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SCIENTIFIC NOTE

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UNUSUAL RESPONSES OF GUIANA DOLPHINS (SOTALIA GUIANENSIS) TO THE PRESENCE OF SWIMMERS AND BOATS

Respostas incomuns de botos-cinza (*Sotalia guianensis*) à presença de nadadores e embarcações

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ABSTRACT

The Guiana dolphin, *Sotalia guianensis*, classified as 'Vulnerable' to extinction in Brazil, exhibits a particularly small population within Mucuripe embayment, Ceará state, Northeastern Brazil. This study investigated their behavioral responses from October 2019 to May 2021 as part of the environmental licensing requirements for dredging and land reclamation activities. Thirty-two boat surveys were conducted, with dolphins observed in 97% of them. Two 'unusual' responses to the presence of boats and swimmers were noted: a neutral reaction, when a group of five dolphins continued foraging despite nearby swimmers; and a positive response, when three dolphins deliberately approached the research boat, engaging in spy-hopping and sideways swimming, suggesting curiosity towards our presence. These unusual reactions highlight concerns regarding potential human-dolphin interactions in Mucuripe embayment, underscoring the need for continuous systematic monitoring. Such efforts are crucial to provide the appropriate subsidies aimed at preserving natural dolphin behaviors.

Keywords: Cetaceans, marine mammals, endangered species, behavior, interactions, Mucuripe embayment.

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RESUMO

O boto-cinza, Sotalia guianensis*, ameaçado de extinção no Brasil, possui uma população extremamente pequena na enseada do Mucuripe, estado do Ceará, nordeste brasileiro. Este estudo investigou as respostas comportamentais dessa espécie de outubro de 2019 a maio de 2021, como parte dos requisitos de licenciamento ambiental para atividades de dragagem e engorda de praia. Trinta e duas saídas de campo foram realizadas, com a presença de botos observada em 97% delas. Durante as saídas de campo, foram identificadas duas respostas 'incomuns' à presença de barcos e nadadores: uma reação neutra, quando um grupo de cinco botos continuou se alimentando apesar da presença de nadadores próximos; e uma resposta positiva, quando três botos se aproximaram deliberadamente do barco de pesquisa, realizando periscópio e nadando de lado, sugerindo curiosidade em relação à nossa presença. Essas reações incomuns ensejam preocupações sobre potenciais interações entre humanos e botos na enseada do Mucuripe, reforçando a necessidade de monitoramento sistemático contínuo. Tais esforços são essenciais para fornecer os subsídios adequados destinados a preservar os comportamentos naturais dos golfinhos.*

Palavras-chave: *Cetáceos, mamíferos marinhos, espécies ameaçadas, comportamento, interações, enseada do Mucuripe.*

The Guiana dolphin, *Sotalia guianensis* (van Beneden, 1864), is a small cetacean predominantly found in coastal and estuarine waters along Central and South America, ranging from Nicaragua to Santa Catarina, southern Brazil (Simões-Lopes, 1988; Flores & Da Silva, 2009). It is listed as 'Near Threatened' by the International Union for Conservation of Nature's Red List of Threatened Species (Secchi *et al.*, 2018) and as 'Vulnerable' on the Brazilian National List of Threatened Species since 2014 (MMA, 2014; MMA, 2022). In the state of Ceará, the Guiana dolphin is also subject to special protection, where it is categorized as an 'Endangered species' (SEMA, 2022) and declared Fortaleza municipality's 'Natural Heritage' (Fortaleza, 2012). Such measures imply scientific and conservation commitments, including the mitigation of damages to the dolphins' natural habitats

In Brazil, the species faces significant threats due to its coastal habits, including accidental captures in fishing gear (Monteiro-Neto *et al.*, 2000; Meirelles *et al.*, 2010; Bertozzi, Silva & Flach, 2020), exposure to chemical contaminants (Santos-Neto *et al.*, 2014; Alonso *et al.*, 2015; Dorneles *et al.*, 2016; Lailson-Brito *et al.*, 2020), noise pollution (Bittencourt *et al.*, 2017; Pais *et al.*, 2018; Rossi-Santos, Monteiro-Filho & Azevedo, 2020), unregulated dolphin-watching activities (Santos-Junior *et al.*, 2006; Valle & Melo, 2006; Filla & Monteiro-Filho, 2009), boat traffic (Santos, Schiavetti & Alvarez, 2013; Schiavetti *et al.*, 2020), and harbor operations (Meirelles, 2013; Marcondes, 2021; Meirelles *et al.*, 2022).

