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Fishers' knowledge as a source of information about the estuarine dolphin (*Sotalia guianensis*, van Bénéden, 1864)

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Abstract Fishers' local ecological knowledge (LEK) is an additional tool to obtain information about cetaceans, regarding their local particularities, fishing interactions, and behavior. However, this knowledge could vary in depth of detail according to the level of interaction that fishers have with a specific species. This study investigated differences in small-scale fishers' LEK regarding the estuarine dolphin (*Sotalia guianensis*) in three Brazilian northeast coastal communities where fishing is practiced in estuarine lagoons and/or coastal waters and where dolphin-watching tourism varies from incipient to important. The fishers (N=116) were asked about general characteristics of *S. guianensis* and their interactions with this dolphin during fishing activities. Compared to lagoon fishers, coastal fishers showed greater knowledge about the species but had more negative interactions with the dolphin during fishing activities. Coastal fishing not only offered the opportunity for fishers to observe a wider variety of the dolphin's behavior, but also implied direct contact with the dolphins, as they are bycaught in coastal gillnets. Besides complementing information that could be used for the management of cetaceans, this study shows that the type of environment most used by fishers also affects the accuracy of the information they provide. When designing studies to gather information on species and/or populations with the support of fishers, special consideration should be given to local particularities such as gear and habitats used within the fishing community.

Keywords Local ecological knowledge · Local classification · Cetaceans · Small-scale fishing · Incidental catch · Fishers' perception

Introduction

The estuarine dolphin (*Sotalia guianensis*, van Bénéden 1864) is a small cetacean (suborder: Odontoceti, family: Delphinidae) that typically does not grow over 220 cm (Flores and Da Silva 2009). *S. guianensis* is described as a coastal species that prefers estuaries and bays, but could also occur in mangroves and rivers (Cremer et al. 2012; Monteiro-Filho et al. 2008). The species is distributed nearly all over the Atlantic coast of South and Central America (Borobia et al. 1991; Carr and Bonder 2000; Simões-Lopes 1988) and several aspects of its biology (conservation, distribution, habitat, feeding ecology, etc.) have been studied in its distribution

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range for many decades (Bossenecker 1978; Rossi-Santos et al. 2006; Cremer et al. 2012).

Nevertheless, *S. guianensis* is still classified as "data deficient" by the International Union for Conservation of Nature (IUCN), indicating that there is insufficient information to define the conservation status of the species. Whereas the IUCN Red List classifies species according to their global conservation status, it could disregard potential threats at a regional level. In fact, species that are widely distributed are hardly ever considered threatened or endangered, which by no means implies they are safe at a regional level. For example, *S. guianensis* is already included in regional lists of endangered species provided by some Brazilian states (Chiarello 2010).

Fishers' local ecological knowledge (LEK) can be an important tool to gather missing information about local populations of this species, particularly through small-scale fishers who usually fish close to the coast, the occurrence area for *S. guianensis*. LEK is a practical and specific knowledge developed for each place (Yli-Pekolnen and Kohl 2005), which can be more detailed if it concerns species of direct interest and/or use (Begossi 2008), such as fishing resources. In small-scale fishing communities, LEK could supplement scientific information about the feeding ecology, reproduction, and migration of different aquatic species (Davis and Wagner 2003; Silvano and Begossi 2012). Such knowledge could also be used to complement management plans and foster the monitoring of populations (Silvano and Begossi 2012).

However, there has been no specific investigation about the extent to which LEK could be influenced by the fishing areas most used by fishers or by the fishers' exposure to or participation in tourism. For instance, information provided by industrial fishers who spend days at sea might differ from information provided by fishers who operate in coastal waters. Likewise, in places with developed dolphin-watching tourism, fishers will probably be more exposed to information regarding the species regardless of their level of interaction with dolphins.

In the present study, the three studied communities (Tibau do Sul, Pipa and Baía Formosa) belong to neighboring villages in Brazil but differ in terms of the fishing areas that fishers usually use (estuarine lagoon or coastal waters) and the level of development of dolphin-watching tourism (do Valle and Melo 2006). Here, it was analyzed whether the different fishing environments and levels of tourism resulted in changes in small-scale fishers' LEK, controlling for their socioeconomic characteristics. The study examined the fishers' popular classification and perceived general characteristics (e.g., species' size and color) of *S. guianensis*, as well as the types of interactions between fishers and this species. Differences in fishers' LEK could be due to the different interactions with *S. guianensis* in different environments and/or the access to information provided by tourism.

Coastal fishers are expected to have higher LEK than lagoon fishers because of the greater complexity of the coastal environment and for being in closer contact with *S. guianensis* due to incidental catches in gillnets likely to happen in coastal waters (Lodi and Barreto 1998). Tourism is also expected to affect the fishers' correct identification and naming of *S. guianensis*, as this knowledge would be required to teach tourists. Lagoon fishers are likely to perceive this dolphin as more "useful", due to an expected fishing cooperation, where dolphins could push schools to fishing nets during its foraging, as observed in other studies (Peterson et al. 2008; Pryor and Lindbergh 1990). This could result in fishers recognizing *S. guianensis* based on its feeding habits. On the other hand, coastal fishers are likely to recognize this dolphin by its morphological features, based on their interactions during incidental catches.

Knowing if and how the environment used by fishers affects their knowledge could be an important contribution to the direction of future studies regarding LEK and its reliability (Huntington 2000; Silvano and Begossi 2010). Identifying factors that affect its reliability could be a step forward in enriching biological and ecological information about multiple species, habitats, and ecosystems, besides contributing to better cetacean management initiatives.

Materials and methods

Study area

The three studied communities, Tibau do Sul (S6°11′12.72″, W35°05′29.66″), Pipa (S6°13′43.71″, W35°02′54.39″) and Baía Formosa (S6°22′03.18″, W35°00′29.30″), lie on the southern coast of Rio Grande do Norte in the Brazilian northeast (Fig. 1). Pipa and Tibau do Sul belong to the same municipality and are 8 km apart, while Baía Formosa is an independent village about 30 km south of Pipa.

