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Short Note

Preliminary Study on Occurrence and Ecological Aspects of *Sotalia guianensis* from an Estuarine Area, Northeast Coast of Brazil

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The Guiana dolphin (*Sotalia guianensis*; Van Benéden, 1864) is a small coastal delphinid that occurs exclusively along the western Atlantic coastal waters from Honduras, Central America (14° N), to Santa Catarina, Brazil (27° S) (Flores & Da Silva, 2009; Figure 1). This species prefers estuarine and protected shallow waters (Flores, 2002; Da Silva et al., 2010). In these waters, Guiana dolphins are exposed to potential threats such as loss of habitat resulting from the establishment of dams, ports, aquaculture activities, chemical and noise pollution, intense vessel traffic (disturbance and strikes), and overexploitation of marine life (Crespo et al., 2010). *S. guianensis* is currently classified as "Data Deficient" by the International Union for the Conservation of Nature (IUCN) (2017).

Scientific investigations conducted in the last decades have improved our knowledge of the biology and ecology of Guiana dolphins. Coastal regions of north and northeastern Brazil, including the São Marcos Bay, are some examples of relatively poorly studied areas that deserve special attention for their particular geographical and hydrological characteristics to improve our knowledge about the habits of this species.

The Bay of São Marcos is located in São Luís, Maranhão, Brazil (2º 31' S, 44º 26' W) (Figure 1); it is considered to be the largest estuarine bay on the northeast coast. The estuary is about 130 km long and stretches more than 20 km wide (Rios, 2001). It is bordered to the west by the continent, to the east by the city of São Luís, and to the south by the mouth of the Mearim River (Diretoria de Hidrografia e Navegação [DHN], 2013). The hydrodynamics of the bay are characterized by large variations of semidiurnal tides (Max: 7.2 m; Average: 4.6 m) (El-Robrini et al., 2006).

This study is part of an environmental project carried out in São Marcos Bay during 2013 and 2014, which was designed to investigate the interaction between coastal cetaceans and port activities. The goals of this study were (1) to describe the occurrence and group characteristics of Guiana dolphins in the São Marcos Bay, and (2) to characterize ecological aspects linked to habitat use of the dolphin population in the bay.

The surveyed area comprises approximately 600 km^2. Field data were acquired over a period of 25 non-consecutive days in 2013 (between 10 & 19 December, totaling 10 d) and 2014 (between 7 & 21 January, totaling 15 d). Boat-based surveys utilizing a search and visual census technique (Fuller & Mosher, 1981) were conducted onboard a fishing boat (15 m length and central four stroke engine with 180 hp) at speeds ranging between 7 and 15 km/h. The survey followed a zig-zag design to maximize chances of encountering dolphins (Santos & Rosso, 2007; Figure 1). Two observers searched for the Guiana dolphin groups at the bow using reticular binoculars (Bushnell 7 × 50 waterproof). Each covered a 90° field of view within a range of about 200 m each.

When the Guiana dolphin groups were sighted, the boat was stopped, and the following data were collected: date, time, geographic position, tidal amplitude, sea conditions (Beaufort scale 1 through 5), group size, group composition (adult and calf), and behavioral activities (foraging/feeding, socializing, resting, and traveling).

The environmental variables measured to characterize the habitat of the Guiana dolphins in the