Nevertheless, due to a land reclamation in Diário's Beach (area 01) and reinforcement of a previous one at Iracema's Beach (area 02), hydraulic dredging was conducted to bring substrate from an underwater sand deposit off Mucuripe embayment (ME), in Fortaleza coastal waters, to lay it down along these two shore areas (Figure 01).

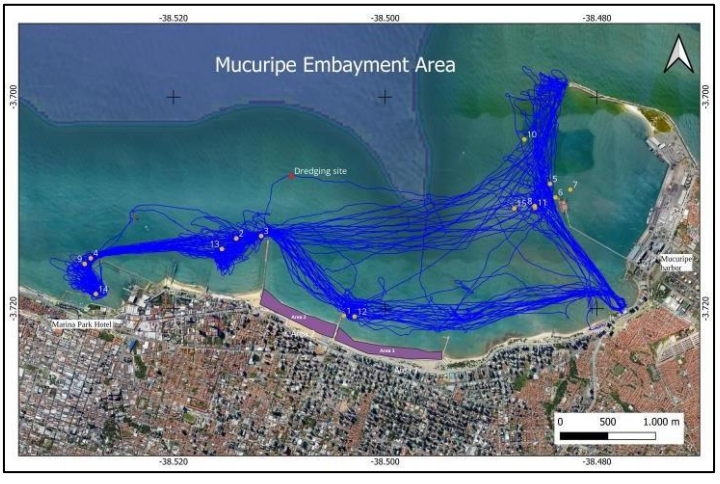
Therefore, these activities were carried out in a highly impacted urban harbor region, where: 1) Guiana dolphins occur year-round in small groups (Oliveira *et al.*, 1995; Meirelles, Campos & Fonteles-Filho, 2020) in the study area; 2) the species comprises almost 70% of the

total number of cetacean strandings along Ceará state (Monteiro-Neto *et al.*, 2000; Meirelles *et al.*, 2010); and 3) an extremely reduced population of these dolphins uses this embayment daily (Meirelles *et al.*, 2022).

To obtain the necessary environmental license, a monitoring program was implemented to assess the effects of these interventions on the local Guiana dolphin population. This program included behavioral observations using the 'ad libitum' sampling method (Mann, 1999). Despite the dredging lasting only a month (October-November 2019), the monitoring program extended from October 2019 to May 2021 due to interruptions caused by COVID-19 pandemic lockdowns.

Dolphins were monitored using a 265 Fishing fiberglass boat, equipped with two inboard 150hp engines. Transects covered approximately 16 km^2, navigating a route from Mucuripe harbor towards Marina Park Hotel and back, totaling about 20 km per survey (Figure 1). Cruise speed was usually about 6 knots, and one to three surveys were conducted monthly, from 08:00 am to 12:00 pm. The field team comprised a pilot, two observers handling Comet 8x42 e Nautika 8X40 binoculars, and one photographer using DSLR Canon 80D or Canon 6D digital cameras, with 70-300mm IS or 100-400m L IS lenses. Data on observed dolphins were recorded on standardized field forms, and their geographical positions were obtained using an Etrex10 Garmin GPS (see Meirelles, 2013 and Meirelles *et al.*, 2022). Dolphin responses to swimmers and boats were classified as negative (when dolphins changed their regular route or interrupted their activity), neutral (when dolphins neither interrupted their activity nor changed their route), or positive (when dolphins demonstrated interest, spontaneously coming closer) to the presence of swimmers or boats (Pereira *et al.*, 2007; Araújo *et al.*, 2008).

Figure 01 - Mucuripe embayment area, in Fortaleza city, Ceará state, Northeastern Brazil. Blue lines indicate the surveyed tracks, yellow dots represent the location where dolphins' responses were sighted and the red dot refers to the dredging site. Purple regions indicate Iracema's (area 2) and Diário's (area 1) land reclamation areas.



A total of 32 surveys were conducted, totaling 128 hours of effort, during which dolphins were encountered in 97% of the surveys. *S. guianensis* specimens were sighted on 104 separate occasions, accounting for 39 hours of effective observation. Surface responses of Guiana dolphins to swimmers and boats were recorded in 15 of these sightings (Table 01).

