Chapter 2
Long-Term Monitoring of Dolphins in a Large Estuarine System of Southeastern Brazil

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Abstract Considering long-term study as one that through constant efforts subsidizes future studies, an example in Brazil is "Projeto Boto-Cinza" adding up more than 36 continued years of research and data application on Guiana dolphin biology, ecology and conservation. The first effort we dedicated was toward understand the fishing strategies used by this species, lasting about 10 years. Latter, as we gained knowledge in behavior study, the next step was to access parental care, youngling behavior, learning process of fishing, acoustic repertoire, and recently social networks. Throughout this time, it was possible to access also the mortality, and based on carcasses that gave such information, access parameters of life history such as reproductive anatomy of males and females, pregnancy period, birth size, and even age. Population density estimates could be done in different periods and areas; photo-identification enabled the detection of individual spatial fidelity. Modeling permitted to observe which parameters seem to be associated with the spatial distribution of population units inside the estuary. All these data contributed to a greater knowledge about the species, creation of public policies by conservation units' chiefs, education purposes, and conservation of the species.

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2.1 Historic Background

Although not being common, researchers developed in African ecosystems several natural history long-term studies – those in which constant efforts subsidizes future. Some examples of these studies are Jane Goodall's with chimpanzees (*Pan troglodytes*), Craig Packer's with lions (*Panthera leo*), Holly Dublin's with elephants (*Loxodonta africana*), Robert Sapolsky's with baboons (*Papio cynocephalus* and *Papio anubis*), Laurence Frank's with hyenas (*Crocuta crocuta*), among others.

Despite the challenges that arise in marine environment long-term studies, a handful of good examples can here be listed. Regarding these studies, we point out efforts conducted by Roger Paine as of 1967, initially dedicated to Humpback whales (*Megaptera novaeanglia*) in the United States, then to cetacean conservation, and more recently to Right whales (*Eubalaena australis*) in Argentina coast. Also, Paul Spong and collaborators since the 1970s with Killer whales (*Orcinus orca*) in Vancouver Island, Canada, and by John Reynolds with Manatees in (*Trichecus manatus*) in Florida also since the 1970s.

Particularly in the Brazilian coast, different studies have been made in long-term projects such as the ones conducted by Flávio J. Lima Silva and José Martins Silva Júnior with Spinner dolphins (*Stenella longirostris*) in Fernando de Noronha Archipelago, the ones by Leonardo Flach and Elaine Ferreira with Guiana dolphin (*Sotalia guianensis*) in Sepetiba Bay, and the ones by Marta J. Cremer with Franciscanas (*Pontoporia blainvillei*) in Babitong Bay. All of the above lasting more than 15 years of integrated research. Adding up more than 36 years of uninterrupted studies in the Cananéia estuary in Southeastern Brazil, the "Projeto Boto-Cinza" studies gave support for the presentation here made about aspects of biology, ecology, and conservation studies about this species.

2.2 Target Species

Sotalia guianensis (Fig. 2.1) is a Delphinidae with wide coastal distribution between Honduras (Edwards and Schnell 2001) and Baía Norte, southern Brazil (Simões-Lopes 1988). Since its description, this species received different denominations, having been originally described as *Delphinus guianensis* van Bénéden, 1864 (Hershkovitz 1966). With a review by Gray in 1866, the species started to belong to *Sotalia*, not *Delphinus*, remaining for about 100 years. By this time, the *Sotalia* had three species: *S. fluviatilis* (Gervais and Deville 1853) in Amazon

Fig. 2.1 A Guiana dolphin, *Sotalia guianensis*, photographed at Cananéia Lagoon Estuarine Complex, State of São Paulo, Brazil (Photo: Caio N. Louzada)

Basin, *S. guianensis* van Bénéden, 1864 in the northern South America, and *S. brasiliensis* van Bénéden, 1875 strictly at Guanabara Bay in southeastern Brazil (Hershkovitz 1966).

During the 1960s, some doubts arose about the validity of such names and in 1963, Carvalho reports for the municipalities of Santos and Cananéia the presence of a common dolphin known as the boto-da-baía-de-guanabara (Guanabara Bay dolphin) (Monteiro-Filho et al. 2008a). In the following years, the doubt remained on which name should be given to animals observed in several spots of the Brazilian coast. After short considerations about the species, Rice (1977) started to consider the existence of a single species (*Sotalia fluviatilis*), with two subspecies being one restricted to the Amazon Basin (*S. f. fluviatilis*) and the other to the marine coast (*S. f. guianensis*).

For 25 years the classification proposed by Rice (1977) remained, even with some authors arbitrarily refusing the possibility of the subspecies. In 2002, Monteiro-Filho et al. (2002) published a paper questioning the name given to marine and fresh water animals of *Sotalia*. Authors used geometric morphometric to access the skull shape of 104 individual from different locals of the Brazilian coast and Amazon fresh waters. In addition to biological knowledge already published about the species (see Monteiro-Filho et al. 2008a), the results point to two distinct biological units, and therefore repurposing the use of *S. fluviatilis* to describe fresh water animals and *S. guianensis* for marine ones (Monteiro-Filho et al. 2002, 2008a).

Latter, molecular studies (Cunha et al. 2005) converged to the same conclusion. These morphometric and molecular studies surely contribute so that researchers can designate the results of their own studies to specific biological units. However, despite of the academic importance, such studies are no news since researchers described the species as separate units more than 150 years before. This fact brings up the fantastic capacity of natural observation of such researchers of the nineteenth and twentieth century.

2.3 Study Area

Studies performed by this project were conducted mainly in a large estuarine system called Estuarine Lagoon Complex of Iguape Cananéia Paranaguá. The huge biodiversity of the region attracted the attention of researchers to this area at the beginning of 1980s. They looked to main species that inhabit that place and one received particular attention, the Guiana dolphin. This region presents an environmental complexity, composed by several river that flow into the estuary and creates many lagoons, mangrove islands, flooded areas and sand beaches. At many of these places is possible to watch plenty of coastal and estuarine species that here to forage, breed, and raise offspring.

The estuary is part of the biggest remaining patch of Atlantic rain forest (SOS Mata Atlântica 2013), located between boundaries of States of São Paulo and Paraná (Fig. 2.2). Belongs to one of the most important Brazilian coastal ecosystem

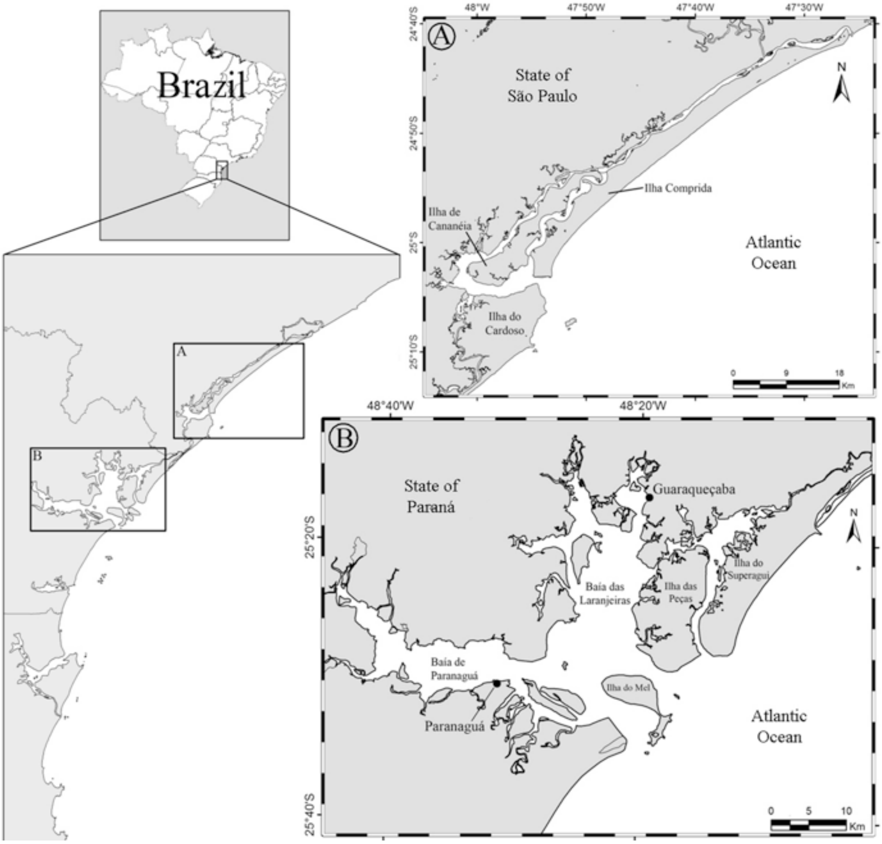

Fig. 2.2 Map of at Estuarine Lagoon Complex of Iguape Cananéia Paranaguá, located at boundaries of States of São Paulo and State of Paraná, Brazil. (**a**) Detailed map of Cananéia estuary, State of São Paulo, Brazil. (**b**) Detailed map of Paranaguá estuary, State of Paraná, Brazil

(Diegues 1987) and is considered as an internationally sanctuary that needs to be preserved (Mendonça and Katsuragawa 2001). According to IUCN (1984), this regions is one of the five most productive and less disturbed estuary in the world and is a priority to conservation according to the World Conservation Strategy. The estuary is legally protected by several federal, state and municipal protected areas, which together create a mosaic of conservation units that aims the conservation of local biodiversity (Schaeffer-Novelli et al. 1990). Besides that, is stated as "The Mata Atlântica Biosphere Reserve" and "World Heritage Site" by UNESCO at 1991 and 1999 (UNESCO 1992, 1999).