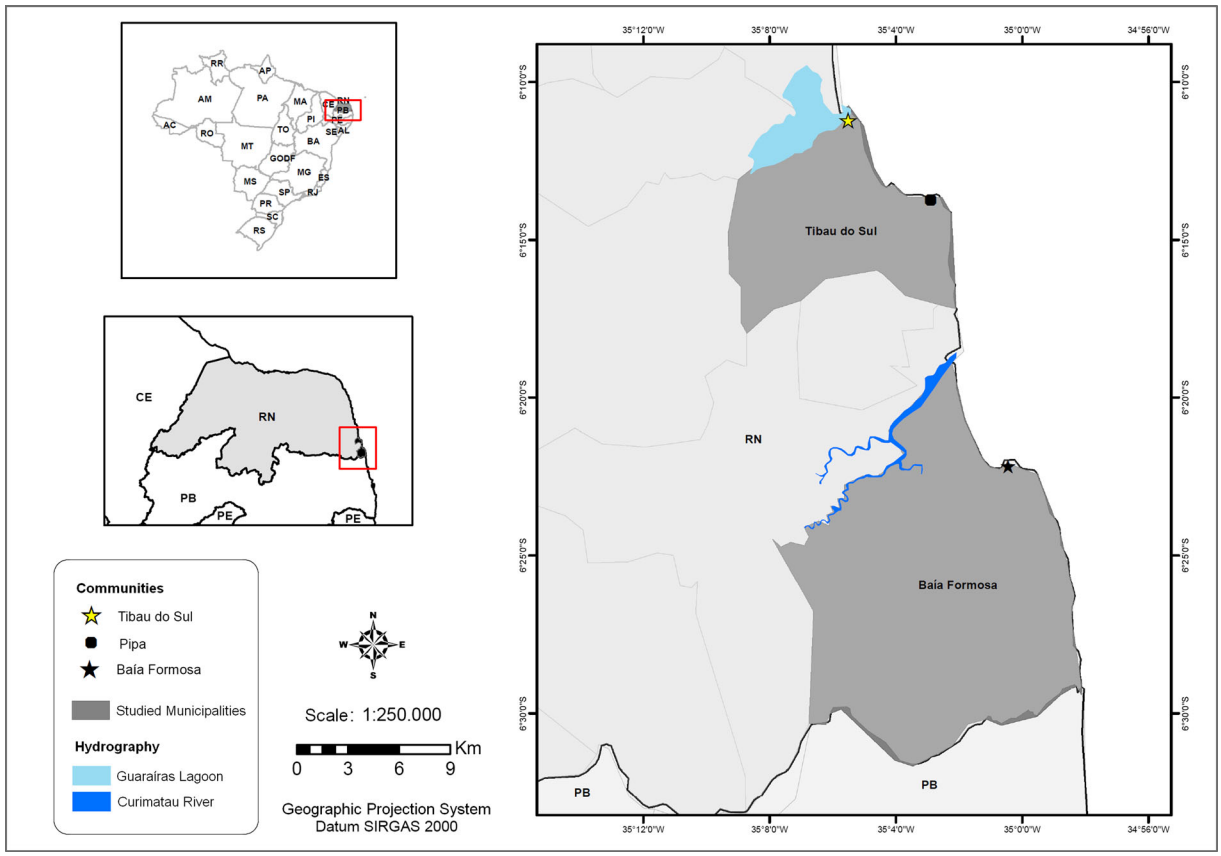

Fig. 1 Studied communities: Tibau do Sul, Pipa, and Baía Formosa. *Top left*: Rio Grande do Norte, Brazil. *Bottom left*: Study area in Rio Grande do Norte

Although the communities are in the same region, they vary in terms of their main fishing environment (estuarine lagoon or coastal waters), and tourism influence on fishers' lives. Tibau do Sul, for example, has been slowly increasing its touristic activity, while the relevance of its fisheries has decreased. Fisheries take place mainly in an estuarine lagoon at the north of this village (Fig. 1). Pipa, a former fishing village, is currently the main touristic destination in the region, which modified the local economy and livelihoods (Xavier 2008). Fishing, although not as relevant anymore, takes place on coastal waters. Pipa also hosts dolphin-watching tourism (Schlindwein 2011), which has just begun to develop in Baía Formosa, where other kinds of tourism are even less common and fishing in coastal waters represents an important activity for the village.

Participants

The fishers' associations estimated approximately 150 active small-scale fishers in Tibau do Sul, 80 in Pipa, and 190 in Baía Formosa. To ensure sample representativeness, we tried to interview all the fishers that fulfilled the criteria: being above 20 years old, whose main income was from the small-scale fisheries and who had been living and fishing in the region for at least 10 years. Such criteria aimed to select fishers who would show some reasonable knowledge about the region (Lopes et al. 2009; Souza and Begossi 2007). All fishers were informed about the purpose of the research and chose to participate in it voluntarily. Four fishers refused to participate without specifying why.

Procedures

The data collection was done through interviews guided by a semi-structured questionnaire with closed (with some expected answers, such as yes or no) and open questions (fishers were free to use their own words, which were later categorized) (Suppl. material 1). The fieldwork started in October 2010 with visits to the study areas to adapt the sampling design. The fishers'

associations were visited to explain the aims and procedures of the research and to ask for their permission and support. Also, a first draft of the questionnaire was tested, which was later discarded due to multiple adjustments. The definitive interviews took place on the streets, beaches, squares, and fishers' association headquarters between April and July 2011.

After ensuring that the fishers were familiar with the occurrence of a locally common small dolphin on their coast and beaches (*S. guianensis* is the only coastal cetacean in the study area), they were presented with images of 14 cetacean species and asked to point out which one was this usual dolphin. Besides *S. guianensis*, the following species were used in the photographs (not in this order): *Balaenoptera acutorostrata*, *Balaenoptera edeni*, *Delphinus sp*., *Eubalaena australis*, *Megaptera novaeangliae*, *Orcinus orca*, *Peponocephala electra*, *Physeter macrocephalus*, *Pontoporia blainvillei*, *Stenella attenuata*, *Stenella clymene*, *Stenella longirostris*, and *Tursiops truncatus*. Such selection encompassed species that occurred near the region but in ocean waters; species that do not occur at all in the region but shared morphological similarities and species that are famous due to the media, just to make sure fishers were really familiar with the visual identification of *S. guianensis*.

