WP18

HABITAT USE OF THE ESTUARINE DOLPHIN, *SOTALIA GUIANENSIS* (VAN BÉNÉDEN, 1864), IN THE CARAVELAS ESTUARY, EASTERN BRAZIL.

Marcos Rossi-Santos [1, 2], Leonardo Wedekin [1, 2] & Emygdio Monteiro-Filho [2, 3]

[1] Instituto Baleia Jubarte. Rua Barão do Rio Branco, 26, Caravelas - Bahia, Brazil, 45900- 000, marcos.rossi@baleiajubarte.com.br; [2] Pós-Graduação em Zoologia, Universidade Federal do Paraná; [3] Instituto de Pesquisas Cananéia

Introdution

Cetacean distribution has been related to a variety of environmental variables such as depth and ocean bottom relief (Hui, 1979), water temperature and salinity (Selzer & Payne, 1988), and others. Particularly, for the estuarine dolphin, *Sotalia guianensis* (van Bénéden, 1864), classified as "Data Deficient" (Ibama, 2003), some studies linked behavior and tidal state (Araujo et al. 2001, Hayes et al. 1999), behavior and environmental daily and seasonal cycles (Daura-Jorge et al. 2005), occurrence and distance from the coast (Edwards & Schnell, 2001). Despite these studies, the knowledge about how distinct environment features influence the estuarine dolphin spatial use is still scarce. The present study aims to describe physical habitat use patterns for the estuarine dolphins in the Caravelas River estuary and adjacent waters, eastern coast of Brazil.

Material and Methods

Study area

The Abrolhos Bank (16°40' – 19°30'S and 38°00' – 39°30'W) is an enlargement of the Brazilian continental shelf located between the southern Bahia State and northern Espírito Santo State, eastern Brazilian coast (Figure 1). For a detailed description of the study area see Rossi-Santos & Wedekin (2006).

Field procedures

Boat surveys, with mean duration of 7 hours, were conducted following routes designed to cover the study area homogeneously. Data such as geographic positions, group size and behavior were colleted in blocks of five minutes when a group of dolphins was being followed. Environmental data such as tidal state, salinity, depth and surface water temperature were collected regularly every one-hour interval.

Data analysis

To characterize the habitat utilization of the estuarine dolphin, a Geographic Information System (GIS) was created through Arcview GIS 3.1 (Environmental Systems Research Institute, Inc.- ESRI), including a quadrat grid (5x5 km) a TIN model of the sea bottom (Triangulated Irregular Network), generated using ESRI Spatial Analyst 1.0 and 3D Analyst extensions, and the distribution of dolphin' sightings. The fixed Kernel density (Worton, 1989) was applied to identify dolphins'core areas, using the first geographical position of each group.

For the characterization of the physical habitat of each quadrat, the means of five measures were extracted for four variables (depth, contour index – following Hui, 1979, distance from the sand banks and distance from the coast): one at the center and the other four at the vertexes of each quadrat.

The univariate Chi-square test (Zar, 1999) was used to determine whether the groups were homogeneously distributed in relation of the proportion of the different classes of each environmental variable (available habitat).
To calculate the expected distribution of each class of environmental variable, we applied the equation proposed by Hui (1979):

$$\mathbf{Ei = Ot \cdot Li / Lt}$$

where *Ei* is the expected number of animal sightings in the quadrats of each class; *Ot* = total number of sightings of estuarine dolphin groups; *Li* = total number quadrats of each class; *Lt* = total number of quadrats.
Overall salinity and surface water temperature data (without dolphins' presence) were compared to the values collected during dolphins' sightings.

Results
During a three years period (2002- 2004), 191 surveys were conducted (Figure 2), totaling 990 hours of sampling effort and 128 hours of direct observation of estuarine dolphin groups. We observed 834 adult estuarine dolphins and 112 calves during 187 encounters with dolphin groups.

The Kernel density method indicated that the Caravelas River mouth was the core area for *S. guianensis* distribution in the study area (Figure 3b). About 14 dolphin sightings (7,5% of the total sightings) were registered in the quadrats inside the estuary (2B, 2C e 3C), with a mean distance from the river mouth of 10,8 Km (min= 7,5, max= 14). These sightings occurred during the years 2002 (n=10) and 2003 (n=4), with no register for 2004. On the other hand, only 1,6% (n= 3) of the sightings were registered over distances larger than 5 Km from the coast.