Table 01 – Responses of *S. guianensis* to the presence of swimmers and boats in Mucuripe embayment area. *Unusual reactions

Record of surface response	Date	Group size	Location (UTM coordinates-24M)	Response	Comments
1	October 18, 2019	7	555089/ 9588735	Neutral	Dolphins remained near a breakwater when a motorized boat was nearby
2	November 8, 2019	4	553960/ 9589542	Neutral	Dolphins remained foraging when non-motorized fishing boat came closer
3	November 14, 2019	2	554221/ 9589568	Neutral	Dolphins remained foraging near a breakwater when a motorized boat was nearby
4	November 14, 2019	5	552433/ 9589336	Negative	Dolphins moved away when a motorized boat came closer, but returned when the boat went away
5	November 14, 2019	4	557251/ 9590110	Negative	Dolphins moved away when a motorized boat came closer, but returned when the boat went away
6	November 21, 2019	4	557309/ 9589969	Negative	Dolphins remained in the area but moved far from the boat when it came closer. When the boat moved away, dolphins returned to the original position.
7	November 29, 2019	2	557464/ 9590050	Negative	Dolphins moved away when a ship and a tugboat were passing nearby
8	December 6, 2019	6	557091/ 9589878	Neutral	Dolphins remained in the area when a ship was moving nearby
9	January 17, 2020	5	552370/ 9589277	Neutral	Dolphins chasing school of fish did not change their way and moved beneath the monitoring boat
10	January 17, 2020	3	556983/ 9590575	Negative	Dolphins moved away when a ship and a tugboat were passing nearby
11	February 14, 2020	3	557093/ 9589862	Neutral	Dolphins remained in the area when two tugboats were moving nearby
12	July 29, 2020	5	555200/ 9588725	Neutral*	Dolphins remained foraging when swimmers were nearby
13	January 22, 2021	8	553809/ 9589432	Positive*	Three dolphins came closer and demonstrated curiosity toward the research boat
14	April 23, 2021	3	552487/ 9588963	Neutral	Dolphins remained in the area when kayaks were nearby
15	May 7, 2021	2	556876/ 9589854	Neutral	Dolphins remained in the area when a ship and a tugboat were moving nearby

On two occasions, dolphin responses were considered 'unusual': one was neutral towards swimmers, and the other was positive towards a boat (records 12 and 13, Table 01—both instances occurred when dredging operations were inactive).

Interactions between *S. guianensis* and swimmers were rarely documented in this study, except on July 29, 2020 (record 12, Table 01), when dolphins appeared undisturbed by human presence nearby. On this occasion, five Guiana dolphins were observed foraging at Diário's Beach while three swimmers from Iracema's Beach swam around the pier separating areas 02 and 01 (Figure 01) and passed through the dolphins' feeding area. One swimmer approached very close to the dolphins (Figure 02), which continued indifferently engaged in fluke-up diving around him, likely performing Independent Random Feeding (Rossi-Santos & Flores,

2009) near the seabed.

Although the Guiana dolphin is typically considered shy and cautious, often demonstrating evasive behavior compared to other dolphin species (Lodi, 2003; Santos & Rosso, 2008; Pierry, 2021), on this occasion, the dolphins' foraging activities appeared enticing enough to induce them tolerate the nearby human presence. However, this does not imply that the presence of swimmers does not potentially negatively impact the behavior, welfare or activities of Guiana dolphins (see Carzon et al, 2023). Instead, it suggests that under specific circumstances, the species may exhibit a higher tolerance for human proximity than previously assumed.

Figure 01 - A swimmer near a foraging Guiana dolphin group in Diario's beach, Fortaleza city, Ceará state, Brazil (Photo credits: Heideger Nascimento/AQUASIS Collection.

While this marks the first formally documented instance of such close proximity and a neutral reaction between Guiana dolphins and swimmers in the state of Ceará, other unusual interactions involving the species have been reported elsewhere in Brazil. These interactions include instances where humans and Guiana dolphins were engaged in activities such as hand-feeding, swimming alongside, consenting to touching, besides interactions between *S. guianensis* and other animal species such as domestic dogs (*Canis familiaris*), birds, and fish (Santos *et al.*, 2000; Nascimento, 2006; Monteiro-Filho *et al.*, 2008).

Despite the limited sample size, in the majority of encounters, Guiana dolphins exhibited neutral responses (57%) or negative responses (36%) to boat presence. This finding is consistent with similar studies that either reported no positive reactions (Araújo *et al.*, 2008; Izidoro & Le Pendu, 2012; Marega-Imamura *et al.*, 2018) or observed a low frequency of positive responses of *S. guianensis* towards boats (Pereira *et al.*, 2007).

Moreover, on January 22, 2021 (record 13, Table 01), we observed a group of eight Guiana dolphins engaging in Front Cooperative Feeding (FCF) behavior (Rossi-Santos & Flores, 2009), actively herding fish schools towards shallow waters near the concrete pier in the

partially sheltered environment of Iracema Beach (see Meirelles, Campos & Fonteles-Filho, 2020). After completing one FCF movement, these dolphins regrouped and returned to the starting point. Subsequently, a subgroup of three individuals separated from the remaining five dolphins, who were still engaged in FCF activity, and calmly approached the research boat. Coming within approximately 5 meters of our vessel, one dolphin engaged in surface sideway swimming while another performed spy-hopping (Figure 03), indicating curiosity. Afterwards, all three dolphins swam under the boat and continued eastward, definitively separating from the other dolphins.