All fishers were interviewed, regardless of whether they identified the species (pointing out the correct photograph). Although a fisher could misidentify the dolphin for multiple reasons, he would still know that the estuarine dolphin appeared in the area, as this is the only coastal cetacean in the region. The three villages are home ranges of a permanent large population of *S. guianensis* (Queiroz and Ferreira 2009) that can be observed daily even from the streets facing the ocean.

Fishers were asked about their socioeconomic (e.g., age and schooling) and fishing data (e.g., experience, place—environment—they used to fish, type of boat, fishing gear, and target species) and about the estuarine dolphin (*S. guianensis*) (Suppl. Material 1). For *S. guianensis*, fishers were specifically asked to give its local name, classification according to life form—expression commonly used in LEK studies that is equivalent to class or order in the Linnaean classification (Berlin 1992; Souza and Begossi 2007), adult size and color, recognized features of the species, relative abundance, existence and also the types of interactions, incidental catches (and description of the occurrence place and species bycaught), and its destination when incidentally caught.

Data analyses

Fishers' responses were organized into categories mostly based on their own expressions. The number of categories a given question got was not necessarily the interviewed fishers' number, as a fisher may not have answered or may have given more than one answer to a specific question. The analyses were then based on the number of answers provided by the fishers. Answers such as "I do not know" were also computed, as they could suggest lack of knowledge about specific topics (Silvano *et al*. 2006).

The communities were compared in terms of the fishers' socioeconomic characteristics such as age, schooling and fishing experience, as these aspects could have affected fishers' knowledge about *S. guianensis* (Kruskal-Wallis tests). If such characteristics were shown to be similar across communities, then differences in knowledge could be at least partially correlated with the main fishing environment used by each community and the level of tourism in each area.

Categorical answers were analyzed through frequency tests: chi-square tests or G-tests (for categories with low frequency of responses, as the latter is a more robust test) (Doria Filho 1999). These tests compared the communities regarding the frequency that categories of answers were cited.

In order to quantify fishers' LEK, some questions (identification of *S. guianensis* through images, their classification according to life form, the color and size of the species) were scored on the number of correct, partially correct, or incorrect answers, with scores ranging from 0 (incorrect) to 10 (fully correct) (Table 1). Partially correct answers were those that met the following conditions:

1) the fisher identified two out of 14 images as *S. guianensis*, even though only one was the correct image (no fisher pointed out more than two images);
2) the fisher classified the dolphin with an indirect answer (e.g., "It is not a fish"), which was neither wrong nor right, but pointed out that the fisher can distinguish a cetacean from a fish; and
3) the fisher gave an ambiguous answer regarding the animal color, such as "It is dark" without explaining what dark meant and/or which part of the animal was dark.

For the question on animal adult size, answers between 1.5 m (slightly smaller than the minimum

Table 1 Criteria used to score fishers' responses regarding their knowledge about the estuarine dolphin (*Sotalia guianensis*)

Questions	Fishers' answers	Scores				
		Zero	2.5	5	7.5	10
A. Identification of *S. guianensis* based on the choice of an image	Incorrect image	X				
	Two images (one correct)			X		
	Correct image					X
B. Classification of *S. guianensis* life form	Does not know	X				
	Fish	X				
	Mammal-fish	X				
	Not a mammal	X				
	Not a fish			X		
	Dark flesh			X		
	Comparison with another marine mammal			X		
	Mammal					X
C. *S. guianensis* size	Incorrect size	X				
	Correct size (1.5 m–2.2 m)					X
D. *S. guianensis* color	Does not know	X				
	There are two species (one lighter and one darker)	X				
	Light color		X			
	Dark color		X			
	Gray			X		
	Dark dorsum and light belly				X	
	Gray dorsum and pink belly					X

registered sexually mature female size) (Ramos et al 2000; Rosas and Monteiro 2002) and 2.2 m (the largest individual registered in its occurrence area) (Flores and Da Silva 2009) were considered fully correct. Answers outside this range were considered incorrect.

In each of these questions, the score was given per fisher and an average score per community was also calculated. A Kruskal-Wallis test was performed for each question to see if the median values differed between the communities. If the differences were significant, this was followed by a Student-Newman-Keuls (SNK) post-hoc test to identify which community was responsible for the observed difference. The same tests were performed also using each fisher's total score (sum of the four scored questions) to compare the communities' knowledge about *S. guianensis*.

A generalized linear model (GLM) with Gaussian distribution was used to investigate whether knowledge about *S. guianensis* is affected by schooling, age, experience as a fisher, community where the fisher is from, and the type of environment mostly used by the fisher (estuarine lagoon, coastal waters, or both). The model considered the interaction between the community variable with his schooling, age, and experience, as these values could be significantly different between villages. The response variable, knowledge about the species, was determined by the total sum of the scores achieved by each fisher. The complete model was defined as follows:

$$\mathrm{K_v} = \beta_0 + \beta_1 \mathrm{S} + \beta_2 \mathrm{A} + \beta_3 \mathrm{E} + \beta_4 \mathrm{C} + \beta_5 \mathrm{F} + \beta_6(\mathrm{C:S}) + \beta_7(\mathrm{C:A}) + \beta_8(\mathrm{C:E}) + \varepsilon$$

where K_v is the inferred knowledge of a given fisher, S is the schooling level (years), A is the fisher's age (years), E is his experience as a fisher (years), C is the community, F is the fishing environment, and the remaining terms are interactions (represented by ":") between community and schooling, age, and experience. The symbol ε represents the error and β_0 the intercept. All possible model combinations were tested, and non-significant variables were removed until the best model was chosen

based on the Akaike criterion (AIC). The differences between the models were tested using ANOVA. Here, only the results for the significant model are presented.

The GLM analyses were done using R software (Team 2009). For the frequency tests (G-test and chi-square test) and Kruskal-Wallis test, the program Bioestat 5.0 was used (Ayres et al. 2007).

Results

One hundred and sixteen fishers were interviewed (39 in Tibau do Sul, 36 in Pipa and 41 in Baía Formosa). In Pipa and Baía Formosa, all fishers said to fish exclusively in coastal waters (usually up to 15 km from the shore). In Tibau do Sul, 82.6 % of them fish exclusively in the estuarine lagoon and the other 17.4 % fish in both environments.