Cananéia estuary (24°40′S; 47°25′W and 25°05′S; 48°02′W; Fig. 2.2a) has 110 km of extension, consisting of a large protected channel (Mar Pequeno), one bay (Baía de Trapandé) and three islands (Ilha Comprida at east, Ilha do Cardoso at south and Ilha de Cananéia at west). Which communicate with the Atlantic Ocean by two inlets (Barra do Icapara at north and Barra de Cananéia at south). The channels are composed by brackish water, bordered by mangrove vegetation. The three main species of mangroves are *Rhizophora mangle* (red mangrove), *Laguncularia racemosa* (white mangrove) and *Avicennia schaueriana* (black mangrove) (Schaeffer-Novelli et al. 1990).

Paranaguá estuary (25°13′S; 48°06′W and 25°45′S; 48°44′W; Fig. 2.2b) shows two distinct components. The first one is represented by sandbars and many lagoons. The second one is more affected by the fluvial system. The flow of the water inside the estuary is regulated mainly by tidal currents, commonly found in estuarine systems. The fresh water and salt wedge interacts with each other creating a great distinctness during low and high tide (Bigarella 1978). The vegetation is mainly composed by mangroves, salt marshes and "restingas" (Lana 1986).

Both regions show a high variation of the bathymetry. Sand and mud banks are commonly found, which increases heterogeneity of underwater landscape. This ground depth variation builts many different coastal formations, flooded marshals and floodplains. The formation of vegetation islands enforces the water currents to narrow channels, creating a strong flow of water during tidal currents, which impacts water dynamics (Miyao and Sarti 1986). All complexity of this system receives high influence of tides, fluvial flow, and ocean winds (Miranda et al. 1995). The salinity patterns change seasonally, according to fresh water outflow, being higher during the Austral winter (dry season) and lower at Austral summer (rain season) (Miyao and Sarti 1986). Consequently, all these features are suitable to build a high heterogeneity habitat, which supports the presence of several species, including the Guiana dolphin.

2.4 Morphology

As part of our efforts, some studies started almost at the same time because of the necessity of collecting carcasses along the beach shores. One example of carcass-based study is described above, with the use of geometric morphometric (Monteiro-Filho et al. 2002), counting with great support of other institutions' scientific

Fig. 2.3 Skulls of two specimens of *Sotalia guianensis* used in cranial morphometric studies. Upper skull is from a calf specimen and below skull is from an adult. The skull of tucuxi (*S. fluviatilis*) is very similar to the skull of a calf *S. guianensis*, due to minor development of temporal region and minor projection of condyles occipitals. Specimens are deposited at Instituto de Pesquisas Cananéia (IPeC) scientific collection, municipality of Cananéia, State of São Paulo, Brazil (Photo: IPeC)

collections [Projeto Mamirauá (State of Amazonas), Museu Nacional (State of Rio de Janeiro), Museu de Zoologia da USP (State of São Paulo), Museu de História Natural da UNICAMP (State of São Paulo), Laboratório de Mamíferos Aquáticos da UFSC (State of Santa Catarina)] besides the collection from Instituto de Pesquisas Cananéia (IPeC), responsible for the "Projeto Boto-Cinza". Besides the discussion about the group systematics, the study points out to some other aspects. Specific adaptive characteristics in skulls were linked to the difference in the environment as well as different needs for each species. The authors discuss about differences in size of both species, showing that fresh water individuals have skull shape similar to younglings (paedomorphosis, Fig. 2.3.) and end up by making a reflection on the possibility of both species being more similar if fresh water individuals grew up to proportions of marine individuals. It seems not to be the case, since the divergence would tend to be even greater.

Concomitantly, Rosas and Monteiro-Filho (2002) evaluated the species' gonads shapes and sizes, describing testis as cylindrical with conical tips with average length of 7.36 cm (±1.82) and average width of 2.28 cm (±0.90) in immature and up to 25.52 cm (±3.48) and 9.65 cm (±1.14), respectively, in mature animals. Just like

Fig. 2.4 Testis of *Sotalia guianensis* of a sexually mature specimen dissected after necropsy. Specimen was found during beach monitoring activities at Cananéia estuary (Photo: IPeC)

Fig. 2.5 Ovaries and bipartite uterus of *Sotalia guianensis* of a sexually mature specimen dissected after necropsy. Specimen was found during beach monitoring activities at Cananéia estuary (Photo: IPeC)

the size, testis mass vary largely between immature, with 52.3 g (±33.5), and mature animals, with 2.270 g (±0.86) (Fig. 2.4). The testis mass correspond to 0.11% of body mass in immature and 2.52% in mature individuals, keeping these proportions throughout the year, with no apparent seasonality in testis activity detected. Female, just as with other Delphinidae, have bipartite uterus (Fig. 2.5) with the shape of a small almond (Rosas and Monteiro-Filho 2002; Rosas and Barreto 2008). The authors detected little variation in ovary morphometric, ranging from 2.3 cm (±0.5) long and 1 cm (±0.2) wide in immature to 3 cm (±0.4) long and 1.7 cm (±0.3) wide in mature animals. Differently, ovary masses increase significantly, from 1.6 g (±1)

Fig. 2.6 Photography of two specimens of *Sotalia guianensis*. Dolphin on left is an adult, while the dolphin on right side is an infant, which is recognized by pinkish color of dorsal fin, back and flanks (Photo: Caio N. Louzada)

in immature to 7.9 g (±4.2) in mature animals (Rosas and Monteiro-Filho 2002; Rosas and Barreto 2008).

The newborn average size was estimated in 92 cm. The estimated gonadal maturity occurs between 165 and 170 cm in females and between 170 and 175 cm in males (Rosas and Monteiro-Filho 2002). In relation to the cetacean morphology, the skin is mostly evaluated regarding the blubber (e.g. Sokolov 1960; Giacometti 1967; Simpson and Gardner 1972; Pfeifer and Jones 1993). The skin thickness changes according to age in *S. guianensis*, with expressive ontogenetic variation in pigmentation (Randi et al. 2008). Therefore, the pink color that appear in infants (Fig. 2.6) results of intense vascularization and a thin blubber layer rather than by red pigmentation on the skin. The only detected pigment was melanin, scarce in infants and increases with aging. Such increase tend to cover the pink tones of vascularization, making adults mostly grey in the dorsal portion of the body, reducing towards the flanks.

2.5 Age Evaluation

Successful age estimates were made with *S. guianensis* carcasses through counting of dentin growth layers deposited in teeth (Schmiegelow 1990; Ramos 1997, Rosas 2000; Rosas et al. 2003; Sydney and Monteiro-Filho 2011; Wanderley 2013; Fig 2.7). The term “Growth Layer Group” (GLG) describes the distinct lines formed by deposition of dentin and cementum in layers. Although different possible techniques may be used to access age in cetacean, Rosas et al. (2003) describe some guidelines for age estimates with teeth since there was no specific model for dentin deposition or GLG reading for the species. Researches in Cananéia (SP) and Paranaguá (PR) registered a variation between 0 (newborn) and 30 years, being female the eldest representation (Rosas et al. 2003; Wanderley 2013) and immature (up to 6 years old) present greater mortality frequency, indicating a possible greater vulnerability to natural and/or anthropic threats due to inexperience of younger animals (Wanderley 2013).

