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The influence of environmental variables on estuarine dolphins (*Sotalia guianensis*) spatial distribution and habitat used in the Estuarine Lagunar Complex of Cananéia, southeastern Brazil

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ABSTRACT

The spatial distribution and the use of the habitat by the estuarine dolphin in the Estuarine Lagunar Complex of Cananéia were studied between August 2009 and June 2010. The samplings were taken twice a month in three different segments, through parallel linear transections where environmental variables were recorded: depth, transparency, temperature, seasons of the year, and also the geographical location of the groups that have been seen. A total of 1.031 individuals were seen in 331 different groups, with the greatest occurrence being in the Trapandé Bay, close to the connection with the adjacent ocean. These dolphins were seen in all classes of variables as found. According to the IH, the dolphins used more opaque waters, at depths between ten and twenty meters; salinity of more than 27 parts per million (ppm) and temperatures above 22 °C. By means of generalized linear models, it was confirmed that the spatial distribution of the estuarine dolphins could be explained by salinity ($z = 3.661$; $p < 0.0001$) and depth ($z = 5.421$; $p < 0.0001$). In the light of the facts here exposed, it is clear that the estuarine dolphins have heterogenous distribution within the estuary as studied and the areas of greater concentration warrant more attention when drawing up preservation strategies.

1. Introduction

In many studies about the use of the habitat, the conclusion reached was that the environmental characteristics had an effective influence on the distribution and on the abundance of food resources, which, in turn, establish the whole distribution of the species within a certain area (Ballance, 1992; Hastie et al., 2004; Lodi, 2002).

Worldwide, several studies have been conducted to characterize the habitat and its use by the cetacean in small, medium and large scale using a variety of environmental features scale (Dalla Rosa et al., 2012; Evans and Bjørge, 2013; Kaschner et al., 2011; Lambert et al., 2014). Studies conclude that the model of habitat usage present in Odontoceti seems to be, in coastal waters, characterized by extreme fluctuations due to the entrances of rivers and a complex hydrology, depending on the sets of seasonal hydrological variables (Bearzi et al., 2008). Therefore, habitat models for coastal species shall be flexible enough to include a wide range of models and types of habitat variables, so that they may explain or predict the distribution of the species (Redfern et al., 2006).

Environmental characteristics such as transparency of the water, type of substrate at the bottom, depth, distance from the banks, surface temperature of the water and types of banks were analyzed in most studies which were conducted with the estuarine dolphin, *Sotalia guianensis* (Lodi, 2002; Rossi-Santos et al., 2010; Santos and Rosso, 2007; Wedekin, 2007).

Sotalia *guianensis* is a Delphinidae species which has coastal and estuarine habits (Hetzel and Lodi, 1993). It is widely distributed along the coast of South and Central America, from the Brazilian state of Santa Catarina (Simões-Lopes, 1988) as far as Honduras (Da

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Silva and Best, 1996).

On the Estuary of the Caravelas River in Northeastern Brazil, the estuarine dolphin has shown a greater use of shallow waters, close to the sand banks and also in areas where the sea bed is flatter. Apart from depth and relief, salinity has also been a distinguishing factor in the behavioral ecology of this species in the area, which means that the animals in this area have been in areas in which water salinity is close to the salinity of the sea (Rossi-Santos et al., 2010). The same occurred at Sepetiba Bay (RJ) on Brazilian Southeast coast, an area with the biggest population of estuarine dolphin. Simão and Poletto (2002) found that the areas used by *S. guianensis* showed similar attributes to those in oceanic coast, with high saltiness and low temperatures and turbidity.

At Guanabara Bay, according to Azevedo et al. (2007), the area with biggest concentration of estuarine dolphin corresponds to those of greater depth, since rarely have been seen on shallow water.

In a study conducted in the Estuary Complex of Paranaguá Bay, in the state of Paraná, Southern Brazil, Bonin (2001) concluded that the behavioral variables affecting the estuarine dolphin had been related to the depth and the distance from the banks. The animals tended to settle in locations closer to the bank, especially when they were feeding, which normally occurred in shallows and also in downhill-sloping locations.

Wedekin (2007) and Wedekin et al. (2007) also observed that, in addition to depth and distance from the margin, the type of substrate on the floor and the currents were also important factors in the appearance of estuarine dolphins in the area of the North Bay (State of Santa Catarina), also in the South of Brazil.