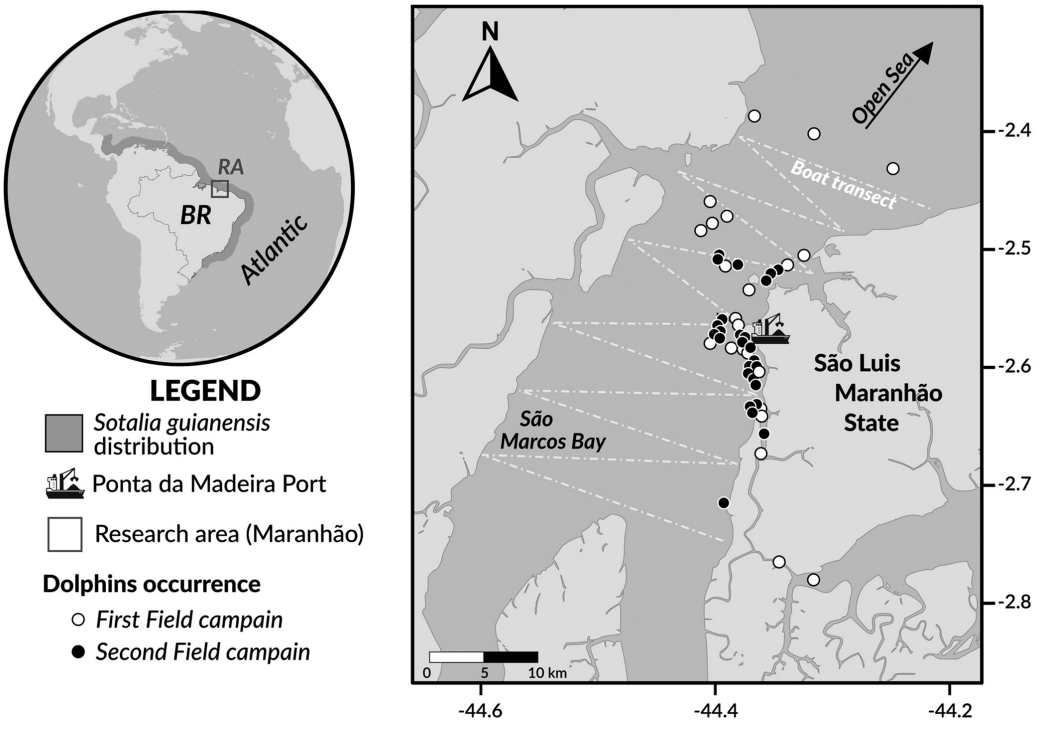

Figure 1. Map of the São Marcos Bay located in the Municipality of São Luis, Maranhão, Brazil. The delimitation of the map shows the study area. Boat transect is indicated with a white dashed line. The white-filled circles represent sightings during the first surveyed campaign (December 2013), and the black-filled circles represent sightings during the second surveyed campaign (January 2014).

São Marcos Bay included depth (m), water temperature at surface (°C), salinity (ppm), and water transparency (cm). Depth was measured using a portable echo-sounder with a 0.1 m precision, while data on water temperature were acquired through an alcohol thermometer, submerged just under the water surface for a 3-min exposure. Salinity was measured with a handheld refractometer, and water transparency was estimated using a Secchi disk.

Group size was determined according to Santos & Rosso (2007) and is defined as any aggregation of two or more individuals, including female–calf pairs, observed in close proximity to each other within a radius of approximately 50 m. Lone dolphins were also counted and included in the analyses. Two types of groups were classified: (1) with calves and (2) without calves. Activities data were recorded every 5 min using the *ad libitum* sampling method (Altmann, 1974; Mann, 1999). The groups were analyzed according to descriptive statistics for quantitative data. A Chi-square Yates Corrected test was used to compare group composition with and without calves.

The photographic records (Canon EOS Rebel T3, Lens EF-S 70-300) as well as information on species and animal conditions were obtained whenever possible given the sea conditions and the success of approaching the animals. Presence of marks on the animals' bodies was also registered, including scars, wounds, and natural marks. These marks provide a classification of individual photo-identification that is valuable for spatial-temporal assessment given the possibility of multiple resightings of individuals (Würsig & Würsig, 1977).

In general, the field effort during both periods (December 2013 and January 2014) was characterized by a constant and intense wind, sometimes more than 20 km/h, with waves up to 4 m high inside the San Marcos Bay (characteristics expected for this time of the year), which made working from the boat difficult. Due to this condition, the average speed of travel was often around 5.5 km/h, making it impossible to finish the transect or even to cross the bay to the points located at the other margin. Winds and the great variation of the tide in the northeastern region of Brazil

generate an intense movement of currents in the bay, making this environment highly dynamic. The formation of sand banks, strong gusts of wind, and waves in the center of the bay prevented the boat crossing several times, compromising the coverage of the pre-established sampling area. Another challenge was the great variation of the tide, which required previous planning to follow the movement of the tide, ensuring that the boat engine would run more efficiently.