Due to the difference in fishing environment, the type of gear, type of boat, and autonomy at sea also varied among the communities. Coastal fishers can spend from 1 to 7 days at sea, while lagoon fishers, who only fish with non-motorized canoes and rafts, fish for less than a day at a time (Table 2). This resulted in coastal fishers targeting mainly mutton snappers (*Lutjanus analis*), blackfin tuna (*Thunnus atlanticus*), king mackerel (*Scomberomorus cavalla*), and dolphin fish (*Coryphaena hippurus*), and lagoon fishers targeting shrimps (mainly *Litopenaeus schmitti*) and mullets (*Mugil* spp.).

Considering the social features, no differences were observed between the communities regarding age (Kruskal-Wallis test, $H=4.4588$; $df=2$, $p=0.108$), schooling ($H=0.4154$, $df=2$, $p=0.812$), and fishing experience in the region ($H=3.1995$, $df=2$, $p=0.202$). Therefore, subsequent results have focused on the three studied communities, assuming that eventual differences between these fishers knowledge would be, at least partially, due to differences in their main fishing environment and tourism level.

Local classification regarding *Sotalia guianensis*

Most fishers (68.9 % of 116) identified the correct image of the *S. guianensis*, although some chose another image in addition to the correct one. No significant difference was observed between the communities regarding the scores on estuarine dolphin identification ($H=1.9192$, $df=2$, $p=0.383$).

Table 2 General fishing features in Tibau do Sul, Pipa, and Baía Formosa. Numbers represent total of responses

Fishing features		Tibau do Sul (lagoon)	Pipa (coastal waters)	Baía Formosa (coastal waters)	
Autonomy at sea	1 day	33	2	6	41
	2–7 days	0	28	29	57
	8–15 days	6	4	5	15
	More than 30 days	0	2	1	3
	Total	39	36	41	116
Boat type	No boat	1	1	0	2
	Motorized boat	5	22	31	58
	Sail raft	1	14	17	32
	Canoe	35	0	0	35
	Total	42	37	48	127
Gear	Manual	1	0	0	1
	Hand line	5	30	29	64
	Dive with compressor	0	0	5	5
	Traps	2	0	3	5
	Longline	1	1	4	6
	Bottom trawling	12	1	5	18
	Gillnet	24	21	26	71
	Castnet	10	2	0	12
	Total	55	55	72	182

Of the 14 species shown to the fishers, 10 were pointed out at least once as the estuarine dolphin: *S. guianensis* (60.2 %), *Delphinus* sp. (12.8 %), *T. truncatus* (9.8 %), *S. clymene* (5.3 %), *S. attenuata* (3.0 %), *S. longirostris* (3.0 %), *P. electra* (2.3 %), *B. edeni* (1.5 %), *P. blainvillei* (0.8 %), and *O. orca* (0.8 %) (N=133 answers). One fisher said that none of the images were of the estuarine dolphin. The frequency that all species were chosen was not significantly different between communities (G=19.706, df=18, p=0.350).

A significant difference was observed in the local naming of the species (G=46.735, df=6, p<0.0001). While most answers (84.8 % of 46) from Baía Formosa named *S. guianensis* as "*boto*", 47.9 % of the answers (n=48) from Tibau do Sul named *S. guianensis* as "*golfinho*", and 30.4 % of Pipa's answers (n=56) named the species "*golfinho* after the tourism boom," implying a change in name from *boto* to *golfinho* after the region became famous for dolphin-watching tourism (Fig. 2a).

The fishers classified *S. guianensis* under five clear life-form categories: "mammal" (44.4 %), "fish" (34.2 %), "mammal-fish" (5.1 %), "animal of dark flesh" (4.3 %), and "like a whale or a manatee", meaning an aquatic mammal (3.4 %). Two other categories described what the dolphin is not: "not a fish" (5.1 %) and "not a mammal" (0.8 %). Only 2.6 % of the fishers did not know how to answer this question (N=117 answers). Both in Baía Formosa and in Pipa, the category "mammal" was the most cited (53.5 % of 43 answers and 52.6 % of 38 answers, respectively). In Tibau do Sul, most fishers believe that *S. guianensis* is a fish (47.2 % of 36 answers) (Fig. 2b), which made this community score significantly less on life form classification (H=10.1320, df=2, p=0.006) than the others (SNK: Tibau do Sul×Baía Formosa, p=0.006; Tibau do Sul×Pipa, p=0.014).

To recognize and/or differentiate *S. guianensis* from other species, fishers reported (N=155 answers) using mostly morphological (32.3 %) and behavioral features (24.5 %). The main morphological features cited were related to the color and size of *S. guianensis*. Its coastal habits and its less restless behavior compared to oceanic dolphins were the main behavioral attributes mentioned. Fishers also said that *S. guianensis* do not tend to get close to fishing boats or do it less often compared to oceanic dolphins. Fishers also recognize the species by interaction patterns (12.9 %). Some said the estuarine dolphin has no difference (12.9 %) in relation to oceanic ones, while others did not know (8.4 %) which features they used to recognize it. Still, few fishers mentioned naming patterns (5.2 %) and *S. guianensis* feeding attributes (3.9 %—such as type of prey and feeding behavior). The communities differed in the main attributes used to recognize *S. guianensis* (G=38.614, df=12, p=0.0001). In Baía Formosa, fishers reported using mostly morphological characteristics (41.2 % of 51 answers), whereas in Tibau do Sul, several fishers either did not know what they used to recognize (24.4 %) or said that *S. guianensis* is not different from the oceanic dolphins (22.0 % of 41 answers) (Fig. 2c).

S. guianensis characteristics

Fishers had significantly different scores on perceptions of the size of *S. guianensis* (H=11.2, df=2, p=0.004). In Pipa, fishers reported that the average size of an estuarine dolphin was 1.89 m ±0.62 m (median=1.75 m), similar to the average size mentioned by Baía Formosa's fishers (1.97 m ±0.51 m, median=2.00 m). In Tibau do Sul, however, fishers reported an average size of 2.58 m ±1.79 m (median=2.00 m), significantly larger than in the other communities (SNK: Tibau do Sul×Baía Formosa, p=0.004; Tibau do Sul×Pipa, p=0.023).

