Mesoregion coast, southern coast and along the Espírito Santo coast | 'in front of Vitória,' 'it appears in front of Piúma and Anchieta,' 'it is along the entire Espírito Santo coast' | Secchi et al. 2003b, Cunha et al. 2014, Amaral et al. 2018 |
| | | Eastern coast of Rio de Janeiro, Cabo Frio coast, Arraial do Cabo coast | 'near Papagaios Island, between Arraial do Cabo and Cabo Frio,' 'in Arraial do Cabo, close to the stone' | Secchi et al. 2003b, Cunha et al. 2014, Amaral et al. 2018 |

**Table III. Comparison of LEK by status areas related to franciscana dolphin (*Pontoporia blainvillei* Gervais & D'Orbigny, 1844).**

| Percentage | Status | Region | Type of coastline | Why the fishers may or may not identify the species |
|---|---|---|---|---|
| 0% | No identification | Central RJ* | Cove | Distribution gap in the species |
| 1% to 10% | Extremely low identification | Southern ES* | Exposed | Distribution gap in the species |
| 11% to 49% | Partial identification | Northern ES* | Exposed | The physical and behavioral features of franciscana dolphin, the characteristics of the coastline and the northern limit of the species distribution, where the population probably shows lower abundance |
| Over 50% | Good identification | Northern RJ * | Exposed | The physical and behavioral features of franciscana dolphin, the characteristics of the coastline and incidental captures where fishers manipulates the live specimen or its carcass |
| Over 50% | Good identification | PR* | Estuary | The physical and behavioral features of franciscana dolphin and the characteristics of the coastline considered the preferred habitat for franciscana dolphin |

***Caption: Central RJ – Cabo Frio and Arraial do Cabo; Southern ES – Anchieta and Piúma; Northern ES – Conceição da Barra, Regência and Barra do Riacho; Northern RJ – Atafona; PR – Superagui Island and Peças Island.**

## RESULTS

The interviewed fishers were mostly men ranging from 15 to 78 years old, and fishing practice time varied from 4 to 73 years. Only one woman was interviewed, in Regência, ES. The educational level was low in all studied communities: 64.2% (n = 212) of the interviewees attended only elementary school, went to school for less than 5 years, or had never been in school. The boats were made of wood or aluminum. In terms of fishing gear, they had nets (trawl net, gillnet, cast net, squid net, 'jerivau/gerival,' artisanal sieve, and 'cambal and lanço' (beach sieve), handlines (longline and 'zagarejo'), traps (octopus trap), and sticks and hooks (tuna fishery) (Table IV). Fishers cited bony and cartilaginous fish, as well as crustaceans as their main fishing targets.

In northern ES, artisanal fishing occurs mainly close of the Rio Doce river mouth, extending towards the extreme north of the state, up to 30 meters deep. In southern ES, the main fishing areas extend from the Guarapari coast (20°38'S - 40°27'W) to northern RJ in the

**Table IV. Characteristics of the artisanal fisheries in the southeastern and southern regions of Brazil according to the reports of the interviewed fishers.**