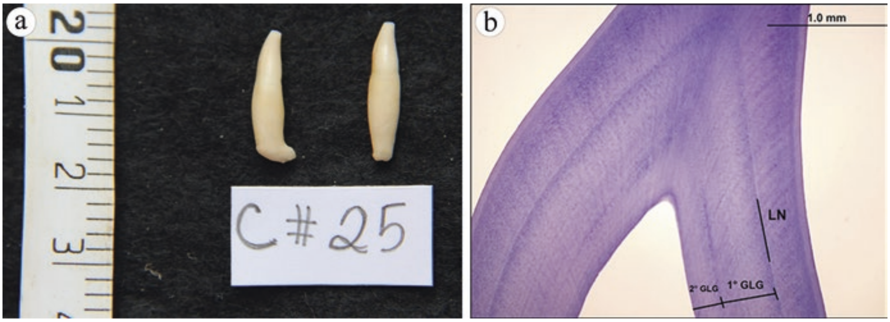

Fig. 2.7 (**a**) *Sotalia guianensis* teeth deposited at Instituto de Pesquisas Cananéia (IPeC) scientific collection, municipality of Cananéia, State of São Paulo, Brazil. (**b**) Photomicrography of apical region of *Sotalia guianensis* teeth, cut at 30 μm and colored with Harris' Hematoxylin. *LN* Neonatal line, 1° GLG – first growth layer group referring to the first year of life, *2° GLG* second growth layer group referring to an incomplete second year of life (Photos: Rebeca P. Wanderley)

Beyond the importance of GLG in age estimation in *S. guianensis*, there is strong evidence that the end of milk-feeding period is also registered. Rosas et al. (2003) described an accessory layer deposited in the dentin between the neonatal layer and first GLG as being possibly linked to the end of milk-feeding of the infants, which varied between 6.7 and 10.3 months. According to the authors, the decrease of calcium caused by ablactation could reflect in a hipomineralized layer. Rosas and Monteiro-Filho (2002) described the milk composition, where protein (9.5 g/100g) and fat (17.1 g/100g) values were similar to those observed in other delphinids' milk.

2.6 Population Parameters and Habitat Index

Monteiro-Filho (2000) conducted the first studies related to Guiana dolphin group organization in Cananéia, defining three categories: individual (Fig. 2.8a), family (Fig. 2.8b), and school (Fig. 2.8c). The family organization is the most commonly seen in the study region, registered in more than 80% of the field observations (Monteiro-Filho 2000). The basic structure is composed by a female and its calf, or even by an adult, a female and its calf. For the first months after birth, while the calf remains close to its mother (Fig. 2.9), the associated adult may aid the mother in feeding. Schools happen when there is an association of several families (Fig. 2.8c), which can happen temporary (from 5 to 60 min) for feeding or displacement purposes.

Beside studies about social organization, it was also necessary to estimate dolphin density in the region. For cetaceans, researchers use diverse techniques to assess population density such as census, mark-recapture method, land observations and line transect. Bisi (2001) and Havukainen et al. (2011) made density estimates for Cananéia region based on line transect, dividing the area in sectors and obtaining values reaching 12.41 individuals/km^2. The division of the area in sectors enabled results to show a non-uniform use within sectors.

Fig. 2.8 Examples of most frequent group structure found at Cananéia estuary Guiana dolphin population, State of São Paulo, Brazil. (**a**) Solitary individual. (**b**) Family, composed by one adult and one calf, and frequently a plus one adult. (**c**) School, which represents an association among several families (Photos: Caio Louzada)

Fig. 2.9 A calf of Guiana dolphin (*Sotalia guianensis*) is frequently observed swimming side-by-side with its parental (Photo: Caio N. Louzada)

The distribution pattern of animals may also be investigated in an individual basis and to assess such information the capture-mark-recapture method is the most usual. Since the physical capture of the Guiana dolphin would not be an adequate procedure, we made use of individual characteristics, captured on film by camcorder (de Oliveira and Monteiro-Filho 2008) or photographic camera. The photo-identification (Fig. 2.10) well known among cetacean researches, were originally based on film revelation (Würsig and Würsig 1977). Being non-invasive and therefore unlikely to alter natural behavior of the target species, the individual identification through images can answer questions related to individuals. De Oliveira and Monteiro-Filho (2008) reported the same individuals captured in image repeatedly in the same place: two individuals seen frequently close to a traditional local fishing trap, cerco-fixo, and a mother-calf association observed in two beaches in different islands. Medeiros (2014) presented similar results for both beaches (Fig. 2.11). In one of these areas, the Ponta da Trincheira, the author identified several individuals using the area, with no significant difference between them, while in the other, Praia do Pereirinha, fewer individuals were captured and all but two individuals were captured only once. These two individuals used this site significantly more than any other individual did, constantly accompanied by calves. Thereby, it is pos-

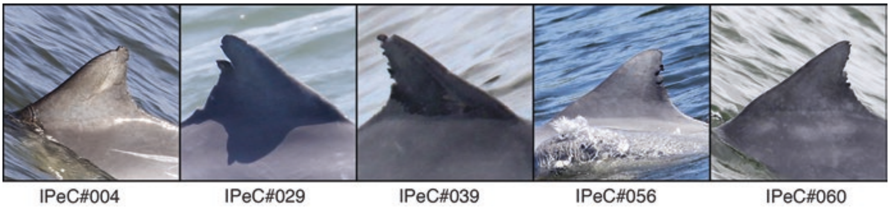

Fig. 2.10 Individuals of photo-identification catalogue of Instituto de Pesquisas Cananéia, used in studies of population dynamics, special patterns and social organization of Guiana dolphin's population of Cananéia estuary, State of São Paulo, Brazil

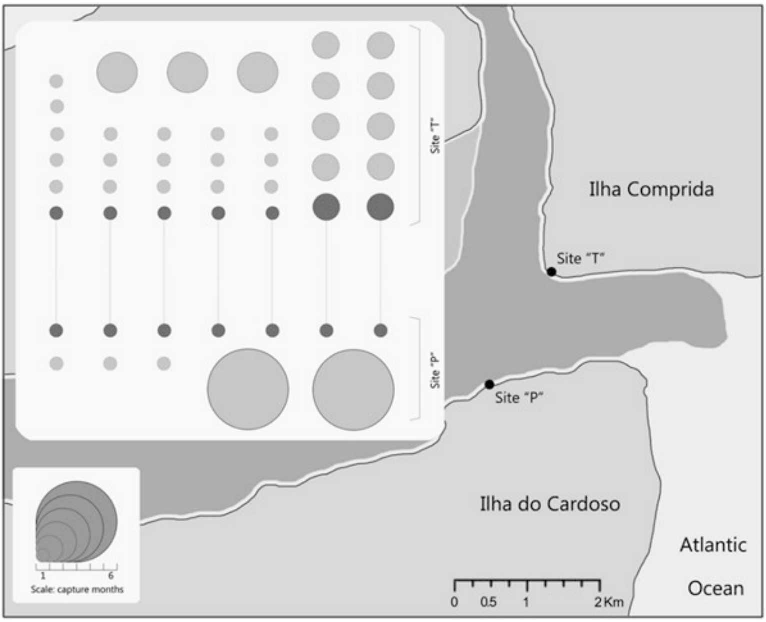

Fig. 2.11 Individual photo-identification in two close, but geomorphologically distinct sites; Site "T", known as "Ponta da Trincheira", and Site "P", known as "Praia do Pereirinha". *Light shaded circle* and *dark shaded diads* represents single individual captured exclusively in one or in both sites, respectively. Circle size refers to the number of months individuals were seen in each site, regardless the capture frequency within each month

sible to observe that dolphins use the area irregularly and some individuals may use more frequently one sector. Knowledge such as this may indicate different degree of fidelity for the area as a whole as well as for different sectors, besides assisting in the creation of management plans for conservation units according to local need of a better understanding of the area use of the Guiana dolphin.

Further, recent studies seek to understand what factors influence the occurrence and habitat use of Guiana dolphins in Cananéia region. Godoy et al. (2015) observed that dolphins concentrate mainly in the region close to the adjacent ocean. The authors verified that the generalized linear model with best fit presented salinity and depth with a positive correlation with the Guiana dolphin occurrence in the region. For a better understanding about the correlations between the species occurrence and environmental factors, the former researcher is developing additive generalized model to evaluate the use of habitat surrounding Cananéia Island, using several environmental variables and fish captured in the cerco-fixo fishing gear (Godoy et al. unpublished data). This study aims to evaluate anthropic interference in the distribution of Guiana dolphins through a predictive modelling.

2.7 Behavior

The first activities carried out with this species in the Cananéia region were the behavior studies. The naturalistic observations of the Guiana dolphin began early, in the 1980s, and had as main objective to document and describe the various behaviors performed by these animals, even facing various difficulties at the time. Initially, researchers did only land-based observations, since the geomorphological characteristics of the region favored this method of observation from some beaches. However, over time, there was the need to expand the observations of behavior in different areas of the estuary, thus scientists started to use different types of boats, making it possible to obtain data from different perspectives.