The fishers used the words "gray" (39.2 %), "dark color" (22.4 %), "dark back with light belly" (14.7 %), "light color" (9.1 %), and "gray with pinkish belly" (6.3 %) when describing the estuarine dolphin's color. In addition, 7.7 % of the fishers said there were two kinds of estuarine dolphins, one dark-colored and one light-colored, and 0.7 % did not know how to answer (N=143 answers). The communities did not differ in their scores regarding the color perception of *S. guianensis* (H=3.87, df=2, p=0.144). Some fishers (n=21; 42.9 % from Pipa, 38.1 % from Baía Formosa, and 19.0 % from Tibau do Sul) reported that the color of this animal changes along with its development.

Fishers' interactions with *S. guianensis*

Most fishers believe that the abundance of *S. guianensis* has changed locally in the past decade: 43.1 % said it has increased and 24.1 % said it has decreased. Still, 28.5 % did not believe this dolphin's abundance has changed and 4.3 % did not know how to answer (N=116). This perception of abundance did not vary across communities (G=5.504, df=6, p=0.481). Of the fishers who said

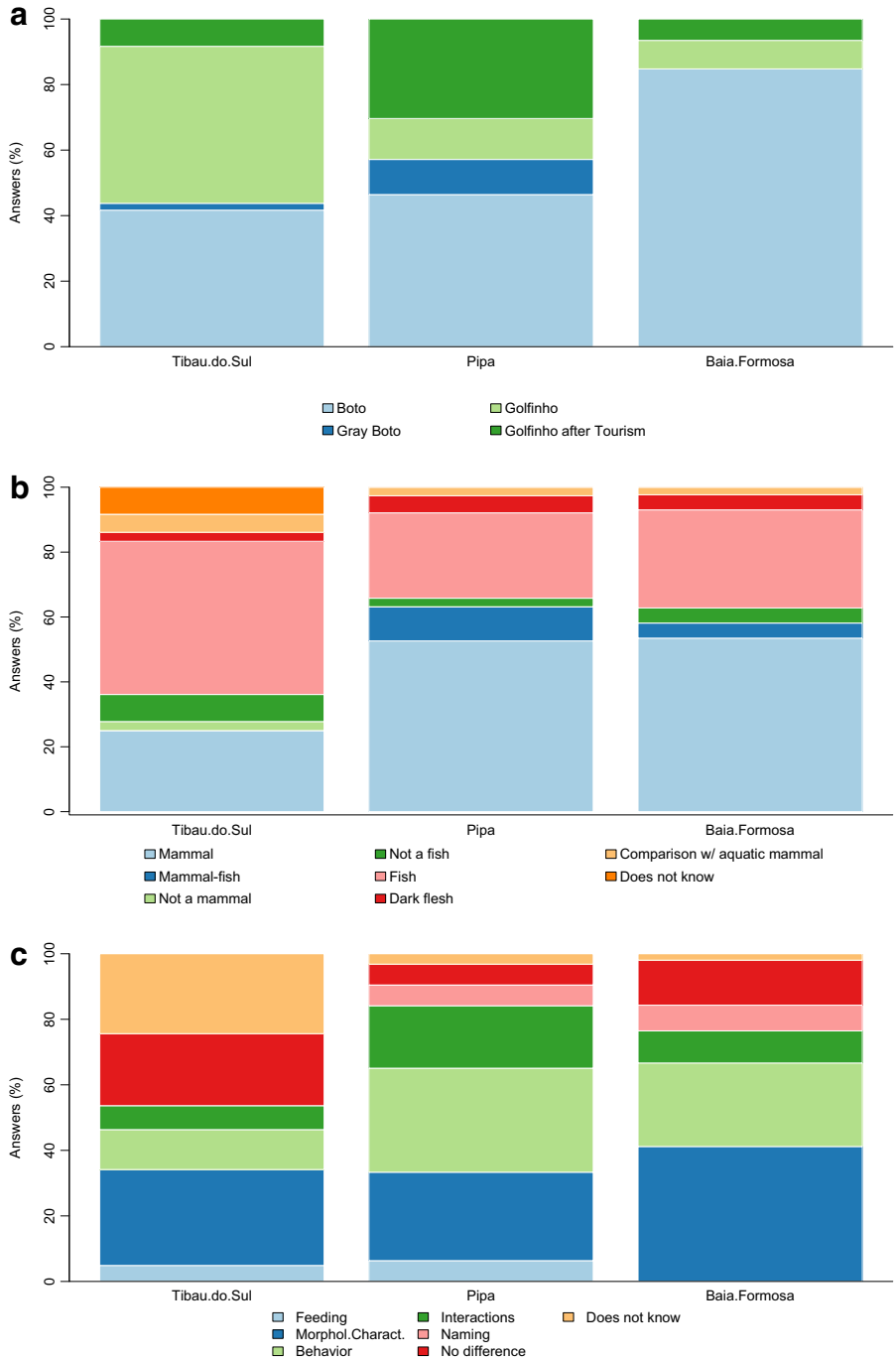

Fig. 2 Local ecological knowledge about *Sotalia guianensis* in Tibau do Sul, Pipa, and Baía Formosa on the Brazilian NE coast. **a** Local names given to *S. guianensis*. **b** Classification of *S. guianensis* life form according to the fishers. **c** Features used by the fishers to recognize *S. guianensis*

the local population of the estuarine dolphin increased, some justified (n=46 answers) that the animal is no longer caught or killed by fishers (47.8 %) and that it reproduces successfully in the region (36.9 %), besides other answers (15.3 %). The ones who believe this dolphin's population has decreased (n=41 answers) said that this was mainly due to the interference of boats in

general (26.8 %) and dolphin-watching boats in particular (24.4 %), besides other answers (48.8 %).

More than half of the fishers (58.5 %) said they had no interaction with the estuarine dolphin during fishing activities. The remaining fishers reported both negative (25.4 %) and positive (16.1 %) interactions (N=118 answers), with no significant difference between communities (χ^2=8.341, df=4, p=0.079). Negative interactions referred to the bycatch of dolphins in fishing nets and the dolphins' occasional stealing of fish or scaring of fish away from the nets. Positive interactions referred to the finding of fish schools by dolphins, which could also surround the schools and lead them toward the fishing net (cooperative fishing). The communities differed regarding the reported types of interactions (G=13.464, df=6, p=0.036), with Pipa and Baía Formosa reporting mostly negative (80.0 % of 15 and 73.7 % of 19, respectively) and Tibau do Sul mostly positive interactions (83.3 % of 14) (Fig. 3a).