S. guianensis distribution was significantly different from an expected uniform distribution in relation to the four physical habitat variables (Figure 4). Dolphins tended to use more shallow waters (total range used: 0-15m / preferred range: 0-6m; X^2 = 110,78, df = 4 p < 0,005; Figure 4a), closer to sand banks (total range used: 0-12km / preferred range: 0-6km; x2 = 54,62; df = 3 p < 0,005; Figure 4b), closer to the coast line (total range used: 0-12km / preferred range: 0-5km; X^2 = 80,35; df = 2 p < 0,005; Figure 4c), and flatter areas, where the contour index was lower (X^2 = 99,72; df = 3 p < 0,005; Figure 4d). Dolphins also used waters with salinity similar to open sea waters (Figure 5) and the same usual temperature found in the study area (Figure 6).

Overall, estuarine dolphin groups were observed more frequently when the tide was rising (Figure 7). This trend was more pronounced when the moon phase was full or new, when tidal currents and, consequently, its influence on the estuary are stronger.

Discussion
Recent studies indicate that core areas of dolphins' use are related to the foraging (eg. Hastie et al. 2004, Johnston et al. 2005). Indeed, the Caravelas River mouth was used intensively by estuarine dolphin groups while foraging, and, for this reason, may be regarded as a critical habitat for the species in the region.

The sightings outside of the estuary, although less frequent than sightings inside the estuary, represent important information for the species occurrence outside bays and other protected areas where most studies on the species have been conducted. The results presented herein report wide amplitude of habitat utilization, ranging from estuarine/riverine to open coastal waters. The species was also observed using waters near coral reefs and more than 70 Km far from the coast in the Abrolhos Bank (Borobia *et al.* 1991, Wedekin *et al.* 2001), but our systematic effort did not included such habitats.

In the present study, we verified that *S. guianensis* occurred more in areas with flatter bottoms. This is different from what was observed in southern Brazil, where the species showed preference for steeper areas (Cremer, 2000; Wedekin *et al.* 2004). It was suggested that steeper areas would propitiate more heterogeneous habitats, favoring the concentration of prey or foraging strategies (Cremer, 2000). Two explanations for this contrasting pattern may be raised. First, the scale of analysis in the present work was coarse in comparison with other studies and a preference for steeper bottoms may be revealed at finer-scales. Alternatively, the heterogeneity of the habitat may be promoted by other characteristics of the habitat in the Caravelas River Estuary besides bottom relief.

One of these characteristics may be the proximity with sand banks, which dolphins showed to prefer in the Caravelas River Estuary. These sand banks are concentrated in the adjacencies of the river mouth, where shallow channels and passes are formed by the accumulation of sediment carried by the constant discharge of the Caravelas River.

Areas closer to the coast and more shallow were also used more intensively by the estuarine dolphin in the Caravelas River Estuary and adjacencies, corroborating other studies which showed these habitat characteristics as important for the species (Cremer, 2000, Bonin, 2001, Edwards & Schnell, 2001, Lodi, 2003, Wedekin et al. 2004). Unanimously, shallow and close to the coast habitats are considered critical habitats for the estuarine dolphin, despite the anomalous occurrence far from the coast (but still shallow), in the waters of the Abrolhos Bank, contiguous to our study area. This suggests that depth, and not distance from the coast, is the main limiting factor for the species. The anomaly in the Abrolhos Bank may be explained by the fact that the area is an enlargement of the continental shelf. Depth and distance from the coast are not necessarily correlated in the area as observed along other regions of the Brazilian coast.

Temperature did not affect the occurrence of *S. guianensis* in the study area. But the species apparently avoided waters with low salinity, indicating that the estuary is used mostly when the sea water intrudes in the system. This is corroborated by the analysis which identified the tide as an important environmental variable related to the *S. guianensis* occurrence in the study area, as preliminarly reported by Rossi-Santos et al. (2003). Other studies in the northeastern coast of Brazil have identified the tide as an important factor affecting the behavior of the estuarine dolphin (Araujo et al. 2001, Hayes, 1999). Estuarine dolphins may take advantage from the rising tide currents, either for saving energy while swimming, or for specific foraging strategies.