A total of 52 groups (174 individuals) were spotted in the São Marcos Bay throughout 178 h 36 min of field efforts (Figure 1). A total effort of 16 h 20 min was conducted in the presence of the Guiana dolphin groups. The number of individuals ranged from 1 to 15 (mean ± SD: 3.35 ± 3.01). It is possible that a few individuals reported were counted more than once. Groups of two animals were most frequently observed in the whole area (35%), followed by solitary individuals (21%). In general, the number of individuals within groups without calves (56%, $N = 38$) was significantly higher when compared to the number of individuals within groups with calves ($N = 14$) (Chi-square Yates Corrected = 12.78; $p < 0.05$).

Regarding the physical aspects of the environment (Table 1), water depth ranged from 2.4 to 47.0 m (mean ± SD: 20.44 ± 10.14 m), water temperature varied from 24 to 27.5ºC (mean ± SD: 26.53 ± 0.63ºC), water transparency varied from 13 to 30 cm (mean ± SD: 19.17 ± 4.97 m), and water salinity varied from 28 to 36 ppm (mean ± SD: 31.85 ± 2.64 ppm).

To maximize our effort, we photographed a few individuals with conspicuous natural markings. As a preliminary study, four individuals were identified by dorsal fin and body marks (Figure 2A & B). The individual photo-identified as BSM #03 (Figure 2C) was seen on three occasions during the second field campaign (12, 13 & 19 January 2014).

The present study generated information about the spatial distribution pattern of this population in addition to presenting important trends on habitat use within the area. Population parameters, such as group composition, behavioral observations, and feeding events, were also registered. Despite not being the main focus of the present study, few individuals were noticed with natural markings, which allows some inferences about site fidelity or population estimation. However, the lack of previous information on cetaceans in the São Marcos Bay makes it difficult to compare individuals and groups throughout the regions.

Table 1. Summary of physical environmental characteristics recorded in São Marcos Bay

Data	Range	Mean ± SD
Depth (m)	2.4-47.0	20.4 ± 10.1
Water temperature (ºC)	24.0-27.5	26.5 ± 0.6
Salinity (ppm)	28.0-36.0	31.9 ± 2.6
Transparency (cm)	13.0-30.0	19.2 ± 5.0

The mean group size observed for the Guiana dolphins in the São Marcos Bay was 3.35 ± 3.01 (mean ± SD). Despite being seen in larger groups in some areas, in general, the characteristic low number of individuals gathering in a group corroborates with previous studies (Table 2). According to Santos & Rosso (2007), it is possible to conclude that there is a tendency to find smaller Guiana dolphin groups in protected waters and larger aggregations in open waters as observed for other species of delphinids (see Würsig, 1986; Gygax, 2002).

Two environmental variables negatively affected the proposed methodology: (1) the wind and (2) the tide. The high-speed wind and great tide amplitude consequently affected the performance of the boat, whose characteristics were already limiting because it was too tall and very slow.

Despite all effort in covering the totality of the area, Guiana dolphins were commonly registered around the port terminal during the two field efforts (Figure 1). Dolphin distribution is directly influenced by prey; therefore, characteristics of the habitat such as water depth, distance to coast, salinity, sea surface temperature, among others, are usually used as proxies of prey availability (Passadore et al., 2018). Probably the high abundance of fish, related to the marine biofouling in boat hulls (Nelson, 2003), explains the presence of the dolphins near the port area.

