PANAMJAS
Pan-American Journal of Aquatic Sciences

Occurrence, group size and site fidelity of *Sotalia guianensis* (Cetartiodactyla, Delphinidae) in an artificially sheltered beach in northern Brazilian coast

ANA CAROLINA O. DE MEIRELLES[1*], ALBERTO ALVES CAMPOS[1] & ANTONIO ADAUTO FONTELES-FILHO[2]

[1] *Associação de Pesquisa e Preservação de Ecossistemas Aquáticos – AQUASIS, SESC Iparana, Praia de Iparana s/n, Caucaia, CE, 61600-000, Brazil.*
[2] *Instituto de Ciências do Mar – LABOMAR, Universidade Federal do Ceará – UFC, Av. Abolição, 3207, Meireles, Fortaleza, CE, 60165-081, Brazil*

*Corresponding author: cameirelles@yahoo.com.br

Abstract. Guiana dolphin ecological aspects are poorly known in open areas such as embayments. The purpose of this study was to verify occurrence, group size and site fidelity of *Sotalia guianensis* in Iracema Beach, northern Brazilian coast. Data were collected at a land-based observation point, from September 2004 to August 2005, totalizing 283 h of sampling effort and 63.31 h of effective observation time. Sixty-eight groups were sighted on 61.7 % of all observation-days. The number of animals sighted per month was higher in December, January, February and July. Mean group size was 3.3 (SD = ± 1.41), ranging from two to seven animals. Sixteen individuals were photo-identified. Re-sighting rate was 50%. Information gathered in this study indicated that Iracema Beach is an important habitat for Guiana dolphins that use the area in small groups.

Key words: photo-identification, site fidelity, group size, delphinidae.

Resumo: Ocorrência, tamanho de grupo e fidelidade ao sítio de *Sotalia guianensis* (Cetartiodactyla, Delphinidae) em uma praia artificialmente abrigada da costa norte do Brasil. Aspectos sobre a ecologia do boto-cinza são pouco conhecidos em áreas abertas, como enseadas. O objetivo desse estudo foi verificar a ocorrência, o tamanho de grupo e a fidelidade ao sítio de *S. guianensis* na Praia de Iracema, na costa norte do Brasil. Os dados foram coletados de um uma plataforma fixa de observação, de Setembro de 2004 a Agosto de 2005, totalizando 283 h de esforço amostral e 63,31h de esforço efetivo. Sessenta e oito grupos foram avistados em 61,6% dos dias de observação. O número de animais avistados foi maior nos meses de Dezembro, Janeiro, Fevereiro e Julho. O tamanho médio dos grupos foi de 3,3 (SD= ± 1,41), variando de dois a sete animais. Dezesseis animais foram foto-identificados. A taxa de reavistagem foi de 50 %. As informações obtidas nesse estudo indicam que a Praia de Iracema é uma importante área para os botos-cinzas, que a utilizam em pequenos grupos.

Palavras-chave: foto-identificação, fidelidade ao sítio, tamanho de grupo, delphinidae.

Introduction

The Guiana dolphin (*Sotalia guianensis* Van Beneden 1853) is a small delphinid found in coastal waters, estuaries, bays and embayments of Central and South America, from Santa Catarina Island, Brazil, to Honduras (Simões-Lopes 1988, Da Silva & Best 1996). Due to its coastal habitat, the species has been suffering from strong human impacts, such as habitat degradation, acoustic and chemical pollution, boat traffic, and incidental captures in

fishing gear (Crespo *et al*. 2010). The species is classified as "Near Threatened" by the International Union for the Conservation of Nature (Secchi *et al.* 2018). In Brazil the species was included in the National List of Endangered Species in 2014 (MMA 2014) as "Vulnerable" due to critical situation of the species in coastal urban bays of the country (e.g, Guanabara Bay, Azevedo *et al*. 2017).

Guiana dolphin ecological features have been studied in several areas along the Brazilian coast, usually on naturally sheltered calm waters, such as estuaries and bays [e.g., in Southern region, Baía Norte (Flores & Bazallo 2004); in Southeastern coast, Cananéia Estuary (Santos *et al*. 2001, Oliveira & Monteiro-Filho 2008) and Guanabara Bay (Azevedo *et al*. 2004, 2017); in Northeastern coast, Caravelas Estuary (Rossi-Santos *et al.* 2007) and Pontal Bay (Santos *et al*. 2010). In these areas, dolphins usually occur year-round, in groups that vary from two to 80 animals, with high site fidelity [i.e, the return to and reuse of a previously occupied location (Switzer 1993)] and different degrees of residency.