The more than 600 h of observations of different behaviors carried out in Cananéia estuary allowed a detailed description of the main behavioral events associated with different strategies, and measure them. The first set of descriptions of the Guiana dolphin behaviors resulted from an effort of 10 years of observations, detailed in the first doctoral thesis on cetaceans in Brazil (Monteiro-Filho 1991). The author observed that the animals spend most of their time foraging activities, and there may be small shifts to other areas suggesting heterogeneity in the distribution of food resources within the estuarine waters. Similarly, night observations also have identified the same behavior performed and previously described for the day periods (Atem and Monteiro-Filho 2006).

Monteiro-Filho (1991) described some basic behaviors such as swimming, shallow diving, deep diving, and rest, as well as a number of hunting strategies, individuals and those carried out in groups. Fishing behaviors described for Guiana dolphin range from more general behaviors such as pursuit (Fig. 2.12a), to more complex behaviors such as pursuit with bubbles (Fig. 2.12b). Beside, there are cooperative fishing activities, as circle formation (Fig. 2.12c), which may involve a large number of individuals fishing cooperatively on a shoal.

The descriptions of such behaviors opened the door to further studies to identify details in each behavior initially observed. Variations of these main behaviors received emphasis and then compared with behavior of populations from other estuaries in order to identify possible variations due to changes in environmental characteristics (Domit 2006). Monteiro-Filho (1992) observed interspecific interactions of the Guiana dolphin with at least five different species of marine and estuarine birds commonly spotted in the region: boobies (*Sula leucogaster*, Boddaert, 1783),

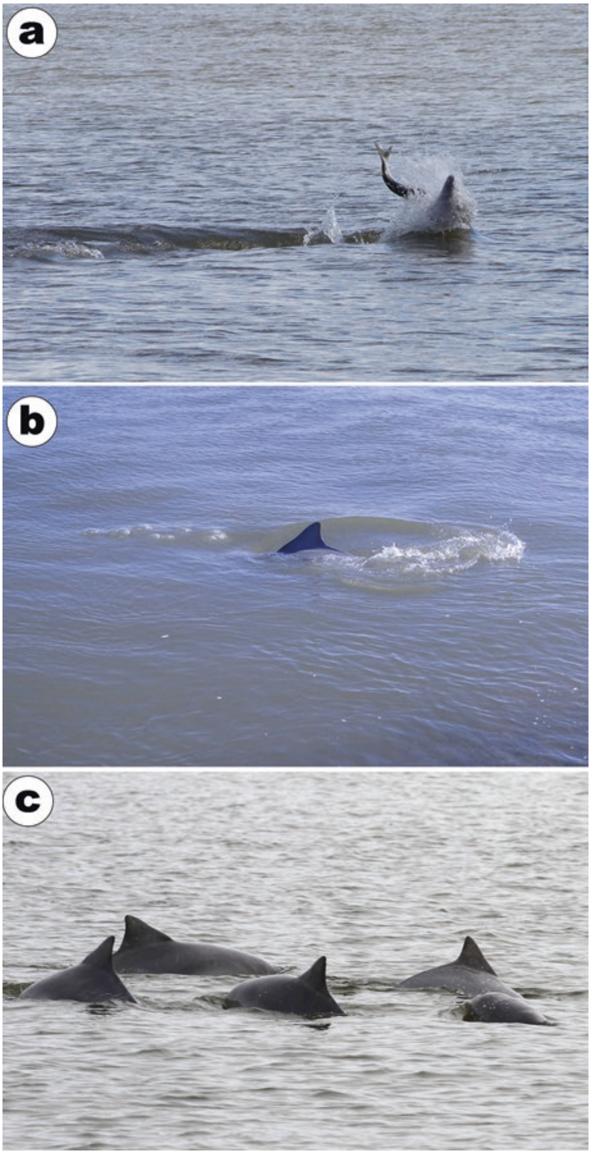

Fig. 2.12 Large variations of feeding behaviors were described for the population of Guiana dolphin at Cananéia estuary and Paranaguá estuary. (**a**) An individual pursuits a shoal of fishes and finalizes its attack with prey capture (a mullet, *Mugil* sp.) at water surface (Photo: Eric Medeiros). (**b**) Another more complex strategy used by dolphins during its foraging is the pursuit with bubbles, whereas the dolphin exhale air from lungs during a dive and creates a bubble barrier that encloses the shoal to opposite direction, where dolphins are waiting to prey on (Photo: Clarissa R. Teixeira). (**c**) Cooperative fishing is also observed as the circle formation in the picture (Photos: Eric Medeiros)

frigatebird (*Fregata magnificens*, Mathews, 1914), terns (*Sterna hirundinacea*, Lesson, 1831), gulls (*Larus dominicanus*, Lichenstein, 1983), and cormorants (*Phalacrocorax brasilianus*, Gmelin 1789; Fig. 2.13).

One notable feature of the Guiana dolphin behavior in Cananéia estuary is the interaction with the artisanal fishing traps, regionally called cerco-fixo (for more information on the operation of the cerco-fixo see Dias 1990; Oliveira and Hanazaki 2011). The dolphins use the fishing apparatus to aid in hunting strategies (Monteiro-Filho 1995; Louzada 2013; Fig. 2.14). In this positive interaction between local fishermen and dolphins, both sides benefit, as the Guiana dolphin is able to catch fish more easily and fishermen get higher fish catch in the presence of animals hunting near the cerco-fixo (Louzada 2010).

Over the years, the accumulation of hours of behavior recordings within the estuary found that dolphins used different sets of fishing behaviors in different areas. Such remarks oriented future studies to search which factors influence the behavioral patterns observed in the Guiana dolphin population in Cananéia estuary. After quantifying different fishing strategies in estuarine regions with different geomorphological characteristics, Louzada (2014) noted that dolphins adapt the fishing strategies to fit better in each distinct areas of the estuary. This finding helped to understand the reasons why dolphins presented some behaviors with particular characteristics at specific locations (adaptations due to site geomorphology) and different one across the estuary (adaptations due to the prey characteristics). Moreover, the different associations between individuals and the group composition, while foraging, was also a factor influencing the fishing strategies used. Therefore, the author suggested that the Guiana dolphin has a behavioral plasticity large enough that allows it to adapt their foraging strategies to different fishing locations and different group structures. This behavioral plasticity had already been suggested to explain small differences in descriptions presented by different authors in different geographic areas (Monteiro-Filho 2008).

Louzada (2014) also assessed whether the fishing strategies varied according to the different types of prey consumed, once that prey exert a great influence on many ecological patterns of their predators (Würsig 1986). By grouping the Guiana dolphin main prey in the region according to their ecological guilds (i.e. resident estuarine species, marine visitors, and juvenile marine species), vertical guilds (i.e. benthic, pelagic, nektonic demersal, and benthic-pelagic demersal), and shoal formation habit (i.e. forming small shoal, forming large shoals, and not forming shoals) and comparing them to the foraging strategies, no relationship was found between both factors. The author suggested, once again, that behavioral plasticity of the Guiana dolphin allows the development of foraging strategies specific to several types of prey and under different environmental conditions. Thus, the set of behavioral studies of dolphins in the region, has allowed us to show that the animal has an extensive repertoire of foraging strategies, leading it to fish effectively, on different guilds, in different regions of the estuary, and in different group structures. If such behaviors were not efficient in the process of prey capture and intake, the same would not be part of this vast repertoire and would be discarded long ago.

Studies such as this, that evaluate the types of prey consumed by the Guiana dolphin, were only possible thanks to years of beach monitoring in the Cananéia region in search of stranded carcasses. Carcasses collected serve as osteological material and as samples for natural history studies of the species. By analyzing the stomach contents (to study methods and analysis of stomach contents see Fitch and Brownell 1968), researchers determined that the Guiana dolphin feeds on a wide variety of prey, which together add up to 34 different species (29 teleost species, two species of cephalopods, and three species of crustaceans). However, even the dolphins being able to consume a large variety of prey, some particular item in their

Fig. 2.13 An interspecific interaction among Guiana dolphin and several species of seabirds is frequently observed at Cananéia estuary. At this picture is possible to see a large group of brown boobies (*Sula leucogaster*) foraging in association with a Guiana dolphin group (Photo: Caio N. Louzada)

Fig. 2.14 At Cananéia estuary, Guiana dolphins have a positive interaction with artisanal fishermen. At the estuarine waters, fixed fishing traps are built, which benefit dolphins foraging due to a limitation of escape routes for shoals during foraging. Groups of Guiana dolphins are found frequently using these traps during fishing activities (Photo: Caio N. Louzada)

diet have a greater relative importance of the total ingested items. These items possibly represent prey species that are abundant in the region during some periods, since the richness of teleost, crustaceans and cephalopods available for consumption is almost twice as much as the number of species ingested by the Guiana dol-

Fig. 2.15 One of most executed parental care behavior is the echelon swimming, in which calf swim side-by-side of its parental during whole dive and surfacing time. Most of times the behavior is synchronic and the calf keeps a physical contact with the adult (Photos: Caio N. Louzada)

phin in the region, showing that the dolphins are able to select some species for consumption (Louzada 2014).