When asked specifically about incidental catches, most fishers (62.9 %) said they have seen small cetaceans entangled in fishing nets, with significant differences between communities (χ^2=45.351, df=2, p<0.0001), as this event was more common in Baía Formosa (85.4 %) and Pipa (83.3 %), and relatively rare in Tibau do Sul (20.5 %).

Among fishers who observed incidental catches, about half (50.9 %) said these catches occur close to the beach (up to 1 km from the coastline), a third (33.3 %) reported them happening in waters between 1.5 and 10 km from the shore, and few (15.8 %) reported them occurring further away from the coast (more than 10 km). This spatial pattern of bycatch occurrence did not differ between the communities (G=6.863, df=4, p=0.143). Bycatches of *S. guianensis* were mentioned significantly more often than of other cetacean species (83.8 % of 68 answers), a pattern that prevailed among the communities (G=0.663, df=2, p=0.718). Most fishers said that the incidental catches they observed did not

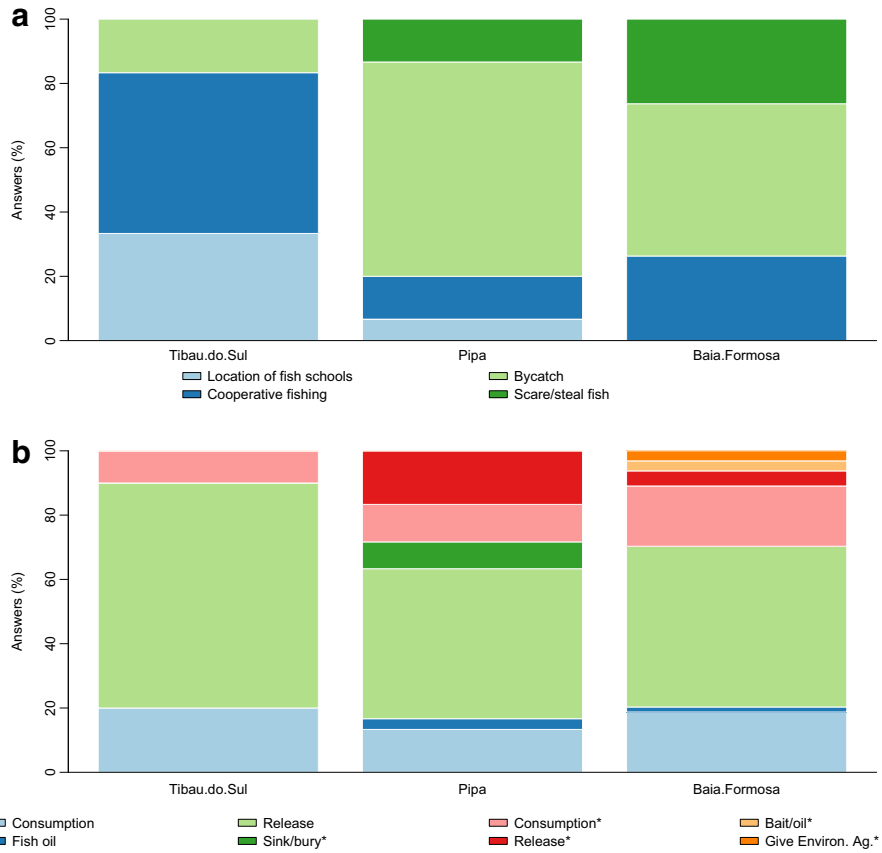

Fig. 3 Interactions between fishers and *Sotalia guianensis* in Tibau do Sul, Pipa, and Baía Formosa, on the Brazilian NE coast. **a** Types of interactions. **b** Fishers' attitudes when faced with an entangled dolphin in nets. *Applies for dead animals

Table 3 Average scores obtained by fishers from Tibau do Sul, Pipa, and Baía Formosa in relation to their knowledge about the estuarine dolphin (*Sotalia guianensis*)

Graded questions	Community scores		
	Tibau do Sul	Pipa	Baía Formosa
A. Identification of *S. guianensis* through images	5.77	6.94	6.22
B. Life form classification	2.56	5.69	5.98
C. Size of *S. guianensis*	3.33	6.39	7.07
D. Color of *S. guianensis*	4.17	5.28	5.06
Average scores	3.96	6.08	6.08

happen in their own nets (69.2 % of 65). Fishers (n=20) mentioned the following gear as mainly responsible for such bycatches: floating gillnets (80.0 %), bottom gillnets (10.0 %), beach-seine nets (5.0 %), and castnets (5.0 %).

When asked what was done with dolphins trapped in nets, most fishers said they were released if alive (50.0 %) or consumed, regardless if they were found alive (16.4 %) or dead (14.9 %; N=134 answers), with significant difference between the communities (G=23.998, df=14, p=0.046). Only fishers from Pipa reported sinking and burying dead entangled animal (8.3 % of 60 answers). Some fishers from Baía Formosa said they return the dead animal to the Environmental Agency (3.1 % of 64 answers) (Fig. 3b).

LEK about *S. guianensis*

Fishers from Pipa (6.08±2.49) and Baía Formosa (6.08 ±1.88) had significantly higher LEK scores (H=16.508, df=2, p=0.0003) than fishers from Tibau do Sul (3.96± 2.48) (SNK: Tibau do Sul×Pipa, p=0.0003; Tibau do Sul×Baía Formosa, p=0.0008) (Table 3). There were no significant interactions in the first GLM model between the community and the socioeconomic variables, which highlights that differences in LEK were not due to socioeconomic features of a given place (AIC=214.84, results not shown).

A second model, excluding the community variable, showed that schooling, experience, and the main fishing environment affected the fishers' knowledge of *S. guianensis* (AIC=205.98). As such, a final model was built considering only these three variables (AIC= 200.99). The model showed that a higher level of schooling and longer experience as a fisher improved fishers' knowledge of *S. guianensis*, while those who fish in the lagoon have less knowledge of the species than those who fish in coastal waters. Fishing in both environments does not have a significantly different effect on knowledge from fishing in coastal waters. The three models were not significantly different (ANOVA: $\text{deviance}_{1,2}$=−0.91, $\text{deviance}_{2,3}$=−0.30, p>0.05), justifying the choice of the simplest one with the lowest AIC (Table 4). However, schooling should be carefully interpreted because there is a wide variation in knowledge among those with lower schooling levels. As the fishers' level of schooling increases, this variation in knowledge decreases to around an average value (Fig. 4).