| Location* | Period of fishery | Fishery gear (in order of preference) | Boats |
|---|---|---|---|
| CB | Day | Trawl net (n=22)<br>Gillnet (n=18)<br>Handline (n= 15)<br>Longline (n= 5)<br>Cast net (n= 1) | Type: wooden boat with marry and deck; wooden boat without marry and deck; aluminum boat, trawler, and canoe.<br>Length: 5 – 13 m.<br>Motor: 3 - 180 HP or rowing. |
| RG | Day | Gillnet (n= 30)<br>Longline (n= 16)<br>Handline (n= 8)<br>Trawl net (n= 3) | Type: wooden boat with marry and deck; wooden boat without marry and deck; trawler, and canoe.<br>Length: 3.5 – 11.8 m.<br>Motor: 5 - 25 HP or rowing. |
| BR | Day | Trawl net and gillnet (n= 23)<br>Handline (n= 19)<br>Longline (n= 15) | Type: wooden boat with marry and deck; wooden boat without marry and deck; trawler, and aluminum boat.<br>Length: 4 – 12 m.<br>Motor: 11 - 88 HP or rowing. |
| AN | Day | Handline (n= 14)<br>Longline (n= 13)<br>Trawl net (n= 8)<br>Gillnet (n= 2) | Type: wooden boat without marry and deck and trawler.<br>Length: 6 – 15 m.<br>Motor: 10 - 229 HP. |
| PM | Day and night | Gillnet (n= 25)<br>Trawl net and handline (n= 7)<br>Longline (n= 3) | Type: wooden boat without marry and deck, trawler, and canoe.<br>Length: 5 – 9 m.<br>Motor: 6 - 33 HP or rowing. |
| AT | Day and night | Gillnet (n= 30) | Type: wooden boat with marry and deck; wooden boat without marry and deck, trawler, and canoe.<br>Length: 3.5 – 13 m.<br>Motor: 18 – 360 HP or rowing. |
| CF | Day and night | Handline (n= 41)<br>Longline (n= 15)<br>Octopus trap (n= 2)<br>Gillnet (n= 1)<br>Stick and hook for Tuna fishery (n=1) | Type: wooden boat with marry and deck; wooden boat without marry and deck.<br>Length: 5 – 15 m.<br>Motor: 22 – 366HP. |
| AC | Night | Handline (n= 26)<br>Longline (n= 15)<br>Squid net (n= 8)<br>'Zagarejo' (similar to hand line for squid) (n= 4)<br>Trawl net (n= 1) | Type: wooden boat with marry and deck; wooden boat without marry and deck, and trawler.<br>Length: 5 – 12.4 m.<br>Motor: 6 – 140HP. |
| SI | Day | Gillnet (n= 38)<br>Trawl net (n= 37)<br>Longline (n= 13)<br>'Lanço' (similar to beach siege) (n= 4)<br>'Cambal' (similar to beach siege) (n= 2)<br>Artisanal siege (n=2)<br>'Jerivau' or 'gerival' (artifact formed by a stick and gillnets) (n= 1) | Type: wooden boat, canoe, and aluminum boat.<br>Length: 3- 18 m<br>Motor: 7 - 60 HP or rowing. |

**Table IV. Continuation.**

| | | | |
|---|---|---|---|
| PI | Day | Gillnet (n= 37)<br>Longline (n= 32)<br>Trawl net (n= 10)<br>'Jerivau' or 'gerival' (artifact formed by a stick and gillnets) (n= 4)<br>'Cambal' (similar to small Trawling net) (n= 2)<br>Cast net (n= 2) | Type: wooden boat with marry and deck; wooden boat without marry and deck, and canoe.<br>Length: 3 – 11 m<br>Motor: 5 - 180 HP or rowing. |

***Caption: CB – Conceição da Barra; RG – Regência; BR – Barra do Riacho; AN – Anchieta; PM – Piúma; AT – Atafona; CF – Cabo Frio; AC – Arraial do Cabo; SI –Superagui Island; PI – Peças Island.**

municipality of Macaé (22º22'S-41º47'W), with depths varying from 18 to 70 meters. In northern RJ, fishing activity occurs mainly in the coastal areas of the Campos Basin, from 6 to 70 meters deep, between the cities of Macaé and São João da Barra (21º38'S-41º03'W). In central RJ, fishing extends from 10 to 200 meters in depth between the Campos Basin and Macaé. In PR, the fishery occurs from the Paranaguá Estuarine Complex to Superagui Island, up to 13 meters in depth. The areas described by the fishers are different, and they act in open areas and/or areas protected from the tides.