Figure 03 – Guiana dolphin performing spy-hopping in Iracema's beach, Fortaleza city, Ceará state, Brazil (Photo credits: Heideger Nascimento/AQUASIS Collection).

Spy-hopping is a behavior where a dolphin remains stationary with its head raised above the water, exposing its eyes and rostrum pointed skyward (Shane, 1990). This behavior has been previously documented in tucuxi dolphins (*Sotalia fluviatilis*), encompassing both marine and riverine ecotypes (Da Silva & Best, 1996) and was reported, though not explicitly termed as such, by Oliveira *et al.* (1995) in this population. It is associated with various activities such as feeding, playing (Souto *et al.*, 2006), and potentially with sexual (Slooten, 1994) and exploratory behaviors (Delfour *et al.*, 2021).

This type of response is noteworthy considering that *S. guianensis* is typically characterized as timid and cautious, often avoiding 'bow-riding' unlike other cetacean species (Lodi, 2003; Santos & Rosso, 2008; Pierry, 2021). Furthermore, previous studies documenting positive reactions of Guiana dolphins towards boats have primarily noted specimens surfing boat-produced waves (Pereira *et al.*, 2007), but, so far, no specimen had been recorded heading towards boats.

Conversely, neutral responses of Guiana dolphins to boat presence are not uncommon and may indicate habituation to the presence of vessels in their environment (Pereira *et al.*, 2007; Araújo *et al.*, 2008; Carzon et al, 2023). Supporting this idea, previous studies observed

S. guianensis individuals foraging in shallow waters despite the proximity of boats (Santos-Jr *et al.*, 2006). Similarly, during the current study on January 17, 2020 (Table 01), five Guiana dolphins were observed chasing a fish school near a rock breakwater in front of Marina Park Hotel. They showed no apparent disturbance from the presence of the research boat midway through their pursuit; the fish school escaped under and beside our vessel while the dolphins swam in close proximity.

However, it is important to emphasize that habituation to boat presence does not imply absence of impact on the species, since it may reduce animals' fearfulness and antipretator actions, with cascading effects on populations and communities (Carzon et al, 2023). Additionally, changes in acoustic communication and behavioral adaptations to vessel presence can incur energetic costs, potentially compromising energy acquisition (Heiler *et al.*, 2016; Williams *et al.*, 2006).

Another crucial aspect to highlight is the presence of tourism boats in the ME area, which not only offer dolphin-watching opportunities during their trips but also frequently stop these vessels, inviting customers to enter the water for 15-20 minutes at a 'hotspot' of Guiana dolphin occurrence near the Marina Park Hotel boatyard (see Meirelles, 2013; Meirelles *et al.*, 2022). Such scenarios increase the likelihood of close contact between *S. guianensis* and humans and may contribute to dolphins becoming habituated to the presence of boats and humans in their vicinity.

Therefore, long-term systematic studies are essential to definitively ascertain whether Guiana dolphins are habituating to boats and swimmers in the ME and to potentially document close interactions using appropriate methodological approaches. Supporting this perspective, Santos *et al.* (2000) employed a similar methodology to report and analyze unusual responses of Guiana dolphins, underscoring the necessity for extended research to better understand some aspects of *S. guianensis* behavior. In fact, the sampling method employed in this study is classified as the 'anecdotal' protocol (sensu Altmann, 1974), and thus, the use of the 'ad libitum' methodology can provide critical information and insights regarding rare events, often the only feasible way to record such occurrences (Mann, 1999).

Finally, it must be emphasized that there exists national legislation in Brazil prohibiting any intentional disturbance of cetaceans in national waters (Brasil, 1987). Considering this, if closer interactions between Guiana dolphins and either swimmers or boats are confirmed through further studies in the ME, additional management measures to preserve the natural behavior and physical well-being of Guiana dolphins could be implemented. These measures include: 1) educational campaigns targeting boat users, stand-up paddleboarders, kayakers, swimmers, bathers, and tourism boat operators and their customers (Santos *et al.*, 2000); 2) establishment of a marine protected area (MPA) encompassing the ME region (Meirelles *et al.*, 2022); 3) implementation of boat traffic regulations within the designated MPA boundaries (Tosi & Ferreira, 2009; particularly in the 'hotspots' of Guiana dolphin occurrence within the ME region.

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