Discussion

Local classification regarding *S. guianensis*

Most fishers identified the correct picture of *S. guianensis*, and this did not vary between communities. Among the species that were more commonly

Table 4 Results of the Generalized Linear Model, with Gaussian distribution, which checked if independent variables (schooling, experience, and fishing environment, which could be lagoon, coastal waters or both) affected fishers' knowledge about *Sotalia guianensis*

Coefficient[a]	Estimate	St. error	Conf. interval (95 %)	*t* value	*P*
Intercept	1.37	0.28829	0.80–1.93	4.736	>0.0001
Schooling	1.03	0.01707	0.99–1.06	60.473	>0.0001
Experience	1.01	0.00452	0.99–1.01	222.905	>0.0001
Fishing environ. (lagoon)	−0.71	0.23888	−1.17–0.23	−2.954	0.003

[a] The results are presented only for the significant variables, based on the choice of the best model through the use of the Akaike criterion

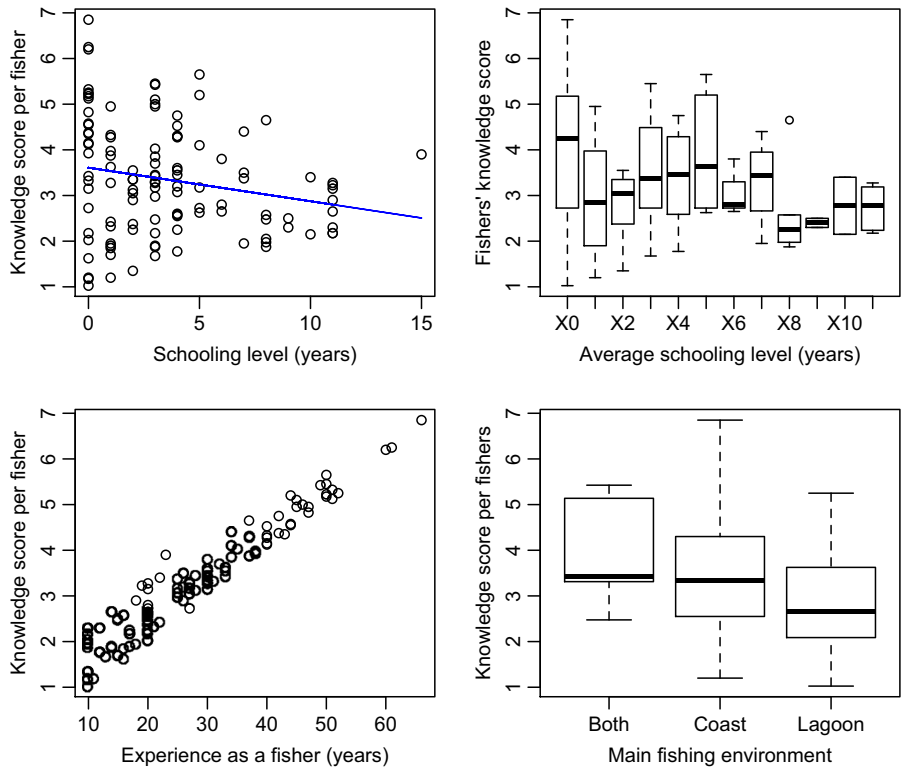

Fig. 4 Factors affecting fishers' knowledge about *Sotalia guianensis*. *Top (left and right)* Relationship between knowledge and fishers' schooling level. *Bottom left* Relationship between knowledge and fishers' experience. *Bottom right* Average score for fishers' knowledge about *S. guianensis* depending on their main fishing environment. Median (*darker line in the box plot*), minimum and maximum values (*vertical lines*), and *outer lines of the box plots* showing the quartiles (25 and 75 %)

misidentified as the estuarine dolphin were *Delphinus* sp. and *T. truncatus*. *Delphinus* sp. presents similar color pattern as *S. guianensis* (Randi et al. 2008). *T. truncatus*, besides sharing some morphological features (e.g., having a gray dorsum and being a small cetacean) with *S. guianensis*, has been shown to collaborate with fishers by helping them encircle fish schools in some areas (Peterson et al. 2008; Pryor and Lindbergh 1990). Finally, *T. truncatus* is widely publicized by the media as the "Flipper" species (from the American TV show), which could affect the local culture by making a locally rare animal more salient (Souza and Begossi 2007). However, it is likely that these species' shared morphological features can make it hard for fishers to distinguish them based solely on pictures. Specifically, in a previous ethnotaxonomy study, fishers considered both *Delphinus* sp. and *T. truncatus* a relative of *S. guianensis* (Souza and Begossi 2007).

Tourism clearly affects the naming of the species: "*golfinho*" or more specifically "*golfinho* after the tourism boom" is used where there is dolphin-watching activity (Pipa) and some active constant tourism (Tibau do Sul), while "*boto*" prevails where tourism is incipient (Baía Formosa). Both *boto* and *golfinho* are common names for dolphins in Portuguese, but the latter is the term popularized by the media and often used by tourists.

Communities where fishing is done on coastal waters (Pipa and Baía Formosa) were more prone to associate the estuarine dolphin with the life form "mammal", while the lagoon fishers (Tibau do Sul) mostly classified this dolphin as a fish. Dolphins are sometimes mislabeled as fish due to their aquatic life, although in many instances, fishers could be aware of the dolphins' nursing behavior (Oliveira et al. 2008). According to these authors, fishers might classify the nursing calves as "mammals" and the adults as "fish". In the present study, lagoon fishers saying more often that dolphins were fish could suggest the absence of calves and/or parental care in the lagoon. This would support findings

from a previous study in the region that showed that the estuarine lagoon is used for foraging activities, while bays such as Pipa are used for parental care (Paro 2010).

S. guianensis characteristics

Coastal fishers displayed more accurate knowledge of the characteristics of *S. guianensis* than lagoon fishers. For instance, the average estimated size of the adult estuarine dolphin in Baía Formosa and Pipa was similar to the average reported in the literature (Rosas and Monteiro 2002; Flores and Da Silva 2009), but not in Tibau do Sul. The description of color patterns was also slightly more accurate among the coastal fishers.