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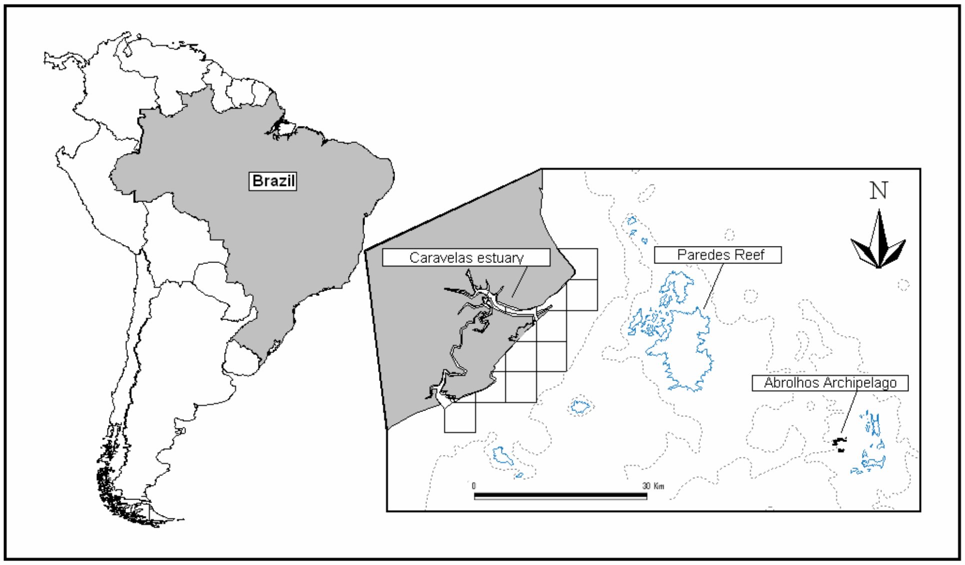

Figure 1: Study area map, located at Abrolhos Bank, eastern Brazilian coast. The 5x5 km Quadrat net is shown in detail.

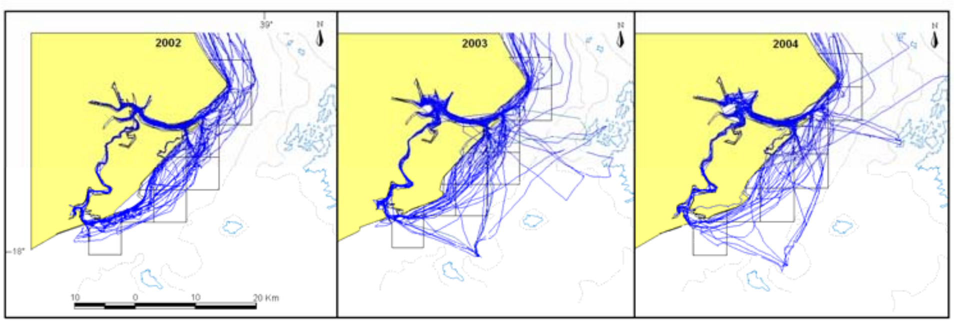

Figure 2: Sampling routes (blue lines) in the Caravelas river estuary, southern Bahia State, between 2002 and 2004.

