

NURSERY AREA FOR THE THREATENED GUIANA DOLPHIN, *SOTALIA GUIANENSIS*, ON THE NORTHEAST COAST OF BRAZIL

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Abstract

Cetacean calves are considered fragile and vulnerable, especially in the first year of life. To guarantee safety and increase the likelihood of survival, females with calves use habitats with unique characteristics, called nursery areas. In the present study, we investigated whether the Guiana dolphin *Sotalia guianensis*, considered a threatened species in Brazil, uses the Tibau do Sul Coastal Wildlife Reserve (REFAUTS) as a nursery area. We identified the Guiana dolphins through photographs and recorded the composition of the groups during the 41-day sampling period, between 2013 and 2019. We identified 17 adults/juveniles in the company of calves, five of which were recorded in three or more years of the study. The average size of the Guiana dolphin groups (mean±SE) was 2.4±0.08 individuals, ranging from 2 to 5 individuals (n = 98). Groups with calves were recorded in every year of the study and on 53.7% of the sampling days. A total of 35.8% of the Guiana dolphin groups had calves. These results suggest that REFAUTS is an important nursery area for Guiana dolphins on the Northeast coast of Brazil.

Keywords: Cetacean; Conservation; Photoidentification; Protected area; Threatened species

Introduction

Reproductive success is one of the parameters used to estimate population growth and monitoring [1, 2]. In cetaceans, reproductive success is estimated based on the number of offspring, the interval between gestations, and the survival rate, which may be influenced by complex interactions between biological, social [1], and ecological factors [2]. The offspring care is provided primarily by the mother, who accompanies her offspring from birth to independence (e.g. [3]). Parental care patterns may be variable, from minimal protection to the prolonged supply of food resources by the mother [4]. In small cetaceans, prolonged parental care may reflect the effort required by offspring to acquire the behavioral and social skills needed to survive in a complex and dynamic marine environment (e.g. [3]).

In coastal habitats, where resources are relatively predictable, female delphinids may remain in their native areas and form groups with other females whose reproduction conditions are similar [5, 6]. In these habitats, groups of pregnant females or those with offspring are

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benefitted by shallow environments, which provide greater protection against predation, allow swimming energy economy, and hinder sexual coercion by males [5-7]. However, shallow habitats near the coast may also compromise offspring survival, exposing them to anthropic and ecological pressures [8]. The preference of female delphinids for habitats with specific characteristics may also be related to specialized individual foraging strategies taught by the mother. As mothers are teaching foraging strategies to their offspring, they also may influence the selection of habitats associated with food acquisition [9].

Understanding the aspects of life history that drive the selection of specific habitats by females with offspring can be particularly challenging for highly mobile species, such as delphinids [10]. Photographic records of offspring can be difficult to obtain in this age range because offspring exhibit fewer markings to identify them on photographs, making them difficult to monitor, and some calves die before being photographed [11]. However, some studies have successfully monitored photo identified groups with calves for extended periods [8-13]. Despite these difficulties, recording the occurrence and spatiotemporal distribution of calf individuals in their natural habitat is one of the most important components in the environmental planning of species conservation [11]. Understanding the factors that influence the reproductive success of females may provide valuable information on viability, population decline, and risk of species extinction [8-13].

The Guiana dolphin, *Sotalia guianensis*, is currently considered a threatened species in Brazil [14], Venezuela [15], and Colombia [16], and categorized as a Near Threatened (NT) at a global level in the IUCN Red List [17]. This small cetacean exhibits parental care, with the mother's effort in caring for her offspring varying according to age, dependency level, and group size and composition [3]. Females reach sexual maturity between five and seven years of age and bear only one offspring at a time. Gestation lasts around 12 months, with up to three years and nine months between deliveries. The offspring remain with their mother for a long time [17], but adults and juveniles may also take turns caring for them. This behavior offers opportunities for the young to observe and learn social and communication skills from the adults [3].

The Tibau do Sul Coastal Wildlife Reserve (REFAUTS), located in Rio Grande do Norte state, is one of the main areas of Guiana dolphin concentration on the northeastern coast of Brazil. In this Wildlife Reserve, the Guiana dolphin can be observed throughout the year, especially in feeding and parental care activities [18]. In the REFAUTS, calves are frequently recorded in Dolphin and Madeiro bays [18, 19], suggesting that this reserve is used by females to raise their offspring. As such, the present study proposes to investigate whether the REFAUTS is indeed a nursery area for the Guiana dolphin, based on variables that determine the frequency of calves in Guiana dolphin groups across a time scale.

Material and methods

Study site

The study area is located at Pipa beach in Rio Grande do Norte state (RN), Brazil. The Tibau do Sul Coastal Wildlife Reserve (REFAUTS), which was created in 2006, covers an area of 53.9km² and includes a marine environment and a stretch of beach [20]. The REFAUTS is divided into three zones: the restricted use zone, which includes Dolphin and Madeiro bays, the controlled use zone, which provides access to these bays, and the buffer zone, which includes Guarairas lagoon and the adjacent coastal and marine areas (Fig. 1). Dolphin and Madeiro bays are shallow and protected from strong winds and ocean currents. The local climate is classified as tropical rainy, with an annual average temperature of 25.9°C [21].