However, in regions where there are no sheltered bays or large estuaries available for Guiana dolphin, the species occurs in open beaches and embayments [e.g Curral Beach (Santos-Junior *et al*. 2006), Iracema Beach (Oliveira *et al*. 1995, Meirelles 2005, 2013)]. Iracema Beach is located in Mucuripe Embayment, along the coast of the largest city of the state of Ceará, Fortaleza, northern Brazilian coast, with more than 2 million habitants.

Guiana dolphin strandings are commonly recorded in Mucuripe Embayment, and most of recovered carcasses had evidence of incidental capture in fishing nets (Monteiro-Neto *et al*. 2000, Meirelles *et al.* 2010). Many ecological aspects of the species in this area are still unknown. Thus, the objective of this study was to analyze occurrence, group size and site fidelity of *S. guianensis* in Iracema Beach.

Material and Methods

Study area: Iracema Beach (3º43'S, 38º31'W; Fig. 1), situated in Fortaleza Metropolitan Region, State of Ceará, Brazilian northern coast, is located at the western portion of Mucuripe Embayment, a highly degraded area that comprises most of the city's beachfront urban sprawl, with 18 perpendicular rock breakwaters, three perpendicular piers, one shipyard and one of the most important harbors of the region, Mucuripe Harbor.

The study area is located between a pier and a rocky breakwater, and it is partially protected from the action of coastal currents (Fig. 1). The area is shallow, with depths usually less than 6m, and water temperatures ranging from 27ºC to 29ºC (Campos *et al.* 2003).

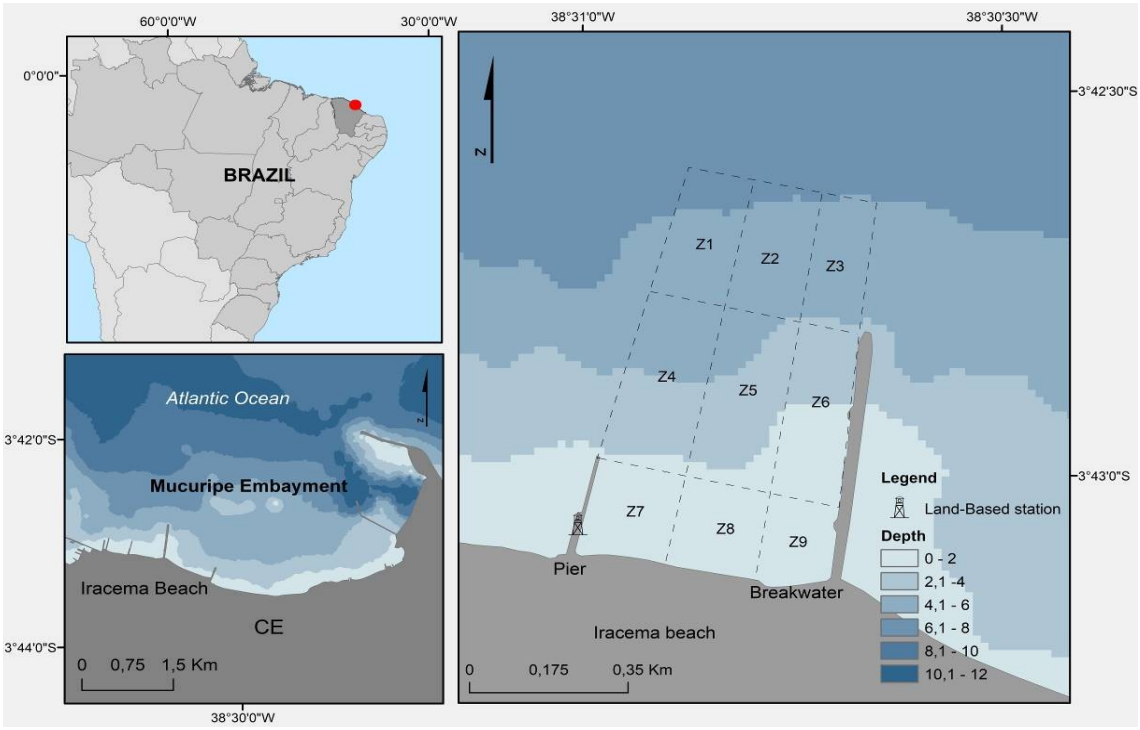

Figure 1. Map of Mucuripe Embayment (city of Fortaleza, State of Ceará) coastline, showing Iracema Beach, and the zone division used to study *Sotalia guianensis* movements. The observation tower is located at the pier.

Typically, there are two seasons in the study area: the rainy season extends from January to June (mean of 1,377mm), with slightly lower temperatures; and the dry season extends from July to December (mean of 215 mm) (Moura *et al* 2015).

Data collection: Between September 2004 and August 2005, observations were performed from a tower 9 m above the water surface, located at a pier, in the western portion of the beach. Monitoring efforts were conducted from 0700 to 1100 h, with five to seven observation days per month (N=73). Monitoring time was selected according to the results obtained by Oliveira *et al.* (1995) who recorded a higher dolphin observation frequency at Iracema beach on the morning hours.