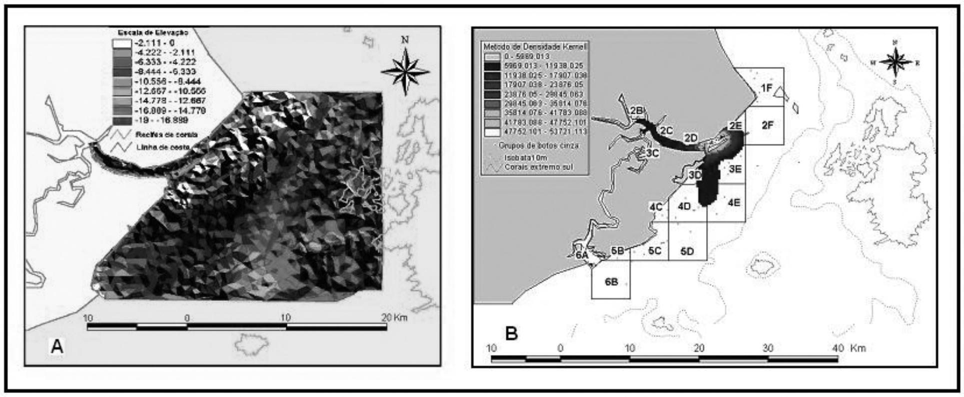

Figure 3: (a) TIN (Triangulated Irregular Network) model, providing the bottom declivity data for the Caravelas river estuary, southern Bahia State. (b) Core area for the *S. guianensis* sightings in the Caravelas river estuary, southern Bahia State, through Kernel method, between 2002 and 2004.

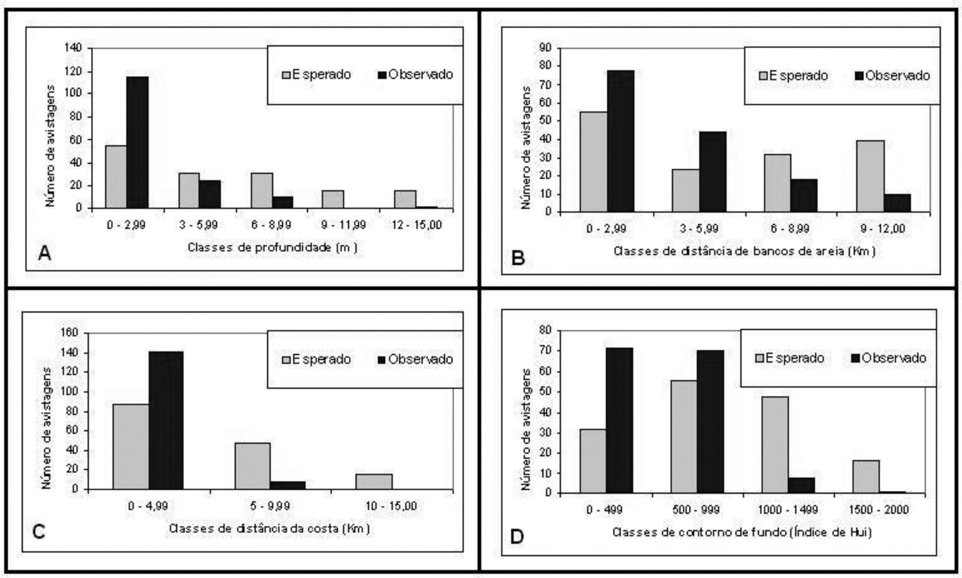

Figure 4: (a) Frequency distribution for habitat use of the estuarine dolphin, *S. guianensis*, based on depth classes (meters); (b) on classes of distances from sand banks (meters); (c) on classes of distance from the coast (kilometers); (d) on classes of bottom declivity (Hui contour index) in the Caravelas river estuary, southern Bahia State, between 2002 and 2004.

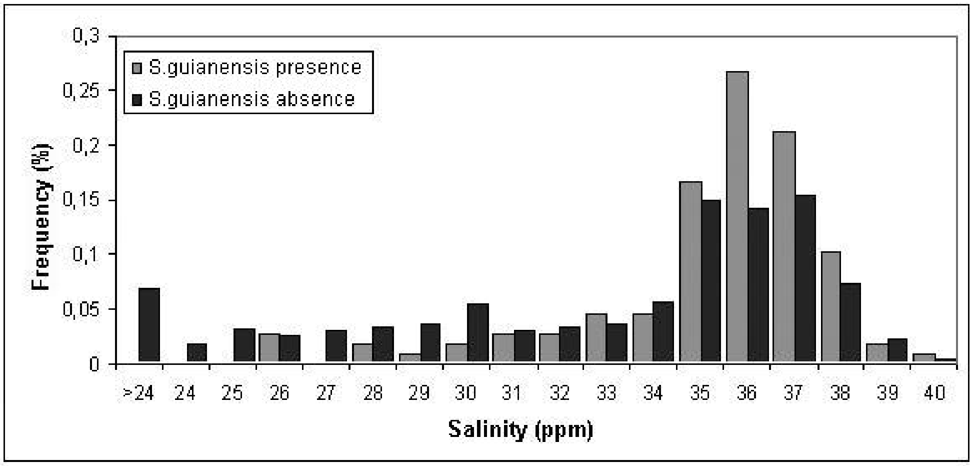

Figure 5: Salininity (ppm) frequencies during the presence and absence of the estuarine dolphin, *S. guianensis*, in the Caravelas river estuary, southern Bahia State, between 2002 and 2004.