In studies with *S. guianensis* in Cananéia, in the Brazilian Southeast, Santos and Rosso (2007) showed that among the variables considered which were: water transparency, salinity, depth and water temperature, only depth had an influence on the estuarine dolphin presence or absence (event). However, the region still lacks information about the use of the habitat by this species. In this estuary, we have seen small groups of *S. guianensis* that can be seen daily in different locations (Santos and Rosso, 2008). The region is used by the species for fishing and also for reproduction, and the young estuarine dolphins can be seen throughout the year (Havukainen et al., 2011).

The data in this piece will help at the elaboration of a handling plan for the protected areas in which the author works, aiming to stablish the legal zone and use for this area, in order to preserve the estuarine dolphin population living in this area, that is suffering anthropic threat inside the protected areas (Di Beneditto and Rosas, 2008; Filla et al., 2008; Zappes et al., 2009). As Azzellino et al. (2012) mentioned, the anthropic activities are acting rising pressure onto the ocean, threaten the sea ecosystem. The mitigation option, that is sometimes promoted to minimize the impact of the anthropogenic activities in the sea environment, suits to avoid any impact onto critic habitats of sensitive species. The creation of an area management plan would effectively contribute to the conservation of estuarine dolphin population.

The only restriction is a bylaw, enacted in 2011, about the nautical planning of the region (Cananéia, 2011), after studies concluding that human activities can cause a great impact to the estuarine dolphins (Filla et al., 2008; Filla and Monteiro-Filho, 2009b).

The co-operation between protected area managers and researchers not only guarantee that both groups have some level of property about the information produced by the research, being relevant to the management and will be applied directly to the taking decision processes. The managers and researchers tend to agree with the major importance of the themes and the necessity to respond to the fundamental questions about main threat that ponder on to protected area management (Cvitanovic et al., 2013).

The object of this study was to investigate the distribution and use of the habitat by the estuarine dolphins in Cananéia region, their seasonality, and also to identify the "key habitats" of this species in the area associated with environmental variables distinguishing them. To de Boer et al. (2014), studies in great scale do not give detailed information about environmental variation that can induce these animals distribution. The author suggests that the studies of habitat usage need to be done in larger scale, as did it was done on the presented study. This information shall be used as support for actions towards the conservation of this species and also its natural habitat, in the Estuarine Lagunar Complex of Cananéia.

2. Material and methods

2.1. Species and area of study

The Estuarine Lagunar Complex of Cananéia is located in the southern of the state of Sao Paulo, southeastern Brazil (Fig. 1). It is formed by the islands of Cananéia, Comprida and Cardoso, separated by the Trapandé Bay. The region is part of the largest continuous remnant of Atlantic Forest (MMA, 2000; SMA, 2013). It is an area of higher expression of the "restinga" ecosystem, being part of the UNESCO World Network of Biosphere Reserve (SMA, 2000; UNESCO, 2010). Also located at Cananeia-Iguape-Peruibe Environmental Preservation Area (APA CIP) and, along with 30 federal, state, cities areas protected by the State of Sao Paolo and Parana Coast altogether make the Lagamar Mosaic (MMA, 2006). The Estuarine Lagunar Complex of Cananéia is considered of extreme biological importance, identified as priority area for conservation (MMA, 2007).

The area considered in the sample runs from the place where the ferry boat crosses, connecting Cananéia island and Ilha Comprida island, through to Cananéia Inlet, where the estuary connects with the adjacent ocean, thus including much of Trapandé Bay, to the Southern part of Cananéia island, close to Prainha.

2.2. Field activities

Between August 2009 and June 2010 (December 2009 not included), two sorties were made every month in studied area, making a total of 20 field researches, using preset routes (Fig. 1), and at these locations there was the reading of environmental variables and also the observation of the occurrence of estuarine dolphins in the area.

To have all areas showed in different periods of the day, the area was divided into three sectors which were labeled A, B and C, and transections were followed with the help of GPS TrackMaker 13.5, these being parallel to each other; a distance of 500 m was also observed between the transections to avoid the oversampling or under sampling of the area. Sector A, with transections 1 to 7, covered the area between the ferry boat connecting Cananéia island and Ilha Comprida island and Trincheira Point being the most narrow area studied; the B sector, transections 08, 09, 10, between Trincheira Point and the pier of the Ilha do Cardoso State Park (*Parque Estadual da Ilha do Cardoso* – PEIC), is closest area to the connected bar with sea adjacent and suffers the highest influence by salt water and tides; finally Sector C, with transections 11 and 12, covered the area from the PEIC pier and Prainha, on the Southern side of Cananéia island (Fig. 1). The area subdivision held on the samples execution randomly since the sequence from beginning/middle/end had been altered in sectors at each field research and in between two periods of the day (mornings and afternoons). Each sector were shown in every field research.