To describe the dolphins' movements, the study area was divided into nine zones using visual reference points on the pier, the breakwater and on land, easily identifiable from the tower (Fig. 1). A group of dolphins was defined as the maximum number of animals in spatial proximity to one another, according to the "10-m chain rule" (Smolker et al. 1992) and usually engaged in the same activity or behavior pattern. The term "sighting" was defined as the presence of dolphins, either a group or solitary animals, in the study area.

Once a group of dolphins was sighted, time, movements of the animals between the zones, and group size (including variations in group size observed when animals arrived and left the area) were continuously voice-recorded using a micro cassette recorder. When the animals approached the observation point about 15-20m of distance, photographs were taken of dorsal fins of as many dolphins as possible. Notches that were visible from both sides of dorsal fin were used for dolphin individual identification. However, other marks were used as auxiliary identification features. Shutter speeds between 1/800 to 1/2,000 sec and ISO values of 100 and 200 were used. The low ISO values were used to obtain pictures with higher resolution of details that would allow larger visualization of dorsal fin notches. The abundant light conditions in the study area permitted the use of such low ISO values combined with fast shutter speeds, with adequate aperture range.

Photographs were taken using a Canon EOS 300D digital camera (6.3 megapixels) equipped with a 100-300 mm (f 5.6) telephoto zoom lens. The largest resolution of JPEG compression in the camera options was utilized, resulting in files size ranging from 2.0 to 3.5 MB. Whenever it was necessary to identify group size in distant zones, observations were carried out using 8X21mm binoculars.

Data analysis: Chi-square test (χ^2) at $P < 0.05$ was used to verify significant differences in dolphin's occurrence frequency (relative number of days of sampling effort with sighting of dolphins) per month and season (rainy and dry). The same test was used to verify differences in the time of direct observation; the number of dolphins sighted in each month and season; the number of sightings in each tide phase (low, rising, high, ebbing – 3 hours duration each); and zone use frequency.

Kruskal-Wallis H-test at $P < 0.05$ was used to verify the differences in the number of animals sighted in a single day for each month, and in the amount of time that the dolphins spent in the study area for each month. It was also used to verify monthly variation in group size, and differences between group size and tidal phases. The Mann-Whitney (U) test at $P < 0.05$ was used to verify seasonal variations in group size, significant differences in the number of animals sighted per day and in each season and in the mean time spent by a group in the area in each season.

In the laboratory, photographs were sorted using Adobe Photoshop Elements 2.0 software. These images were cropped along the edges of the dorsal fins and selected according to focus and angle that clearly allowed the identification of the animal. Necessary adjustments on brightness and contrast were made. Using Corel Draw 11.0 software, the contour of all dorsal fins was highlighted using the *bézier* tool. All identified animals received a code with a letter and three digits, according to the quantity of marks on its dorsal fin [adapted from Defran *et al.* (1990)]. Each new dolphin picture and fin contour was compared with the others in the catalogue, and if it did not match previously identified dolphins, it received a new code. When a picture-picture and a contour-contour matched, the animal was considered a re-sighting. Site fidelity was quantified through the re-sighting rate that represents the proportion of animals that were re-sighted in more than one month.

Results

Seventy-three observation-days, with 283 h of effort and 63.31 h of effective observation time were conducted at Iracema Beach. Time of direct observation varied between months ($\chi^2 = 33.00$; $P < 0.05$), and it was higher in December (12.56 h) and January (12.14 h), and lower in August (1.08 h).

Time of effective observation did not vary between seasons ($\chi^2 = 0.35$; $P > 0.05$).

Guiana dolphin groups were observed on 61.7 % ($n = 45$) of all observation-days. This value varied monthly and ranged from 20% in August 2005 to 100% in February 2005 (Fig. 2). Sixty-eight sightings of dolphin groups were registered, comprising 222 individual sightings. The number of animals sighted per month was significantly different ($\chi^2 = 76.81$; $P < 0.05$) from the higher values observed in December, January, February and July (Fig. 2). These numbers did not vary with seasons ($\chi^2 = 0.02$; $P > 0.05$).

Maximum number of animals sighted in a single day was 12 (mean = 4.93, SD = ± 2.82, range = 1-12). The number of dolphins sighted in a single day did not exhibit significant variation between months ($H = 19.53$; $P > 0.05$) and seasons ($U = 190.50$; $n = 45$; $P > 0.05$). Sightings lasted on average 0.93 hours, with a low of 0.12 h in November to a high of 3.28 h in January and July. There were no significant differences in the average time that the animals spent in the area between months ($H = 15.68$; $P > 0.05$) and seasons ($U = 489.00$; $P > 0.05$). Tidal phases had no significant difference on Guiana dolphin occurrence in the study area ($\chi^2 = 0.06$; $P > 0.05$).