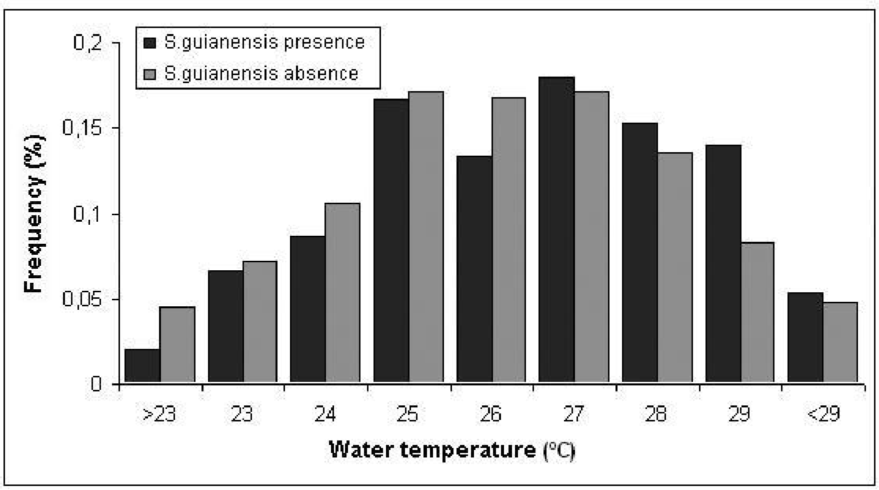

Figure 6: Water temperature (C°) frequencies during the presence and absence of the estuarine dolphin, *S. guianensis*, in the Caravelas river estuary, southern Bahia State, between 2002 and 2004.

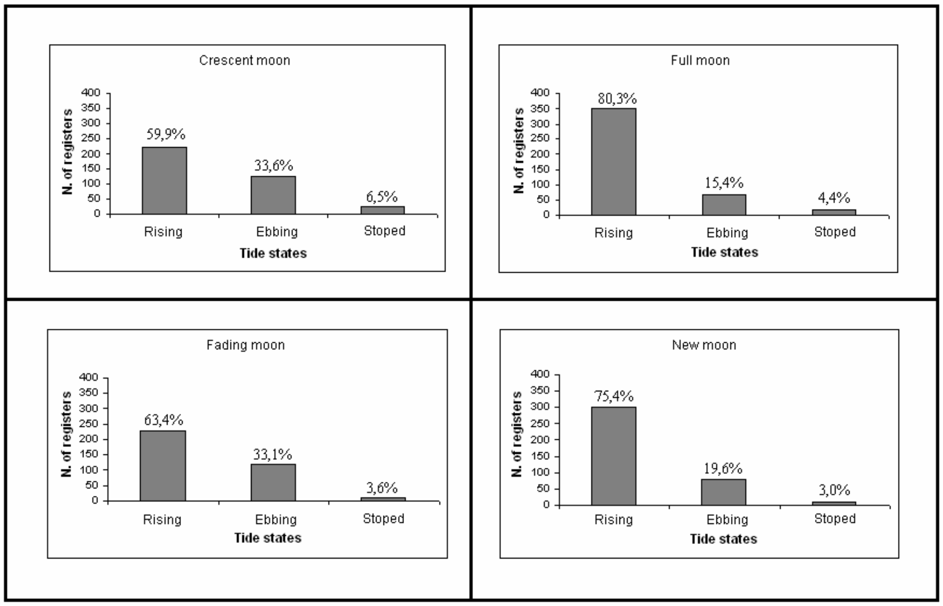

Figure 7: Occurrence frequency of *S. guianensis* during different tide states and moon phases in the Caravelas river estuary, southern Bahia State, between 2002 and 2004.