Among those who were able to identify franciscana dolphin to the species level (n = 95; 45.2% of 210 interviews without counting the gaps), 23 (25.5%) fishers are from northern ES; one (1.6%) is from southern ES (Anchieta); 20 (66.6%) are from northern RJ; and 51 (56.6%) are from PR. Percentages were calculated from the number of interviews conducted in each region. Among the 120 fishers that works within the species distribution gap, none could identify the species, except for one fisher [southern ES - Piúma (n = 30) and Anchieta (n = 29); central RJ - Cabo Frio (n = 30) and Arraial do Cabo (n = 30)]. The only fisher who recognized it was from Southern ES and described the species according to sightings while fishing close to the Rio Doce river mouth (northern ES). Thus, these areas were classified as: 'no identification' - central RJ; 'extremely low identification' – southern ES; 'partial identification' – northern ES; and 'good identification' – northern RJ and PR (Table III). Regarding ethno-denomination, the species is recognized by the fishers as a porpoise, 'tuninha,' dolphin, 'boto,' 'bicuda,' 'vermelho,' 'boto-cachimbo,' and 'boca de panela.' From these results, the following analyses were based on reports from the 95 fishers who recognized the species.

Interviewees described positive (n = 15), negative (n = 8), and neutral (n = 2) interactions involving franciscana dolphin. Positive interactions were related to the fact that the dolphin *'helps to find fish and shrimp*,' *'makes fish approach the net*,' and *'makes the fisherman happy when he sees it'* [northern ES (n = 7), northern RJ (n = 2), and PR (n = 6)]. Negative interactions were related to incidental captures and, thus, to the damage caused to the nets, described as: *'the animal destroys the net'* [northern ES (n = 2); northern RJ (n = 3), and PR (n = 3)]. Neutral interactions did not interfere with the fishing routine, and were described as *'the porpoise does not approach the boat*' and *'the porpoise does not attack, staying in the water*' [PR (n = 2)].

When interviewees were asked about the occurrence of incidental captures of the franciscana dolphin, 87.4% (n = 83) reported these events [northern ES (n = 23), southern ES (n = 1), northern RJ (n = 20), and PR (n = 39)], and gillnet were indicated the only gear type responsible

for these captures. According to some of the fishers, the occurrence of incidental capture is rare (n = 33) [northern ES (n = 7), southern ES (n = 1), and PR (n = 25)], and is caused by the fact that the dolphin does not perceive ('*It cannot see*') the net in the water.

Fishers from northern ES [Regência (n = 7) and Conceição da Barra (n = 1)] reported that harpoon fishing for franciscana dolphin was common, but the practice ended when environmental inspections increased 15 years ago. Incidentally captured dolphins are mostly discarded in the sea [northern ES (n = 11), southern ES (n = 1), northern RJ (n = 16), and PR (n = 35)]. Furthermore, some uncommon uses of the franciscana dolphin's carcasses were: i) fat and muscle tissue being used as bait for shark fishing with longlines [northern ES (n = 7), northern RJ (n = 7), and PR (n = 2)]; ii) carcasses being delivered to researchers from conservation programs and management and inspection programs [northern ES (n = 8), northern RJ (n = 1), and PR (n = 2)]; and iii) the animals being used as food [northern ES (n = 2), northern RJ (n = 2), and PR (n = 1)]. Twelve fishers reported more than one use for the dolphins, which explains why the number of answers (n = 95) was greater than the number of fishers who described incidental captures of the species (n = 83).

Most fishers (n = 52) reported that they did not know how to avoid incidental capture, with 29 of them saying that there is no solution, 13 stating that the solution is to stop gillnet fishing, and one indicating that fishing at night could be a solution. The number of responses (n = 95) was greater than the number of reports of the dolphins (n = 83) because two interviewees gave more than one answer.

## DISCUSSION

The aim of this study was to describe the perception of artisanal fishers from southern and southeastern Brazil toward to the species and to comprehend how they interact with it, combining researchers' information and local actors. This study reaffirms the importance of fishers' LEK as a qualitative tool to obtain data about the interaction between artisanal fisheries and the franciscana dolphin, as indicated in Rosa et al. (2012) and Zappes et al. (2016). Understanding and quantifying fishers knowledge about cetaceans can increase conservation actions throughout the distribution areas of species (Zappes et al. 2013b).