Dolphins were sighted in all zones, except Z9 (see Fig. 1). The animals were consistently sighted in Z7 (31.40%), Z4 (30.31%) and Z5 (21.23%) ($\chi^2 = 547.10$; $P < 0.05$).

Mean group size was 3.3 (SD = ± 1.41), ranging from solitary to seven animals. Groups composed of three ($n = 21$; 31%) and two ($n = 17$; 25%) animals were the commonest. Single animals constituted 7.4% of the sightings ($n = 5$). Group size changed in 23.6% of observations with no constant size. There was no monthly ($H = 7.42$; df = 67; $P > 0.05$) or seasonal ($U = 498.01$; $P > 0.05$; rainy = 37 groups; dry = 31 groups) variation in group size. No difference in group size between tidal phases was observed ($H = 5.40$; $P > 0.05$).

Sixteen individuals were photographically identified and catalogued (Table I). One animal (D003) showed an unusual unpigmented patch in the dorsal fin that did not change throughout the study period (Fig. 3). Individual dolphin sightings ranged from one to eight. Resighting rate was 50% ($n = 8$). Fifty percent of the dolphins were not re-sighted. Dolphin D003 was re-sighted seven times in five different months (Table I).

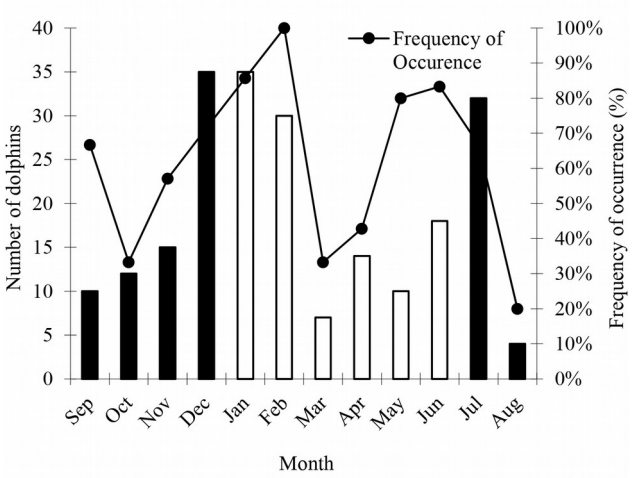

Figure 2. Number of dolphins (maximum) and relative frequency of dolphin occurrence per month in Iracema Beach from September 2004 to August 2005. White columns represent rainy season and dark represent dry season.

The presence of gillnets was detected in the study area in 27% (n=17) of observation days. In nine days, dolphins were observed close to nets (in the same zone), but incidental captures or other kinds of interaction were not recorded. The presence of boats in the study area was rare.

Discussion

Results obtained in this study indicate that Guiana dolphins occur year-round in Iracema Beach, with an observation frequency similar to those observed in more sheltered coastal areas, as estuaries and bays. Besides strong human impacts (e.g, incidental captures, chemical and noise pollution, boat traffic), the area seems to provide some requirements for dolphin's survival. Gurjão *et al.* (2003) described the feeding habits of Guiana dolphins along the coast of Ceará, and most food items listed by these authors were also found by Braga *et al.* (2001) in the Mucuripe Embayment, indicating that the area can provide food for the dolphin population.

Along the Mucuripe Embayment coast, Iracema Beach seems to be one of the preferred spots for the dolphins, as indicated by Oliveira *et al.* (1995) and observed in this study. The concrete pier and the breakwater produce a partially sheltered environment, and may attract marine organisms, providing food for the dolphins. In addition, the pier can act like an artificial reef, attracting marine animals as fish and cephalopods, and consequently their predators, such as Guiana dolphins. The

Table I. Number of sightings of photo-identified Guiana dolphins at Iracema beach between September 2004 and August 2005. Grey boxes represent at least one sighting of the individual during the designated month.

Dolphin	**Month/Year**											
ID code	Sep/04	Oct/04	Nov/04	Dec/04	Jan/05	Feb/05	Mar/05	Apr/05	May/05	Jun/05	Jul/05	Aug/05
A001	1											
A002		1										
A003					1							
B001		1			1		1				1	
B002					1							
B003											1	
C001	1				1	1		1				
C002	1							1			2	
C003											1	
C004											1	
D001	1				1		1				1	
D002	1	1									1	
D003	1			1	1		1	1			1	
D004				1								
D005				1	1							
D006				1	1						2	

Figure 3. Dorsal fin of dolphin #D003, with a permanent white patch on left side, recorded in Iracema beach during the present study.

frequent presence of dolphins in Z7, next to the pier reinforces this idea. Wang *et al.* (1994) described that in some locations coastal dolphins selectively feed in areas where bottom topography enhances their ability to catch prey, as in the Pacific Northwest where Heimlich-Boram (1988) observed killer whales (*Orcinus orca*) using steep gradients as barriers to trap prey. Thus, the apparent preference of dolphins to the study site seems to be related to a higher concentration of prey and to topographic characteristics that enhance prey capture.