One of the factors that strongly influences the fishing strategies is the presence of calves in the group (Monteiro-Filho 1991, 2000). Calves require great attention of parents, especially during the first months of life, when they are more vulnerable to environmental adversities. Rautenberg and Monteiro-Filho (2008) described in detail the key behaviors of parental care observed for the Guiana dolphin in the Cananéia estuary. These authors identified one of the key behaviors, as already described for other species of cetaceans, was the echelon swimming (Fig. 2.15). Other behaviors identified were the alternation, escort, meeting among families and crèche.

Later, it was possible to deepen the studies to understand how the quality and quantity of parental care varies according to the calves' ontogeny and the variations of parental care in different sites of the estuary. Teixeira et al. (*unpublished data*) observed that while offspring developed, contrary to what was initially expected, there is no decrease in the quantity of parental care effort, but a change in the quality. In the same way, extrinsic factors, such as changes in geomorphological characteristics of the site, are able to influence the frequency of care for the calves executed by parents (Teixeira 2013).

Parallel to the study of Guiana dolphin parental care behavior, some studies focused their observations on the behavior of infants and juveniles. The fact that births occur throughout the whole year in the Cananéia region (Schmiegelow 1990; Rosas and Monteiro-Filho 2002) favored behavioral studies of calves, rarely done in other regions of the country by the time. The calves are born after a gestation period ranging from about 11.5 to 12 month (Rosas and Monteiro-Filho 2002), with an average size of 88–98 cm long (Monteiro-Filho et al. 2008b). Through the observations, researchers characterized the behavior of infants, as has been observed for other species, by a high frequency of contacts between calves and parents (Domit 2002). The author also noted that the young are involved in many events of play, consisting of jumps, chases, and capture of possible prey. Many of the observations of these plays are associated with fishing learning periods (Domit 2002, 2006). Markedly, calves also perform various activities near the surface to perform a visual recognition of the area as to spot other individuals in the surroundings (Monteiro-Filho et al. 2008b). Finally, through the behavior, one can recognize four age classes for the Guiana dolphin calves classified as newborn, F1 infant, F2 infant, and juvenile (Fig. 2.16).

Fig. 2.16 The color patterns of calves skins are used to identify different ages classes. (**a**) A newborn shows a strong pinkish color the whole body. (**b**) F2 has an light pinkish color mainly at dorsal fin and flanks. (**c**) In calves, the skin pigmentation is almost complete and only a small region of dorsal fin remains pink, while the whole body is a dark-grey, like other adults (Photos: Eric Medeiros)

2.8 Acoustic

Our acoustic studies with the Guiana dolphin began in the 1980s and after 10 years of sampling, Monteiro-Filho and Monteiro (2001) described the specie's sound repertoire, categorizing sounds in whistles, calls, clicks and gargle (emitted by calves; Fig. 2.17), and even some complex sequences, as possible phrases. This was the first study to assess sounds produced by the species in natural environment, as prior studies only investigated Guiana dolphin in captivity (e.g. Caldwell and Caldwell 1970; Kamminga et al. 1993; Sauerland and Dehnhardt 1998).

Following the sound characterization for the species, studies have assessed the influence of noise generated by vessels, concluding that anthropogenic noise forces dolphins to raise the frequency range of the sounds used in social communication, seeking a new acoustic niche (Rezende 2008; Fig. 2.18). Also in relation to the noise produced by ships, Monteiro-Filho et al. (2008c) found that wooden boats and inboard engines (fishing vessels) generate low intensity noise and in frequencies below those used by dolphins. On the other hand, vessels with outboard engines (fishing sports, passenger transport, and tourism) generate high intensity noise with frequency equivalent to the lowest frequencies produced by dolphin, which may cause the phenomenon of interference (Fig. 2.18).

Despite advances in knowledge of the sound emission of the species and the context in which emission happen such as social, fishing, and nocturnal activities (Monteiro-Filho and Monteiro 2001, 2008; Rodrigues 2003; Atem and Monteiro-Filho 2006; Wanderley 2006; Oliveira et al. 2008; Rossi-Santos and Monteiro-Filho 2008), samples were specific and limited to 8 kHz and then to 20 kHz. Since such frequencies did not allowed the interpretation of some features of dolphins' acoustic universe, from 2011, with availability of better equipment and systematic sampling, we began evaluating sounds that reach sampling frequencies up to 48 kHz (Deconto and Monteiro-Filho 2013, 2016; Fig. 2.19).

The most recent studies have advanced in relation to the characterization of the sounds used in daytime and nighttime activities (Deconto and Monteiro-Filho 2016). The authors brought up a the new classification of dolphin sound emission in the region, braking down the calls, originally described by Monteiro-Filho and Monteiro (2001), into burst pulse sounds and low frequency narrow-band sounds

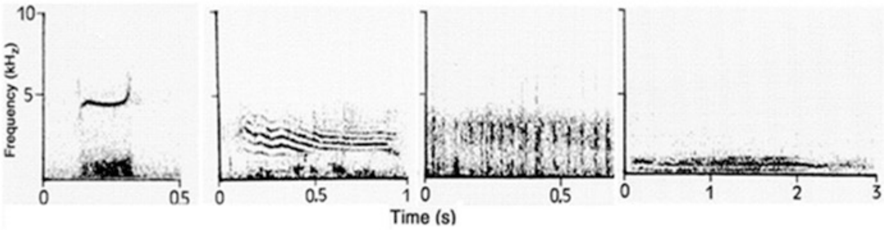

Fig. 2.17 Sounds produced by *Sotalia guianensis* and categorized by Monteiro-Filho and Monteiro (2001). From left to right: whistles, screams, clicks, gargle. Y axis represents frequency in kHz; X axis I time in seconds

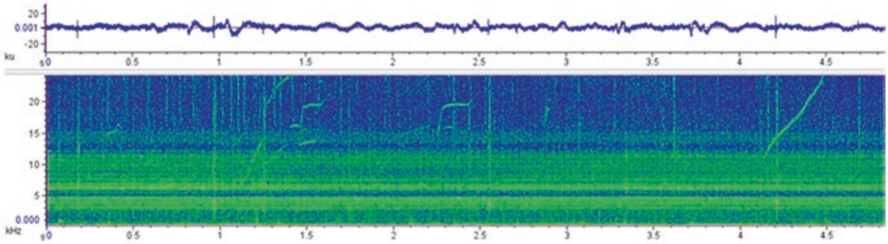

Fig. 2.18 A spectrogram highlighting the "noise" produced by a vessel equipped with an outboard motor, represented by the *green color* horizontal band, which reaches up to 15 kHz
Note that whistles and clicks produced by *Sotalia guianensis* are masked by noise. Y axis represents frequency in kHz; X axis time in seconds

(LFN sounds; Fig. 2.20). Moreover, authors demonstrated a greater amount of sounds emitted, excluding the clicks, with lower frequencies during the day than the night. Thus, the sound repertoire of the species is daylight dependent, with influence on their social communication.

Another result of the study phase that began in 2011 was the observation of high initial and minimum frequencies of Guiana dolphin whistles in the region compared to previous studies for the species in Brazil. Deconto and Monteiro-Filho (2013) recorded sounds with these parameters very close to those recorded in Costa Rica (May-Collado and Wartzok 2009). Until then, the most accepted hypothesis was that the frequencies of the Guiana dolphin whistles increased from higher latitudes toward areas of lower latitudes (Azevedo and Van Sluys 2005; Rossi-Santos and Podos 2006). Thus, reinforcing a hypothesis initially raised by Rossi-Santos and Podos (2006), Deconto and Monteiro-Filho (2013) present new evidence that the latitudinal variations reflect adaptations to the environment, a fact recently confirmed (Leão et al. 2015).