Less than 30% of the interviewees from this study (n = 330) were able to identify franciscana dolphin at the species level. For the 120 fishers from southern ES (Piúma and Anchieta) and central RJ (Arraial do Cabo and Cabo Frio), which are located in a distribution gap of the species, this result was expected (Table III), as the species habitat does not occur withing the fishing areas. The physical and behavioral features of the franciscana dolphin, together with the characteristics of the fishing zones that are present within its distribution area, can hinder observations of the species in its habitat. It is a small dolphin, especially when compared to other small cetaceans in the same area, such as the "boto" or Guiana dolphin (*Sotalia guianensis;* van Benédén, 1864) (Di Beneditto et al. 2001); its body coloration allows it to blend in with the turbid water in coastal areas close to river mouths, which is its preferred habitat; and the species swims in small groups, usually with two to four individuals, and does not jump out of the water (Siciliano et al. 2002, Zappes et al. 2016). Additionally, in fishing areas where the coast line is exposed, such as the fishing zone in northern ES, coastal waters are

generally more agitated by winds and marine currents. Furthermore, this area is influenced by the river mouths of Rio Doce increasing local water turbidity. Therefore, species morphology, behavior and habitat features may hinder the observation and recognition of this inconspicuous dolphin.

Fishers from northern RJ and PR provided a 'good identification' of the Franciscana dolphin and of environmental conditions that facilitate the visualization of the specimens at the sea. Northern RJ has an exposed coast line and its waters are influenced by the river mouth of Rio Paraíba do Sul, which hinders the observation of the species. However, in this region, there are regular reports about incidental captures of franciscana dolphin with gillnets, which are the main gear type responsible for its bycatch (Di Beneditto et al. 2001, Di Beneditto 2003, Siciliano et al. 2019). During capture events, a fisher must manipulate the live specimen or its carcass, which would allow a direct and detailed observation of its features such as body size and coloration. This would lead to a more accurate ability to recognize the species. On the other hand, fishers who use trawl nets, lines, or traps, for example, would have an extremely low probability of incidentally capturing this dolphin during their fishing activity. Therefore, their contact with the animal would only be possible through at sea observations, which are not easy due to the reasons explained above. Fishers from PR who participated in this study work in the Paranaguá Estuarine Complex. This zone is considered a preferred habitat for franciscana dolphin in the state (Rosas et al. 2002, Santos et al. 2009, Zappes et al. 2016), and it has a sheltered coastal pattern, with coves, estuaries and calm waters. This would favor species observations and recognition by local fishers.

Not all fishers who work in the franciscana dolphin's distribution area can identify it. For example, the ability of workers from northern ES to recognize the species was 'partial.' They fish mainly around the Rio Doce river mouth, where there are records of dolphin sightings (Siciliano et al. 2002, 2019, Amaral et al. 2018, Pinheiro et al. 2019, Rupil et al. 2019, Mayorga et al. 2020). However, the region is at the northern limit of the species distribution, where the population probably has a relatively low abundance (Secchi et al. 2003a, Danilewicz et al. 2012, Amaral et al. 2018). This would decrease the chances of observing the franciscana dolphin, either by a sighting or by incidental capture. Moreover, the preferred fishing gear type in the area may also play a role, as trawl nets are more frequently used and is an activity that demands maximum attention from the fishers (Zappes et al. 2016). The practice of this fishery can reduce the chances of observing the marine environment and, consequently, locating the franciscana dolphin.

Positive interactions between artisanal fisheries and the franciscana dolphin were related to the fact that the animal helps identify shoals for the fishers due to its feeding behavior, as described in the literature (Jefferson et al. 2015, Zappes et al. 2016). This type of interaction involving other small cetacean species has already been reported in Brazilian waters, e.g. for the the common bottlenose dolphin (*Tursiops truncatus*; Montagu, 1861) (Zappes et al. 2011, 2014), and the Guiana dolphin (Przbylski & Monteiro-Filho 2001, Zappes et al. 2010).