According to results obtained in the present study, the number of animals sighted per month and the maximum number of dolphins sighted per day were higher in December, January and in July. These findings can be related to the presence of mullet

schools in the study area. The most common mullet species that occurs in Mucuripe Embayment is the white mullet (*Mugil curema*), a widespread pelagic coastal fish that occurs from Massachusetts to southern Brazil (Marin *et al.* 2003). Large aggregations of this fish occur in coastal areas just prior to the offshore spawning migration (Angel 1973). The spawning period and periodicity is quite variable, and it may be the result of variation in the timing of favorable conditions, like high primary productivity that enhances juvenile survival (Marin *et al.* 2003). The increase in primary productivity can be influenced by many factors, such as rainfall and coastal upwelling (Barnes & Mann 1991). These factors appear to influence the spawning period of *M. curema* in Margarita Island, Venezuela (Marin *et al.* 2003). There are no studies on the spawning period of this species of mullet in Ceará. However, as observed in Venezuela, precipitation in the rainy season and coastal upwelling in the dry season can induce spawning. In Fortaleza, rainy season goes from January to June, with highest average rainfall values in April and May (Campos *et al.* 2003). Thus, before these months, schools can aggregate in coastal areas, like Iracema Beach, to start the offshore migration, and this aggregation can attract the dolphins. During the dry season, wind velocity can reach 6m/s in August and September and promote a strong coastal current parallel to the coast (Campos *et al.* 2003). According to Barnes & Mann (1991), this kind of current can create upwellings and increase primary productivity. Thus, before this period, as observed in Venezuela, mullets can aggregate again to start another offshore migration. Seasonal shifts in cetacean distribution in response to movements of a prey species have been documented in British Columbia, where Nichol & Shackleton (1996) observed an increase in the abundance of killer whales in Johnstone strait when salmon migrates through the area; in Sarasota Bay, Florida, seasonal distribution of bottlenose dolphins (*Tursiops truncatus*) was presumed to occur in response to movements of a prey species, the striped mullet, *Mugil cephalus* (Waples 1995).

In the present study, a maximum of only seven individuals per group was recorded, although Oliveira *et al.* (1995) reported a maximum of 10 dolphins per group in the area. This is one of the smallest maximum group sizes recorded for the species, second only to Guaratuba Bay, in southern Brazil, where the largest groups numbered six (Filla & Monteiro-Filho 2009). Mean group size at Iracema beach was low (3.3 individuals) when compared to data recorded in most bays and estuaries of southern and southeastern Brazil [e.g. m= 12.4 in Cananéia (Santos *et al*. 2007); m=30 in Sepetiba Bay (Flach *et al*. 2008); m=13 in Guanabara Bay (Azevedo *et al*. 2005)]. However, it was similar to those recorded in other areas of northeastern Brazil, such as Pipa Beach (m=2.75; Araújo *et al*. 2003) and Ilhéus Harbor (m= 3.08; Izidoro & Le Pendu 2012).

These differences can be explained by the fact that the behavioral ecology of most dolphins is thought to reflect specific adaptive strategies shaped by the unique ecological conditions under which a population exists (Defran & Weller, 1999). *Sotalia guianensis* inhabits coastal areas that differ greatly in physical and environmental conditions, leading to differences in group size. According to Krebs and Davies (1993), group size in many social species is a tradeoff between optimizing foraging efficiency and minimizing predation risk. Although some potential Guiana dolphin predators occur along the species distribution, there is no evidence of such predation in living specimens in Ceará, suggesting that non-human predatory threats to this dolphin are not significant. Consequently, energy intake must be the primary selective pressure on species group size in the study area. According to Flores (2003), larger group sizes of Guiana dolphins in the southernmost limit of the species distribution may be related to prey availability and abundance, since this region is highly productive. The study area, Iracema Beach, is located in the semi-arid coast, with the lowest primary productivity in the Brazilian coast, with a high biodiversity but a low biomass of aquatic organisms (Campos *et al.* 2003). Thus, to avoid conspecific competition and reduce traveling costs to find supplementary food, the small group size of Guiana dolphins observed in this study may be a result of low-density food resources.