Continuing the acoustic study focusing on environmental influence on the spread of Guiana dolphin sounds, IPeC researchers have conducted experiments in natural environment both in the Northeast (Praia da Pipa) and in Southeastern Brazil

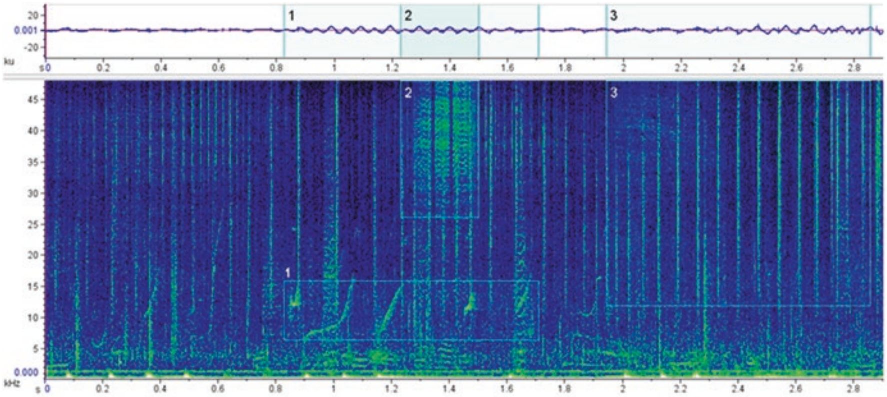

Fig. 2.19 A spectrogram showing the sampling frequency of 48 kHz, highlighting different sounds produced by *Sotalia guianensis*, which could occupy this acoustic niche. *1* Whistles; *2* burst pulses; *3* clicks. Y axis represents frequency in kHz; X axis time in seconds

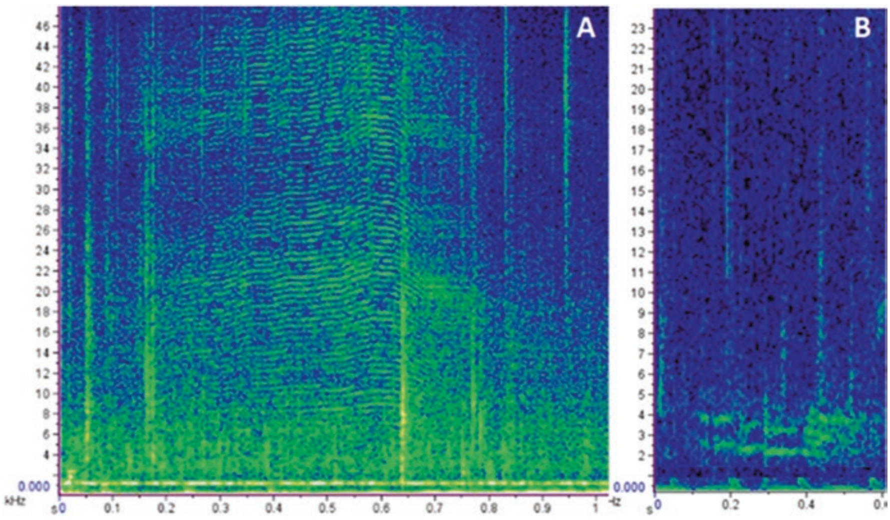

Fig. 2.20 The calls produced by *Sotalia guianensis* described by Monteiro-Filho and Monteiro (2001) were subdivided into two categories by Deconto and Monteiro-Filho (2016), burst-pulse sounds (**a**) and low frequency narrow-band sounds (**b**)

(Cananéia). The two study areas were chosen because they are two different habitats with respect to environmental and geomorphological parameters, which we expect that after the analysis, will recognize the influence of latitude, temperature, salinity, depth, turbidity and the sound source of the distance in the repertoire Guiana dolphin sound.

2.9 Conservation

Throughout this period of study, information on the biology and ecology of the estuarine dolphin allowed us to understand some of its needs in Cananéia estuary as well as the various interactions of this species with humans and their technologies.

Cananéia is within an area of great biological and scenic abundance [“World Natural Heritage Site” and “Atlantic Forest Biosphere Reserve” (UNESCO 1992, 1999)]. Here, two activities are widely developed: artisanal fishing and tourism. Both activities involve the use of vessels with vary propeller engines. Even considering that the estuary is large and the number of vessels is not very big, we could detect different reactions of the Guiana dolphin in relation to wooden vessels with inboard engine, aluminum vessels with outboard motors, and fiber sport vessels (Fig. 2.21). The study showed that the central engine of wooden vessels produce low intensity noise in the water, because wood is a great sound conductor and disperses noise produced into the air. Thus, boats used on local artisanal and some wooden boats used in tourism, produce low intensity noise and are not fast, allowing Guiana dolphin to control proximity (Monteiro-Filho et al. 2008c). However, the same can not be said for vessels with outboard engines, which sometimes alter the behavior of the dolphins (Monteiro-Filho et al. 2008c). Aiming to minimize the possible impact of noise produced by vessels, a series of tests were done and so generated a simple proposal, by reducing the speed when the conductor sighted the dolphins, noise was also reduced and dolphins were able to manage the approach of vessels.

After these studies, new questions began to arise. How many vessels could operate simultaneously with tourism activities? How close these vessels could approach? How should captains proceed before dolphin groups? In search of these answers, studies were conducted for about 3 years evaluating possible interactions between vessels and Guiana dolphin, how vessels were conducted, and periods and distances that these vessels should remain without interfering with the dolphins’ activities (Fig. 2.22).

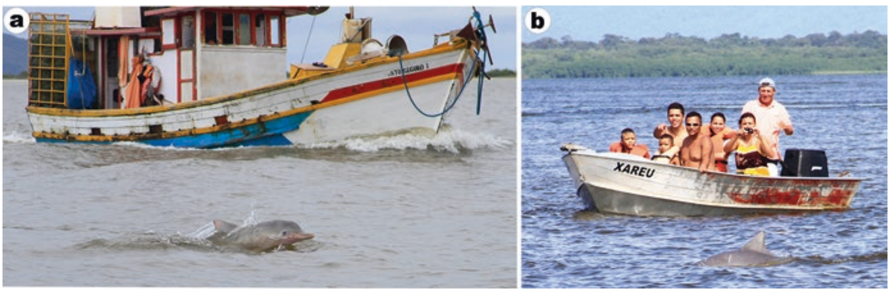

Fig. 2.21 Different kinds of vessels navigate at Cananéia and Paranaguá estuary waters, Brazil. (**a**) Fishing boats are made of wood equipped with inboard engine. (**b**) The dolphin-watching tourism are performed mainly by small aluminum boats equipped with outboard motor (Photos: Eric Medeiros)

Fig. 2.22 An informative poster was created as a public politic activity developed by Projeto Boto-Cinza in order to advertise the population about the best way to approach and observe dolphins with minimum impact created by vessels

The results produced with the studies on the production of noise (Monteiro-Filho et al. 2008c), added to onboard tourism activities (Filla and Monteiro-Filho 2009 a, b, c), on the estuarine dolphin economic valuation in the estuary of Cananéia (Filla et al. 2012), subsidized municipal legislation that established procedures and restrictions of nautical activities in the region (municipal Law No. 2129/2011), without, however, interfering with commercial activities.

Currently, our data is constantly requested by conservation unit managers in the region for the proposal of nautical activities establishment and standardization. In the year 2015, during the development of the Management Plan of the Cananéia-Iguape-Peruibe Environmental Protection Area (ICMBio 2016), the results of works on distribution and space use by the estuarine dolphin in Cananéia estuary were presented to sustain the creation of a Sustainable Use and Protection of Cetaceans Estuarine Zone (ZEUSPC). Through a technical feedback by some of the project's researchers, the total area of the special zoning was expanded to include areas with considerable concentrations of groups, previously not been taken into account.