Based on the interviewees' perceptions, negative interactions with the dolphin involve the damage caused to fishing gear due to incidental capture. Gillnets were noted as being the only artifact responsible for incidental capture in the study area, which is in agreement with information in the literature. Studies that analyzed carcasses from this species throughout its distribution have indicated that gillnets are

the main cause of incidental captures (Bertozzi & Zerbini 2002, Secchi et al. 2002b, 2003b, Di Beneditto 2003, Rupil et al. 2019, Mayorga et al. 2020).

According to the fishers, the main cause of incidental capture is the dolphin's inability to accurately perceive the presence of fishing gear in the water. This scenario is related to the tension of the net material, which makes its fibers imperceptible (Tregenza et al. 1997). As stated by Dawson (1991), small cetaceans get stuck not because their sonar system fails in detecting the net, but because they can occasionally get confused, as they do not use that system all the time during the day. The main problem is related to the perception of the obstacle, and not its detection, as the animals can perceive it as a penetrable object (Au & Jones 1991, Tregenza et al. 1997). It is also possible that the dolphins cannot distinguish the sonar reflection as belonging to prey or to nets, which would lead to its entanglement during feeding (Au & Jones 1991).

The use of pingers and light emitting diodes (LEDs) (a visual cue) in gillnets is another action that can minimize the number of incidental franciscana dolphin captures. The sound-pulse emissions of pingers can make the gear perceptible to animals (Barlow & Cameron 2003, Brotons et al. 2008, Carreta et al. 2008, Mangel et al. 2013). However, the effect of these pulses on targeted fish species is a controversial subject (Dawson et al. 1998, Kastelein et al. 2007, Culik 2011). Another technique that uses LEDs installed on gillnets reduces bycatch of the small cetaceans, seabirds and sea turtles, and the catch-per-unit-effort of the target species is not negatively affected by the presence of these LEDs (Mangel et al. 2018, Bielli et al. 2020). In addition, the cost of the pingers and LEDs would require a financial investment that is not feasible for Brazilian artisanal fishers, meaning that the government or research institutions would have to provide subsidies if their use is encouraged. However, it is possible to use recycled plastic and glass bottles to create acoustic reflectors and mechanical alarms. Recycled 500 ml plastic bottles produce an acoustic reflection when exposed to the dolphin click. Recycled 350 ml glass bottles with a suspended metal pendulum bolt produce the "clinking" sound. Therefore, these 'bottle reflectors' could facilitate gillnet detection by dolphins to avoid entanglement and represent a low-cost method accessible to the artisanal fishers (IWC 2019). Studies can evaluate the potential effects of using pingers, LEDs and recycled plastic and glass bottles to compare their effectiveness as measures to reduce bycatch beyond their implementation costs. Defining fishing exclusion zones to conserve the species could be an alternative to minimizing incidental dolphin captures. Nevertheless, this approach would interfere with fishing activities and the economy of communities that depend on fishing. Another possibility is fishing management through changes in gillnet use patterns, as suggested by Zappes et al. (2013b) for the conservation of the southern right whale (*Eubalaena australis;* Desmoulins, 1822) in southern Brazil. Positioning the nets in deeper waters, going beyond 30 meters, which is the preferred habitat of the franciscana dolphin, could decrease the number of incidental captures. The viability of this change in fishing practice would depend on the autonomy of the vessels, which would need to operate in deeper waters, further from the coastline.

Fishing management is mostly based on scientific data, with little consideration of the LEK of fishing communities (Andrew et al. 2007). This unidirectional approach leads to inefficient actions, as fishers are excluded from decision-making processes in their own territory. Thus, local knowledge and institutions that represent

these workers must be part of these processes to ensure a social identity is attached to the actions developed based on the comanagement of fishing activity and associated resources, which would include incidentally captured organisms (Pomeroy et al. 2007, Ota & Just 2008).