To learn about and classify plants and animals, local communities can use ecological, behavioral, and morphological criteria, aside from aspects related to the organism salience or utility (Alves and Souto 2011; Berlin 1992; Souza and Begossi 2007). Thus, coastal fishers would be more likely to give accurate descriptions of the estuarine dolphin because they observe a wide range of the animal's behaviors and interact more often with these animals. The utility of a species, on the other hand, could also be related to the economic damages it causes (Begossi 1993), such as the more frequent incidental catches in coastal fishing that can result in damages to nets, stress, and fear of being caught by the enforcement agencies (since catching cetaceans is forbidden in Brazil). Moreover, even when none of these occur, handling the animal when disentangling it from a net represents an opportunity to observe and learn some of its characteristics up close, increasing the fishers' knowledge about this species.

Salience implies that humans learn about and classify groups of organisms based on the perception of exotic characteristics, such as those of bright and colorful species (Berlin et al. 1981). Cetaceans are also usually recognized due to their phenotypic and cultural salience (Souza and Begossi 2007). Size, for example, directly affects the likelihood of people noticing and recognizing certain organisms (Hunn 1982), while the media can make a species culturally relevant.

Fishers' interactions with *S. guianensis*

The main fishing environment used by fishers also implies different interactions with the estuarine dolphin. Where fishing is mostly done in coastal waters, the reported interactions were mostly negative; the opposite was true for the lagoon fishers. The type of gear used and the target species in each place are probably why the interactions vary across fishing environments. The lagoon fishers use mostly castnets to catch mullet, an important item in the estuarine dolphin's diet (Lopes et al. 2012). In such fisheries, dolphins could either show the location of schools to fishers or actively push fish toward their nets. Cooperative fishing has been reported in different parts of the world, including Brazil, and apparently it increases the fishers' knowledge about the species (Peterson et al. 2008; Pryor and Lindbergh 1990). On the other hand, the negative interactions, mostly incidental catches, reported by coastal fishers could be the consequence of setting gillnets close to the coast, and leaving them unattended for hours.

The fear of being caught with a dead dolphin in the net by the enforcement agencies possibly masks the real occurrence of bycatch and the fishers' real behavior. For instance, some fishers mentioned that dead dolphins are either sunk or buried before the news spreads for fear of being punished. This could affect the reliability of the reported number of incidental catches of estuarine dolphins in the region, where few cases were reported between 1961 and 2004 (Di Beneditto and Rosas 2008), while most fishers in the present study reported having seen at least one bycatch event during their working life. Some fishers reported the consumption of dolphin meat, also reported for other areas in Brazil (Alves and Rosa 2008; Siciliano 1994). The reliability of this information in the present study is also questionable, as fishers would be afraid of reporting the consumption of poached dolphin.

Establishing positive partnerships (not based on fear) between fishers, enforcement agencies, and researchers could help improve data reliability (Huntington 1999; Monteiro-Filho et al. 2008), enhance the discussion on the utility of dolphin deterrent devices such as pingers, and raise the discussion about where to set gillnets (Goetz et al. 2013).

LEK about *S. guianensis*

The results of the present study indicate that fishing in a specific environment is one important determinant of what a fisher knows. Fishing in coastal waters seems to allow fishers to observe the dolphin's behavior and features up close, as initially expected. One of the likely reasons for this is that this dolphin gets entangled more often in coastal set gillnets. Besides, fishers who only

use the lagoons are able to observe only a limited number of behaviors (no nursing, for example).

However, this relationship between the fishing environment and knowledge is not that straightforward; knowledge is also significantly affected by fishing experience and schooling level. Fishing experience represents a number of opportunities to accumulate knowledge about *S. guianensis*. The longer a fisher practices his profession, the more chances he has of interacting with and observing aquatic species (Davis and Wagner 2003; Ruddle and Davis 2011; Wiber et al. 2012). The way schooling level affects knowledge regarding this dolphin is difficult to interpret, as a wide variation in knowledge was found among fishers with a low schooling level. Nevertheless, knowledge increases (with decreasing variance) as the years of education increase, decreasing again later. Perhaps in the lower schooling levels, fishers' knowledge depends on their own history, such as being the child of a fisher. With more years of formal education, fishers could develop a more accurate sense of observation and be exposed to information regarding charismatic species such as dolphins (Barney et al. 2005). However, after a certain number of years of education, fishers' LEK did not increase proportionally, perhaps because having more formal education could mean having less fishing experience, hence, fewer opportunities to interact with the species.

Contrary to expectations, tourism did not play an important role in the fishers' knowledge. Although tourism was not an explicitly defined variable in the model, it could be easily inferred from the community, which did not affect knowledge. As the model did not include variables that measure fishers' contact with tourists or with dolphin-watching tourism, one should be cautious in interpreting tourism influence. Assessing whether the fishers perform secondary economic activities related to tourism, and determining whether they have relatives living in their households who are involved in tourism activities could shed more light on the influence of tourism on fishers' LEK. Perhaps even in communities where tourism is important, such as Pipa, fishers are excluded from this process and do not experience its economic, social, and cultural benefits (Tosun 2000; Xavier 2008).

Conclusions

For decades, *S. guianensis* has interested researchers, although information is still lacking regarding basic aspects, such as its local population status, which could be provided by fishers (Ruddle and Davis 2011). Nevertheless, such knowledge might be biased depending on the experiences of fishers and their main fishing areas. Hence, researchers who aim to gather ecological information from local people should carefully select their informants, not only by choosing experts (Braga and Schiavetti 2013; Davis and Wagner 2003), but also by considering aspects such as the area mostly used by the informants and the methods they use to access the resource.

Being the focus of the media, tourism, and conservation priorities can have a two-sided effect on a species. On the one hand, fishers potentially have more access to information regarding that species. On the other hand, fishers can hide important information such as incidental catches due to fear of punishment. A punishment-based policy could have a negative effect on the conservation of dolphins, as fishers could see dolphins as a source of problems. Thus, working collaboratively with fishers on reporting incidental catches and, at the same time, looking for methods that minimize such incidents could change fishers' perspective on the estuarine dolphin or other species that are targets of conservation initiatives. Real collaborative work could lead to more accurate information on population status, which could be a valuable complementary source of information for conservation programs.

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