References

Atem ACG, Monteiro-Filho ELA (2006) Nocturnal activity of the Estuarine dolphin, *Sotalia guianensis* (CETACEA, DELPHINIDAE), in the region of Cananéia, São Paulo State, Brazil. Aquat Mamm 32:236–241

Azevedo AF, van Sluys M (2005) Whistles of tucuxi dolphins (*Sotalia fluviatilis*) in Brazil: comparisons among populations. J Acoust Soc Am 117:1456–1464

Bigarella JJ (1978) A Serra do Mar e a porção do Estado do Paraná: Um problema de segurança ambiental e nacional (contribuição à geografia, geologia e ecologia regional). Secretaria de Estado do Planejamento, Associação de Defesa e Educação Ambiental (ADEA), Curitiba, p 248

BISI TL (2001) Estimativa da densidade populacional do boto-cinza *Sotalia guianensis* (CETACEA, DELPHINIDAE) na região estuarina lagunar de Cananéia, SP. Undergraduation thesis. Universidade Estadual Paulista. Rio Claro, SP

Caldwell DK, Caldwell MC (1970) Echolocation-type signals by two dolphins, genus *Sotalia*. Q J Florida Acad Sci 33:124–131

Carvalho CT (1963) Sobre um boto comum no litoral do Brasil. (Cetacea:Delphinidae). Rev Bras Biol 23:263–276

Cunha HÁ, da Silva VMF, Lailson-Brito J Jr, Santos COM, Flores PAC, Martin AR, Azevedo AF, Fragoso ABLZ, Zanelatto RC, Solé-Cava AM (2005) Riverine and marine ecotypes of *Sotalia* dolphins are different species. Mar Biol 148:449–457

de Oliveira FC, Hanazaki N (2011) Ethnobotany and ecological perspectives on the management and use of plant species is the traditional fishing trap, southern coast of São Paulo, Brazil. J Environ Manage 92:1783–1792

De Oliveira LV, Monteiro-Filho ELA (2008) Individual identification and habitat use of the estuarine dolphin *Sotalia guianensis* (Cetacea:Delphinidae) in Cananéia, south-eastern Brazil, using video images. J Mar Biol Assoc UK 88:1199–1205

Deconto LS, Monteiro-Filho ELA (2013) High initial and minimum frequencies of *Sotalia guianensis* whistles in the southeast and south of Brazil. J Acoust Soc Am 134:3899–3904

Deconto LS, Monteiro-Filho ELA (2016) Day and night sounds of the Guiana dolphin, *Sotalia guianensis* (Cetacea:Delphinidae) in southeastern Brazil. Acta Ethol 19:61–68

Dias ERA (1990) Produtividade de um cerco–fixo no Parque Estadual da Ilha do Cardoso, na região lagunar– estuarina de Cananéia, SP. In Livro de Resumos. II Simpósio de Ecossistemas da Costa Sul e Sudeste Brasileira: estrutura, função e manejo Águas de Lindóia, SP: Academia de Ciências de São Paulo, p 400

Diegues AC (1987) Conservação e desenvolvimento sustentado de ecossistemas litorâneos no Brasil. São Paulo, Secretaria Estadual do Meio Ambiente de São Paulo, p 46

Domit C (2002) Comportamento de filhotes de *Sotalia guianensis* (Cetacea: Delphinidae), na região do Complexo Estuarino Lagunar de Cananéia, São Paulo. Undergraduation thesis, Universidade Estadual de Londrina, Londrina, PR, Brasil

Domit C (2006) Comportamento de pesca do boto-cinza, *Sotalia guianensis* (van Bénéden, 1864). Master thesis, Universidade Federal do Paraná, Curitiba, PR, Brasil

Edwards H, Schnell G (2001) Status and ecology of *Sotalia fluviatilis* in the Cayos Misquitos Reserve, Nicaragua. Mar Mamm Sci 17:445–472

Filla GF, Monteiro Filho ELA (2009a) A contribuição do olhar e da percepção do turista na conservação de áreas naturais: o turismo de observação do boto-cinza na região de Cananéia (SP). OLAM – Ciênc Tecnol 9(1):243–269

Filla GF, Monteiro Filho ELA (2009b) Monitoring tourism schooners observing estuarine dolphins (*Sotalia guianensis*) in the Estuarine complex of Cananéia, south-east Brazil. Aquat Conserv Mar Freshw Ecosyst 19:772–778

Filla GF, Monteiro Filho ELA (2009c) O desenvolvimento do turismo náutico e a sua ligação com a observação do Boto-cinza (*Sotalia guianensis*) na região de Cananéia, litoral sul do Estado de São Paulo. Turismo em Análise 20(2):282–301

Filla GF, de Oliveira CB, Gonçalves JM, Monteiro-Filho ELA (2012) The economic evaluation of estuarine dolphin (*Sotalia guianensis*) watching tourism in the Cananéia region, south-eastern Brazil. Int J Green Econ 6:95–116

Fitch JE, Brownell RJ Jr (1968) Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. J Fish Res B Can 25:2561–2574

Gervais FLP, Deville E (1853) Sur les mammiféres marins qui fréquentent les côtes de la France et plus particulìerement sur une novelle espéce de dauphins propre a la Méditerranés. Bulletin Sociéte Centrale d'Agriculture et des Comices Agricoles du Département de l'Herault, Montpellier, pp 140–155

Giacometti L (1967) The skin of the whale (*Balaenoptera physalus*). Anat Rec 159:69–76

Godoy DF, Andriolo A, Filla GF (2015) The influence of environmental variables on estuarine dolphins (*Sotalia guianensis*) spatial distribution and habitat used in the Estuarine Lagunar Complex of Cananéia, southeastern Brazil. Ocean Coastal Mange 106:68–76

Havukainen L, Monteiro-Filho ELA, Filla GF (2011) Population density of *Sotalia guianensis* (Cetacea: Delphinidae) in the Cananéia region, Southeastern Brazil. Rev Biol Trop 59:1275–1284

Hershkovitz P (1966) Catalog of living whales. Smithsonian Institution Press, Washington, DC

ICMBio (2016) Plano de Manejo da Área de Proteção Ambiental Cananéia-Iguape-Peruíbe, SP. Available in: http://www.icmbio.gov.br/portal/unidadesdeconservacao/biomas-brasileiros/marinho/unidades-de-conservacao-marinho/2241-apa-de-cananeia-iguape-peruibe. Accessed in 1 Oct 2016

IUCN (1984) Threatened protected areas of the world. IUCN Commission on National Parks and Protected Areas, Gland, Switzerland

Kamminga C, van Hove MT, Engelsma FJ, Terry RP (1993) Investigations on cetacean sonar X: a comparative analysis of underwater echolocation clicks of *Inia* spp. and *Sotalia* spp. Aquat Mamm 19:31–43

Lana PC (1986) Macrofauna bêntica de fundos sublitorais não consolidados da Baía de Paranaguá (Paraná). Nerítica 1:79–89

Leão DT, Monteiro-Filho ELA, Silva FJL (2015) Acoustic parameters of sounds emitted by *Sotalia guianensis*: dialects or acoustic plasticity? J Mammal 97:611–618

Louzada CN (2010) Interação entre *Sotalia guianensis* (van Bénéden, 1864) e a arte pesqueira artesanal de cerco-fixo no complexo estuarino-lagunar de Cananéia. Undergraduation thesis, Universidade Estadual de Maringá, Maringá

Louzada CN (2013) How do Guiana dolphin (*Sotalia guianensis*), from the Cananéia estuary in state of São Paulo, use cerco-fixo fish traps in their fishing activities? Revista de Etologia 12:18–24

Louzada CN (2014) Características das estratégias de pesca do boto-cinza (*Sotalia guianensis*) em diferentes regiões do complexo Estuarino-lagunar de Cananéia. Master thesis, Universidade Federal do Paraná, Curitiba

May-Collado LJ, Wartzok D (2009) A characterization of Guyana dolphin (*Sotalia guianensis*) whistles from Costa Rica: the importance of broadband recording systems. J Acoust Soc Am 125:1202–1213

Medeiros E (2014) Different types of individual habitat use in two close sites by Guiana dolphin (*Sotalia guianensis*) in the Cananéia Estuary- Brazil. Master thesis, Universidade Federal do Paraná, Curitiba

Mendonça JT, Katsuragawa M (2001) Caracterização da pesca artesanal no complexo estuarino-lagunar de Cananéia-Iguape, Estado de São Paulo, Brasil (1995–1996). Acta Sci Biol Sci 23:535–547

Miranda LB, Mesquita AR, França CAS (1995) Estudo da circulação e dos processos de mistura no extremo sul do mar de Cananéia: condições de dezembro de 1991. Bol Inst Ocean 43:153–164

Miyao SY, Sarti CC (1986) Características Físicas e Químicas Do Sistema Estuarino-Lagunar De Cananéia-Iguape. Bol Inst Ocean 34:23–36

Monteiro-Filho ELA (1991) Comportamento de caça e repertório sonoro do golfinho *Sotalia brasiliensis* (Cetacea:Delphinidae) na região de Cananéia, Estado de São Paulo. PhD thesis, Universidade de Campinas, Campinas

Monteiro-Filho ELA (1992) Pesca associada entre golfinhos e aves marinhas. Rev Bras Zool 9:29–37

Monteiro-Filho ELA (1995) Pesca interativa entre o golfinho *Sotalia fluviatilis guianensis* e a comunidade pesqueira da região de Cananéia. Bol Inst Pesca 22:15–23

Monteiro-Filho ELA (2000) Group organization of the dolphin *Sotalia fluviatilis guianensis* in an estuary of southeastern Brazil. Ciên Cult 52:97–100

Monteiro-Filho ELA (2008) Comportamento de Pesca. In: Monteiro-Filho ELA, Monteiro KDKA (eds) Biologia. Ecologia e Conservação do Boto-cinza. Páginas & Letras, São Paulo, pp 77–89