The carcasses of incidentally captured dolphins are usually discarded at sea. Fishers avoid keeping them on board, as injuring or capturing cetaceans is prohibited in Brazil (Brasil 1987, Federal Law 7643 from December 18, 1987). Using the fat and muscle tissue obtained from the carcasses as bait for shark fishing and food is not a common practice, as demonstrated through the interviews, and there is probably no intention to capture dolphins for this purpose. Although this practice has been described in Brazil since the 1990s, it involves limited and specific occurrences (Lodi & Capistrano 1990, Zappes et al. 2009, 2014). According to fishers, occasionally, incidentally captured dolphin carcasses are transferred to researchers who work on conservation projects, as well as for management and inspection agencies. This scenario could be a result of actions to coordinate fishers and scientists; however although this is efficient, this coordination is rare on the Brazilian coast (Zappes et al. 2009, 2016).

The status of need for educational activities related to the impact of fisheries on *P. blainvillei* was defined based on the local knowledge in the study areas (Table V). The ranking used the criteria established in Table V to identify areas where educational activities are needed. Additionally, Table VI presents proposals for conserving the species together with traditional fishing communities.

## CONCLUSIONS

Artisanal fishers LEK about franciscana dolphin within its distribution area in southern and southeastern Brazil is influenced by the probability of observing or having contact with the species in fishing zones. In this sense, LEK is influenced by the presence of the species in the zones (distribution areas vs gaps), type of fishing gear (gillnets vs other artifacts), and habitat features (sheltered sea vs open sea). These conditions facilitate or hinder the observation/contact (and the correct recognition) with of the species, whose physical/behavioral characteristics already limit its observation in the wild.

When fishers had favorable conditions for recognizing the species, they could identify its features and provide information about its interactions with the fishing activity. Thus, we confirmed LEK as a tool for data generation about *P. blainvillei* populations when its habitat overlaps with areas of fishing activity in the Southwest Atlantic Ocean (SWAO).

Incidental captures while fishing was the main cause of franciscana dolphin mortality within its distribution area. It is therefore important to understand traditional knowledge to facilitate the approach of researchers with communities so that they can assist in the comanagement of fishery practices, focused on the conservation of the species. It is believed that environmental education about this animal in the studied communities could minimize the effects of these captures on the species populations or, at a minimum, allow a regular assessment of its mortality. This study contributes to the goals of the Brazilian government aiming to conserve of the franciscana dolphin.

**Table V. Comparison of artisanal fisher's LEK about the franciscana dolphin (*Pontoporia blainvillei*) and status of the need for educational and conservation actions in the study area.**

| Region | Identification | Interaction | Need for educational and conservationist actions |
|---|---|---|---|
| Northern ES | Partial | Poorly described | High: To incidental captures, areas of franciscana dolphin occurrence, and areas that are used in artisanal fisheries need to be monitored to identify overlapping zones and obtain more data about threats based on scientific knowledge and LEK as sources of joint solutions to reduce accidental capture. |
| Southern ES | Extremely low | Not described | None: There is a distribution gap for the species; thus, there is no need for activities related environmental education. |
| Northern RJ | Good identification | Well described | Low: Monitoring incidental captures and searching for joint solutions are needed to reduce them. |
| Central RJ | No identification | Not described | None: There is a distribution gap for the species; thus, there is no need for activities related to environmental education. |
| PR | Good identification | Partially described | Moderate: Actions with the communities to monitor the incidental capture of the franciscana dolphin are needed, and studies related to LEK about the species need to be maintained to deepen the dolphin/fishers relationship and to identify alternatives for new fishing techniques. |