The proximity with the port area represents a threat to the dolphins, which can be generally associated with, among other threats, physical injuries and diseases. Through long-term monitoring, we might be able to follow individuals through time and space to minimize anthropogenic pressure on the population. Individual identification is an important and non-invasive tool used in cetacean field research as it provides the possibility of following marked individuals naturally (Würsig & Würsig, 1977). That technique was tested in São Marcos Bay to show its efficiency for further investigating ecological aspects such as site fidelity, social structure, home range, and life history, and to search for individual information within a population. Scars and marks on the body and dorsal fin may appear during inter- and intraspecific interactions (e.g., socialization behavior and prey/predator interaction), contact with the environment (e.g.,

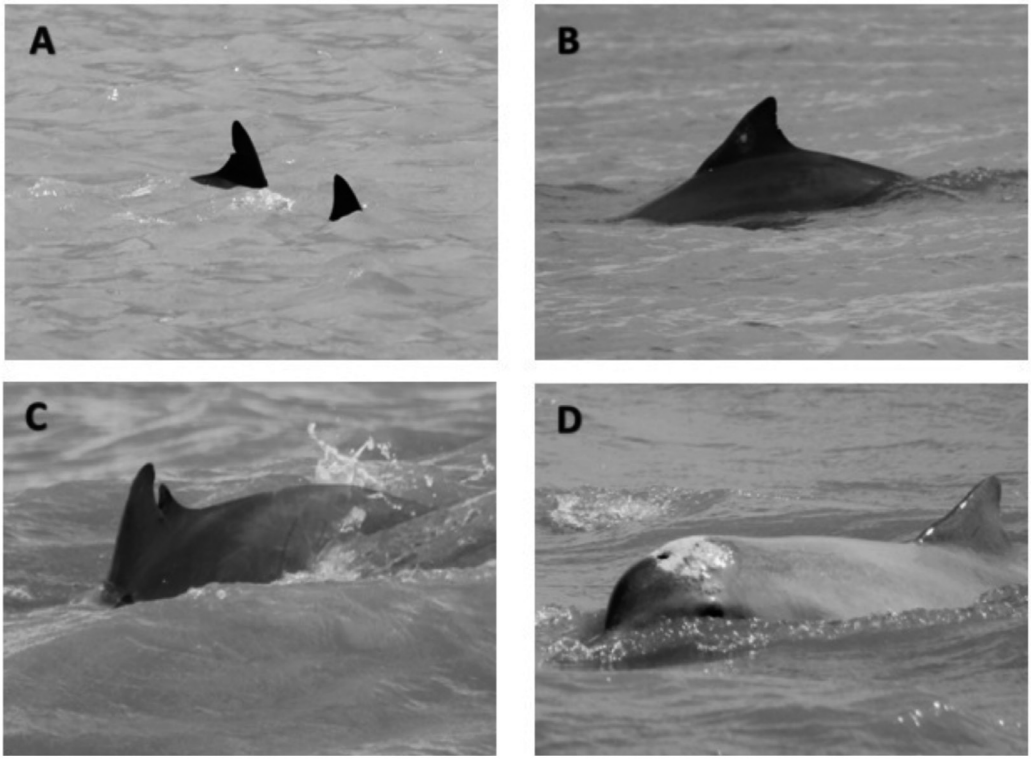

Figure 2. Four individual Guiana dolphins (*Sotalia guianensis*) identified by dorsal fin and body marks in the São Marcos Bay

foraging around rocks), and from anthropogenic sources (e.g., entanglement in gear, boat interaction, and pollution) (Kiszka et al., 2008).