This study also indicates that land-based photo-identification of Guiana dolphins in the study area is feasible and allowed us to create the first catalogue of identified animals for Ceará. Re-sightings of identified individuals indicate that some dolphins have site fidelity to the study area. However, the low re-sighting rate observed may indicate a low level of site fidelity by the majority of identified dolphins. This could be explained by the physical characteristics of the study area; a more open habitat when compared with regions where *S. guianensis* exhibits higher site fidelity, such as Guanabara (Azevedo *et al.* 2004) and Norte Bays (Flores 1999).

On the other hand, the distance between the observation platform and the dolphins sometimes did not allow the observer to take viable photographs, and this might possibly have led to the low re-sighting rate recorded. Cetacean photo-identification studies from shore do not disturb the animals and are relatively inexpensive, as compared to those using boats. However, the distance between the observer and animals is an important factor, especially for dolphins (Würsig & Jefferson 1990). Thus, to reach more precise conclusions on the site fidelity of *S. guianensis* in the study area, additional photo-identification efforts are necessary, preferable from a small boat and investing in more powerful photographic lens.

Information gathered in this study indicated that Iracema Beach is an important habitat for Guiana dolphins that use the area in small groups. There is some indication that prey abundance may have influence in the presence of dolphins in the area, as discussed above. In addition, half of the animals identified have shown site fidelity to Iracema Beach.

The results obtained in this study indicate differences in *S. guianensis* group size and site fidelity when compared to other regions where the species has been studied, mainly sheltered estuaries and bays in southeastern and southern Brazil. Differences in physical characteristics and primary productivity that result in distinct ecological conditions can explain the observed results and indicate that Guiana dolphin group size varies along its range according to ecological factors. Future efforts encompassing a larger area in longer timescales and using small boats as observation platforms may give more insights into the species ecological aspects in the study site. Nevertheless, as a first attempt to promote the photo-identification of Guiana dolphins and create a catalogue for the State of Ceará, this study can provide subsidies for future demographic research, such as abundance and survival estimates, and to further our knowledge regarding the species conservation status in order to propose proper conservation actions.

Acknowledgments

We would like to thank Aquasis for providing important logistic support. We are also grateful to the three anonymous referees and Caio J. Carlos who provided useful comments on the manuscript; the *Departamento de Oceanografia e Limnologia - Universidade Federal do Rio Grande do Norte* for logistic support; and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES-Brazil) through Pro-Reitoria de Pós-Graduação of UFRN, which provided a scholarship to the first author.

References

Angel, C. 1973. Algunos aspectos de la biologia de la lisa, *Mugil curema* Valenciennes, en aguas hipersalinas del nororiente de Venezuela. **Memoria de la Sociedad de Ciencias Naturales, La Salle**, 51: 223-238.

Araujo, J. P., Passavante J. Z. O. & Souto, A. S. 2003. Behavior of the estuarine dolphin, *Sotalia guianensis*, at Dolphin Bay – Pipa-Rio Grande do Norte – Brazil. **Tropical Oceanography**, 31(2): 101-112.

Azevedo, A. F., Lailson-Brito, J., Cunha, H. A. & Sluys, M. 2004. A note on site fidelity of marine tucuxis (*Sotalia fluviatilis*) in Guanabara Bay, southeastern Brazil. **Journal of Cetacean Research and Management**, 6(3): 265-268.

Azevedo, A. F., Viana, S. C., Oliveira, A. M. & Sluys, M. V. 2005. Group characteristics of marine tucuxis (*Sotalia fluviatilis*) (Cetacea: Delphinidae) in Guanabara Bay, south-eastern Brazil. **Journal of the Marine Biological Association of the United Kingdom**, 85: 209-212.

Azevedo, A. F., Carvalho, R. R., Kajin, M., Van Sluys, M., Bisi, T.L., Cunha, H.A., Laison-Brito, J. 2017. The first confirmed decline of a delphinid population from Brazilian Waters: 2000-2015 abundance of *Sotalia guianensis* in Guanabara Bay, South-eastern Brazil. **Ecological indicators**, 79: 1-10.

Barnes, R. S. K. & Mann, K. H. 1991. **Fundamentals of Aquatic Ecology**. 2a. ed. Blackwell Science Ltd.

Braga, M. S. C., Salles, R. & Fonteles-Filho, A. A. 2001. Ictiofauna acompanhante da pesca de camarão com rede-de-arrasto na zona costeira do Município de Fortaleza, estado do Ceará, Brasil. **Arquivos de Ciências do Mar**, 34: 49-60.

Campos, A. A., Monteiro-Neto, C. & Poletti, M. 2003. **A Zona Costeira do Ceará: Diagnóstico para a Gestão Integrada**. Editora AQUASIS, Fortaleza, CE, Brazil.

Crespo, E. A., Alarcon, D., Alonso, M., Bazallo, M., Borobia, M., Cremer, M., Filla, G., Lodi, L., Magalhães, F. A., Marigo, J., Queiroz, H. L., Reynolds III, J. E., Schaeffer, Y., Dorneles, P.