**Table VI. Proposed actions aimed at the conservation of the franciscana dolphin.**

| Proposal | Stakeholders involved | Why? | How? |
|---|---|---|---|
| Ensure the identification of franciscana dolphin by fishers | Researchers studying the species (both from universities and nongovernmental organizations) and environmental agencies | To guarantee the identification of the species by the fishers who work in their areas of occurrence because from this recognition it will be possible to implement measures aimed at conservation | Implementing constant educational campaigns that inform fishers about the biology and ecology of franciscana dolphins, with language accessible to fishers. Such campaigns should take place in areas used by fishers, such as fishermen's institutions and fish market |
| Develop and test franciscana dolphin exclusion devices to be used in conjunction with artisanal fishing devices | Researchers who work directly and indirectly with artisanal fisheries (for example, fishing engineers, biologists, oceanographers), environmental agencies, and artisanal fishers | To test the effectiveness of alternative equipment and devices to exclude cetacean in gear used in artisanal fisheries and to avoid incidental capture. The testing of this equipment is important for this to occur or improve. | Encouraging the development of research by fishery gear designers using low-cost and high-efficiency material that would be viable for fishers; development and test of this equipment with fishers |
| Map preferential areas used by franciscana dolphins in Brazil | Researchers who work directly and indirectly with artisanal fisheries, both technical and sociocultural aspects, environmental agencies, and artisanal fishers | To identify areas of greater and lesser risk for incidental capture of franciscana dolphins and to indicate such areas to artisanal fishers to avoid bycatch | Encouraging the development of research related to the biology, ecology and ethnobiology of the franciscana dolphin, cross-information through traditional and scientific knowledge about preferred areas of the species; dissemination of information on the distribution of the species with accessible language for both fisher communities and environmental agencies |

**Table VI. Continuation.**

| | | | |
|---|---|---|---|
| Encourage compliance with laws related to artisanal fisheries and cetaceans in Brazil | Environmental inspection agencies, specific or Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) | To comply with Federal Law No. 11 959, June 29, 2009, which regulates fishery activities; Decree-Law No. 794, October 19, 1938, which regulates fisheries in the country; and Federal Law no. 7643, December 18, 1987, which prohibits cetacean fisheries in Brazilian jurisdictional waters | Developing fishery legislation in conjunction with individuals involved in artisanal fisheries, and disseminating information on the importance of marine fauna, including cetacean, in language accessible to the community |

| Proposal | Stakeholders involved | Why? | How? |
|---|---|---|---|
| Strengthen partnerships between fishers, researchers, and environmental managers | Researchers working in the socioenvironmental area, environmental agencies, artisanal fishers, and nongovernmental organizations | To establish trust among stakeholders to facilitate the development and implementation of comanagement aimed at the conservation of the franciscana dolphin, working together with fishing communities | Conducting meetings aimed at comanaging the dialogue between stakeholders, combining the knowledge of fishermen with the technical knowledge of researchers in relation to the biology and ecology of target and nontarget fishing species; developing legislation proposals based on the knowledge of fishermen and environmental agencies |
| Increase radio communication between stakeholders | Members of fishery communities, employees of fishing institutions, civil servants of the environmental office of city hall and environmental management bodies, researchers from universities, and nongovernmental organizations | To request an order to obtain real-time information related to artisanal fishery activity and bycatch of franciscana dolphins to estimate the impact of fisheries on this dolphin, and this would enable immediate assistance to fishers in cases of adverse situations | Registering information on fishery activities (fishery gear used, environmental conditions, target species, number, and identification of vessels at sea) and incidental capture of franciscana dolphin (characteristics of the entangled animal and the artifact that caused the capture) |
| Provide instructions on the correct disposal of materials derived from fishing | Artisanal fishers, employees of fishing institutions, civil servants of the environment office, researchers from universities, and nongovernmental organizations | To minimize the irregular disposal of tailings derived from fisheries into the environment, thus minimizing the negative effects of ghost nets on franciscana dolphin and other animals that are not the target of fisheries (for example, other cetaceans, goliath grouper, and turtles) | Conducting monthly meetings in areas used by fishers, such as fisher's institutions, community associations and fish markets, to determine the proper disposal of waste derived from fisheries, with special attention to the language used, which should be accessible to the interested parties |

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