Through the individuals photo-identified in this study, we can infer that the marks presented on the dorsal fin may be related to social or gear interactions (Figure 2A) or injuries from a boat propeller (Figure 2C). Two individuals showed a depigmentation on the dorsal fin and on the head, suggesting a type of skin lesion (Figure 2B & D). Skin lesions have been reported in cetaceans of different regions of the world but mainly in dolphins with coastal habits as is the case of some populations of Guiana dolphin. Although no etiological associations have been identified in most cases, in addition to the fact that there is no clear connection of these lesions with environmental stressors, most authors have attributed skin diseases to the deterioration of marine environments (Van Bressem et al., 2007, 2009). Van Bressem et al. (2009) reported a prevalence of skin diseases of 17.4% in photo-identified Guiana dolphins of the Paranaguá (Paraná State: 25° 30' S). The authors attributed this high prevalence to chemical and biological pollution in the region, which is associated with port activities, a dense coastal human population, and illegal shrimp farming. On the other hand, in more than 10 years of studies, no case of similar skin disease was reported in Cananéia, a more preserved area in the south of São Paulo State (25° 00' S). The coastal distribution of the Guiana dolphin as well as its small home range can expose the species to chemical and microbiological contamination and, consequently, can trigger or facilitate the occurrence of such injuries (Moura et al., 2014). This could be the case of the dolphins identified as BSM #02 and BSM #04 sighted in the São Marcos Bay (Figure 2B & D). However, a long-term monitoring program of the Guiana dolphin population that inhabits the San Marcos Bay is of great importance for two reasons: (1) to trace an epidemiological profile of the disease and (2) to follow the progress and development of the lesions in the individuals or groups.

The São Marcos Bay has an important expanding port area where large ships carry iron, coal, caustic soda, aluminum, bauxite, soy, and other cargo (Mílen et al., 2006). Port activity is a local marine wildlife threat. Air and water quality are reduced due to some types of moving loads that leave many particulate matter suspended in the atmosphere and water; sewage from the port and the vessels is discharged into the bay; intense

Table 2. Summary of the main studies regarding group size and habitat preferences of the Guiana dolphins (*Sotalia guianensis*) throughout its distribution

Location	Group size	Habitat	Reference
Baía Norte, Santa Catarina, Brazil (~27º S)	60 to 80	Open bay, close to shore, shallow	Flores, 2003
Paranaguá Estuarine Complex (~25º S)	2 to 90	Protected estuary	Santos et al., 2010
Cananéia estuary, São Paulo, Brazil (~25º S)	Up to 60	Protected estuary	Santos & Rosso, 2007
Parati, Rio de Janeiro, Brazil (~23º S)	1 to 100	Open waters	Lodi, 2003
Ilha Grande Bay, Rio de Janeiro, Brazil (~23º S)	Up to 450	Protected bay	Lodi & Hetzel, 1998
Ilha Grande Bay, Rio de Janeiro, Brazil (~23º S)	2 to 200	Protected bay	Tardin et al., 2013
Sepetiba Bay, Rio de Janeiro, Brazil (~22º S)	Up to 200	Open bay	Simão et al., 2000
Guanabara Bay, Rio de Janeiro, Brazil (~22º S)	1 to 15	Protected bay	Azevedo et al., 2005
Abrolhos Bank, Bahia, Brazil (~18º S)	1 to 100	Open, shallow waters	Rossi-Santos et al., 2006
Pipa Beach, Rio Grande do Norte, Brazil (~6º S)	1 to 15	Protected bay	Araujo et al., 2001
Marapanim Bay, Pará, Brazil (~00º S)	1 to 60	Protected bay	Emin-Lima et al., 2010
Cayos Miskito Reserve, Nicaragua (~15º N)	1 to 15	Protected estuary	Edwards & Schnell, 2001
Inner lagoons of Nicaragua (~15º N)	1 to 20	Inner lagoons	Carr & Bonde, 2000

ship and vessel-support traffic promote risk of collisions and disturb animals; noise pollution in and out of the water is generated by motorized vessels and cargo handling; there is increased risk of accidents due to fuel leaks; and pollution may be caused by engine room cleaning. Additionally, the physical and chemical transformations caused by the presence of port terminals in the bay dynamics can gradually lead to a decline in the population of fish, squid, and crustaceans ingested by marine animals. A long-term research study in the bay is necessary to understand the population's ecological and biological parameters that would support conservation of this species. Monitoring studies utilizing photo-identification, bioacoustics, presence of contaminants, and water quality are essential to ensure this dolphin population's survival in this threat area.

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