R., Lailson-Brito, J., Wetzel, D. L. 2010. Reporto of the working group on major threats and conservation. **The Latin American Journal of Aquatic Mammals,** 8(1-2): 47-56.

Da Silva, V. M. F. & Best, R. C. 1996. **Sotalia fluviatilis**. American Society of Mammalogists. **Mammalian Species**, 527:1-7.

Defran, R. H. & Weller, D. W. 1999. Occurrence, distribution, site fidelity, and school size of bottlenose dolphins (*Tursiops truncatus*) off San Diego, California. **Marine Mammal Science**, 15(2): 366-380.

Defran, R. H., Shultz, G. M. & Weller, D. W. 1990. A technique for the photographic identification and cataloging of dorsal fins of the bottlenose dolphin (*Tursiops truncatus*), p. 53-55. In: Hammond, P. S, Mizroch, S. A. & Donovan, G. P. (Eds). **Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters.** Reports of the International Whaling Commission, special issue 12. Cambridge: International Whaling Commission.

Filla, G. F. & Monteiro-Filho, E. L. A. 2009. Group structure of *Sotalia guianensis* in the bays on the coast of Paraná state, south of Brazil. **Journal of the Marine Biological Association of the United Kingdom**, 89(5): 985-993.

Flores, P. A. C 1999. Preliminary results of a photoidentification study of the marine tucuxi, *Sotalia fluviatilis*, in southern Brazil. **Marine Mammal Science**., 15(3): 840-847.

Flores, P. A. C. 2003. Ecology of the marine tucuxi dolphin (*Sotalia fluviatilis*) in southern Brazil. **Ph.D. Thesis**, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Brazil,141p.

Flores, P. A. & Bazzalo, M. 2004. Home ranges and movement patterns of the marine tucuxi dolphin, *Sotalia fluviatilis*, in Baía Norte, Southern Brazil. **Latin American Journal of Aquatic Mammals**, 3(1): 37-52.

Flach, L., Flach, P. & Chiarello, A. 2008. Aspects of behavioral ecology of *Sotalia guianensis* in Sepetiba Bay, southeast Brazil. **Marine Mammal Science**, 24(3): 503-515.

Gurjão, L. M., Furtado-Neto, M. A. A., Santos, R. A. & Cascon, P. 2003. Feeding habitats of marine tucuxi, *Sotalia fluviatilis*, at Ceará State, Northeastern Brazil. **Latin American Journal of Aquatic Mammals**, 2 (2): 117-122.

Heimlich-Boran, J. R. 1988. Behavioral ecology of killer whales (*Orcinus orca*) in the Pacific Northwest. **Canadian Journal of Zoology**, 66: 565-578.

Izidoro, F. B. & Le Pendu, Y. 2012. Estuarine dolphin (*Sotalia guianensis*) (Van Bénéden, 1854) (Cetacea: Delphinidae) in Porto de Ilhéus, Brazil: group characterization and response to ships. **North-western Journal of Zoology**, 8(2): 232-240.

Krebs, J. R. & Davies, N. B. 1993. **An introduction to behavioral ecology**. Blackwell Science Ltda., London.

Marin, B. J., Quintero, A., Bussiére, D., & Dodson, J. J. 2003. Reproduction and recruitment of white mullet (*Mugil curema*) to a tropical lagoon (Margarita Island, Venezuela) as revealed by otolith microstructure. **Fishery Bulletin**, 101: 809-821.

Meirelles, A. C. O. 2005. Aspectos da ecologia comportamental do boto cinza, *Sotalia guianensis* Van Bénéden, 1853 (Mammalia, Cetacea, Delphinidae) na Praia de Iracema, Fortaleza-CE. **M.Sc. Thesis**. Universidade Federal do Rio Grande do Norte, Brazil, 113p.

Meirelles, A. C. O. 2013. Ecologia populacional e comportamental do boto-cinza, *Sotalia guianensis* (van Bénéden, 1864), na enseada do Mucuripe, Fortaleza, estado do Ceará. **Ph.D. Thesis**. Universidade Federal do Ceará, Fortaleza, Brazil, 114p.

Meirelles A. C. O., Ribeiro, A. C., Silva, C. P. N. & Soares-Filho, A. A. 2010. Records of marine tucuxi dolphin, Sotalia guianensis, in the State of Ceara´, northeastern Brazil. **Latin American Journal of Aquatic Mammals**, 8 (1-2): 97-102.

Ministério do Meio Ambiente. 2014. Portaria MMA no. 444, de 17 de dezembro de 2014. "**Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção**".