Monteiro-Filho ELA, Monteiro KDKA (2001) Low-frequency sounds emitted by *Sotalia fluviatilis guianensis* (Cetacea: delphinidae) in an estuarine region in southeastern Brazil. Can J Zool 79:59–66

Monteiro-Filho ELA, Monteiro KDKA (2008) Repertório Sonoro. In: Monteiro-Filho ELA, Monteiro KDKA (eds) Biologia, Ecologia e Conservação do Boto-cinza. Páginas & Letras, São Paulo, pp 67–74

Monteiro-Filho ELA, Monteiro LR, Reis SF (2002) Skull shape and size divergengein the genus *Sotalia*: a tridimensional morphometric analysis. J Mammal 83:125–134

Monteiro-Filho ELA, Monteiro LR, Reis SF (2008a) Sistemática e distribuição de Sotalia. In: Monteiro-Filho ELA, Monteiro KDKA (eds) Biologia, Ecologia e Conservação do Boto-cinza. Páginas & Letras, São Paulo, pp 3–10

Monteiro-Filho ELA, Neto MMS, Domit C (2008b) Comportamento de infantes. In: Monteiro-Filho ELA, Monteiro KDKA (eds) Biologia, Ecologia e Conservação do Boto-cinza. Páginas & Letras, São Paulo, pp 51–65

Monteiro-Filho ELA, Gonçalves MLRL, Keinert AC, Sasaki G (2008c) Comportamento como bioindicador das interações entre Boto-Cinza e o homem (Tráfego de embarcações). In: Rossi-Santos MA, Reis MSS (eds) II Workshop do Nordeste: Pesquisa e Conservação de *Sotalia guianensis*, pp 129–136

Oliveira F, Rodrigues RG, Monteiro-Filho ELA (2008) Atividade noturna. In: Monteiro-Filho ELA, Monteiro KDKA (eds) Biologia, Ecologia e Conservação do Boto-cinza. Páginas & Letras, São Paulo, pp 157–163

Pfeiffer CJ, Jones FM (1993) Epidermal lipid in several cetacean species: ultrastructural observations. Anat Embryol 188:209–218
Ramos R (1997) Determinação de idade e biologia reprodutiva de *Pontoporia blainvillei* e de *Sotalia fluviatilis* (Cetacea: Pontoporiidae e Delphinidae) no Norte do Rio de Janeiro**.** Tese de Mestrado. Universidade Estadual do Norte Fluminense, Campos dos Goytacazes, Rio de Janeiro
Randi MAF, Rassolin P, Rosas FCW, Monteiro-Filho ELA (2008) Padrão de cor da pele. In: Monteiro-Filho ELA, Monteiro KDKA (eds) Biologia, Ecologia e Conservação do Boto-cinza. Páginas & Letras, São Paulo, pp 11–16
Rautenber M, Monteiro-Filho ELA (2008) Cuidado Parental. In: Monteiro-Filho ELA, Monteiro KDKA (eds) Biologia, Ecologia e Conservação do Boto-cinza. Páginas & Letras, São Paulo, pp 67–74
Rezende F (2008) Alterações acústico-comportamentais. In: Monteiro-Filho ELA, Monteiro KDKA (eds) Biologia, Ecologia e Conservação do Boto-cinza. Páginas & Letras, São Paulo, pp 155–176
Rice DW (1977) A list of the marine mammals of the world. 3rd ed. NOAA technical report, National Marine Fisheries Services 711:1–15
Rodrigues RG (2003) Análise comparativa das emissões sonoras do boto-cinza (*Sotalia guianensis*) nos períodos diurno e noturno. Undergraduation thesis, Universidade Federal do Paraná. Curitiba, Paraná
Rosas FCW (2000) Interações com a pesca, mortalidade, idade, reprodução e crescimento de *Sotalia guianensis* e *Pontoporia blainvillei* (Cetácea, Delphinidae) no litoral sul do Estado de São Paulo e litoral do Estado do Paraná, Brasil. PhD thesis, Universidade Federal do Paraná. Curitiba, Paraná
Rosas FCW, Barreto AS (2008) Reprodução e crescimento. In: Monteiro-Filho ELA, Monteiro KDKA (eds) Biologia, Ecologia e Conservação do Boto-cinza. Páginas & Letras, São Paulo, pp 51–65
Rosas FCW, Monteiro-Filho ELA (2002) Reproduction of the estuarine dolphin (*Sotalia guianensis*) on the coast of Paraná, Southern Brazil. J Mammal 83(2):507–515
Rosas FCW, Barreto AS, Monteiro-Filho ELA (2003) Age and growth of the estuarine dolphin (*Sotalia guianensis*) (Cetacea, Delphinidae) on the Paraná coast, southern Brazil. Fish Bull 101:377–383
Rossi-Santos MA, Monteiro-Filho ELA (2008) Panorama atual de bioacústica com o boto-cinza. In: Rossi-Santos MA, Reis MSS (eds) II Workshop do Nordeste: Pesquisa e Conservação de *Sotalia guianensis*, pp 144–150
Rossi-Santos MR, Podos J (2006) Latitudinal variation in whistle structure of the estuarine dolphin *Sotalia guianensis*. Behaviour 143:347–364
Sauerland M, Dehnhardt G (1998) Underwater audiogram of tucuxi (*Sotalia fluviatilis guianensis*). J Acoust Soc Am 103:1199–1204
Schaeffer-Novelli Y, Mesquita HSL, Cintrón-Molero G (1990) The Cananéia lagoon estuarine system, São Paulo, Brazil. Estuaries 13:193–203
Schmiegelow JMM (1990) Estudo sobre cetáceos odontocetes encontrados em praias da região entre Iguape (SP) e Baía de Paranaguá (PR) (24º 42′S – 25o 28ºS) com especial referência a *Sotalia fluviatilis* (Gervais, 1853) (Delphinidae). Dissertação de Mestrado, Universidade de São Paulo, São Paulo, SP, Brasil
Simões-Lopes PC (1988) Ocorrência de uma população de *Sotalia fluviatilis* Gervais 1853, (Cetacea, Delphinidae) no limite sul de sua distribuição, Santa Catarina, Brasil. Biotemas 1:57–62
Simpson JG, Gardner MB (1972) Comparative microscopic anatomy of selected marine mammals. In: Ridgeway T (ed) Mammals of the sea. Eds. Springfield, pp 298–418
Sokolov W (1960) Some similarities and dissimilarities in the structure of the skin among the members of the suborders Odontoceti and Mystacoceti (Cetacea). Nature 185:745–747
SOS Mata atlântica (2013) Atlas dos remanescentes florestais da Mata Atlântica período 2011–2012 Relatório Técnico. Fundação SOS Mata Atlântica e Instituto Nacional de Pesquisas Espaciais, São Paulo

Sydney NV, Monteiro-Filho ELA (2011) Efficiency of wear and decalcification technique for estimating the age of estuarine dolphin *Sotalia guianensis*. J Biosci 36(1):117–121

Teixeira CR (2013) Cuidado parental em boto-cinza, *Sotalia guianensis*, na região do complexo estuarino lagunar de Cananéia, Estado de São Paulo. Master thesis, Universidade Federal do Paraná, Curitiba

UNESCO (1992) United Nations Educational, Scientific and Cultural Organization – man and the Biosphere (MAB) programme. Available in: http://www.Unesco.Org/mabdb/br/brdir/directory/biores.Asp?Mode=gen&code=BRA+01. Accessed in 1 Oct 2016

UNESCO (1999) United Nations Educational, Scientific and Cultural Organization – world Heritage convention. Available in: http://whc.Unesco.Org/en/list/892. Accessed in 1 Oct 2016

Wanderley RP (2006) Análise das emissões sonoras de *Sotalia guianensis* (CETACEA: DELPHINIDAE) em alto mar, no litoral norte do Estado do Paraná, Brasil. Undergraduation thesis, Universidade Católica do Paraná, Curitiba, Paraná

Wanderley RP (2013) Estrutura etária do boto-cinza, *Sotalia guianensis*, no sul de sua distribuição: Uma avaliação dos encalhes e interação com redes de pesca. Master thesis, Universidade Federal do Paraná, Curitiba

Würsig B (1986) Delphinid foraging strategies. In: Schusterman RJ, Thomas JA, Wood FG (eds) Dolphin Cogn. Behav. A Comp. approach, 1st ed. Lawrence Erlbaum Associates, Hillsdale, pp 347–359

Würsig B, Würsig M (1977) The photographic determination of group size, composition, and stability of coastal porpoises (*Tursiops truncatus*). Science 198:755–756