Monteiro-Neto, C., Alves-Júnior, T. T., Ávila, F. J. C, Campos, A. A., Costa, A.F., Silva, C. P. N. & Furtado-Neto, M. A. A. 2000. Impact of fisheries on the tucuxi (*Sotalia fluviatilis*) and rough-toothed dolphin (*Steno bredanensis*) populations off Ceará state, northeastern Brazil. **Aquatic Mammals**, 26(1): 49-56.

Moura, I.J.M, Santos, D.F., Pinheiro, F.G.M., Oliveira, C.J. 2015. Caracterização dos

períodos seco e chuvoso da cidade de Fortaleza (CE). **Ciência e Natura**, 37(1): 3-7.

Nichol, L. M. & Shackleton, D. M. 1996. Seasonal movements and foraging behavior of northern resident killer whales (*Orcinus orca*) in relation to inshore distribution of salmon (*Orcorhychus* spp.) In British Columbia. **Canadian Journal of Zoology**, 74: 983-991.

Oliveira, L. V. & Monteiro-Filho, E. L. A. 2008. Individual identification and habitat use of the estuarine dolphin Sotalia guianensis (CETACEA: DELPHINIDAE) in Cananeia, south-esatern Brazil, using video images. **Journal of the Marine Biological Association of the United Kingdom**, 88(6): 1199-1205.

Oliveira, J. A., Ávila, F. J. C., Alves-Júnior, T. T., Furtado-Neto, M. A. A. & Monteiro-Neto, C. 1995. Monitoramento de boto cinza, *Sotalia fluviatilis* (Cetacea: Delphinidae) em Fortaleza, estado do Ceará, Brazil. **Arquivos de Ciências do Mar**, 29(1-2): 28-35.

Rossi-Santos, M. R., Wedekin, L. L. & Monteiro-Filho, E. L. A. 2007. Residence and site fidelity of *Sotalia guianensis* in the Caravelas River Estuary, eastern Brazil **Journal of the Marine Biological Association of the United Kingdom**, 87: 207-212.

Santos, M. C. O., Acuña, L. B. & Rosso, S. 2001. Insights on site fidelity and calving intervals of the marine tucuxi dolphin (Sotalia fluviatilis) in south-eastern Brazil. **Journal of the Marine Biological Association of the United Kingdom**, 81: 1049-1052.

Santos, M. C. O. & Rosso, S. 2007. Ecological aspects of marine tucuxi dolphins (Sotalia guianensis) based on group size and composition in the Cananéia Sturary, southeastern Brazil. **Latin American Journal of Aquatic Mammals**, 6(1): 71-82.

Santos, U. A., Alvarez, M. R., Schilling, A. C., Strenzel, G. M. R & Le Pendu, Y. 2010. Spatial distribution and activities of the estuarine dolphin *Sotalia guianensis* (van Bénéden, 1864) in Pontal Bay, Ilhéus, Bahia, Brazil. **Biota Neotropica**, 10(2): 67-73.

Santos-Jr, E., Pansard, K.C., Yamamoto, M. E. & Chellappa, S. 2006. Comportamento do boto-cinza, Sotalia guianensis (Van Bénédén) (Cetacea, Delphinidae) na presença de barcos de turismo na Praia de Pipa, Rio Grande do Norte, Brasil. **Revista Brasileira de Zoologia**, 23(3): 661-666.

Secchi, E., Santos, M. C .O., Reeves, R. 2018. **Sotalia guianensis** (errata version published in 2019). The IUCN Red List of Threatened Species 2018: e.T181359A144232542. http://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T181359A144232542.en. Downloaded on 19 July 2019.

Simões-Lopes, P. 1988. Ocorrência de uma população de *Sotalia fluviatilis* Gervais, 1853 (Cetaceae, Delphinidae) no limite sul da sua distribuição, Santa Catarina, Brasil. **Biotemas**, 1: 57-62.

Smolker, R.A., Richards, A.F., Connor, R.C., Pepper, J.W. 1992. Sex differences in patterns of association among Indian Ocean bottlenose dolphins. **Behaviour,** 123: 38–69.

Switzer, P. V. 1993. Site fidelity in predictable and unpredictable habitats. **Evolutionary ecology**, 7: 533-555.

Wang, K. R., Payne, P. M. & Thayer, V. G. 1994. Coastal stock (s) of Atlantic bottlenose dolphin: status Review and management. Proceedings and recommendations from workshop held in Beaufort, NC, 13-14 September 1993. **NOAA Technical Memo NMFS – OPR –4**.

Waples, D. M. 1995. Activity budgets of free-ranging bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. **M.S. Thesis**. University of California. Santa Cruz. 61p.

Würsig, B. & Jefferson, T. A. 1990. Methods of photo-identification for small cetaceans. **Reports of the International Whaling Commission**, Special issue 12: 43-52.

Received: January 2018
Accepted: January 2020
Published: June 2020