Sample collection

This study was conducted between 2013 and 2019, totaling seven sampling years. The Guiana dolphins (*Sotalia guianensis*) were photographed in the REFAUTS restricted use zone, from the highest fixed point on the beaches of the Dolphin and Madeiro bays (Fig. 1), so as not to interfere with their behavioral patterns. Photoidentification of the dolphins was obtained with a semi professional camera coupled to a 150-600mm telescopic lens and a monopod. Data collection was carried out by two previously trained researchers. The photoidentification records were gathered on days with little or no cloud cover and values of ≤ 3 on the Beaufort wind force scale. The same effort was applied to identify all the Guiana dolphins in Dolphin and Madeiro bays. The number of sampling days varied in the month, ranging from 1 to 4, depending on the financial resources available for expeditions to the study area.

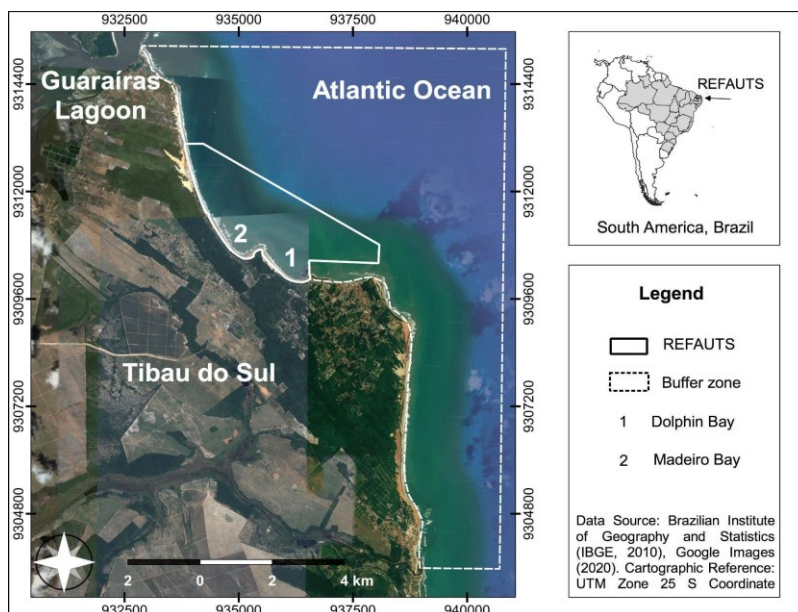


Fig. 1. Tibau do Sul Coastal Wildlife Reserve (REFAUTS), located in the municipality of Tibau do Sul, Brazil. The Dolphin and Madeiro bays are highlighted in the polygon

Photos of the Guiana dolphins' dorsal fin were transferred to a computer, classified, and analyzed, according to the methodology described by M.C.O. Santos and S. Rosso [22], considering image quality. A total of 12,406 dorsal fin photographs were taken, 1,283 of which (10.4%) were selected for analysis, resulting in the photoidentification of 45 Guiana dolphins in the REFAUTS.

Data analysis

The age range of the dolphins was classified by visual estimation of body size and color based on the ontogenetic variation in color patterns, body length and behavioral patterns adopted by C.R. Teixeira *et al.* [3]. We decided to group adults and juveniles into the same age class denominated 'adults/juveniles', and newborns and infants into the 'calves' class, to minimize the chances of age estimation errors. Thus, only calf, but not juvenile frequency in the Guiana dolphin groups, was considered when indicating the REFAUTS as a possible nursery area.

Three aspects were considered to assess REFAUTS as a possible nursery area for Guiana dolphins: (i) calves were recorded annually; (ii) groups with calves were recorded on more than 50% of the sampling days; and (iii) at least $\frac{1}{2}$ of the groups had one calf. We consider that these four aspects are a probable minimum representation of the nursery area, given that the offspring of small cetaceans are not always easy for observers to detect, especially in sampling from the coast [23].

In this study, we considered a group to consist of two or more Guiana dolphins observed in apparent association, moving in the same direction and engaged in the same behavior [19]. When the group composition changed, with the arrival or departure of an individual, we considered a new group composition. We also considered that groups containing two individuals, one of which was an adult/juvenile and the other a calf, consisted of an adult female or juvenile animal in the company of a calf, based on the premise that delphinids recorded in coastal areas are typically female-calf pairs [6-8].

Results and discussion

Between 2013 and 2019, over a 41-day sampling period, totaling 164h of sampling effort, we recorded 98 groups of Guiana dolphins (*Sotalia guianensis*) during observations made from the stretch of beach. The average size of the Guiana dolphin groups (mean \pm SE) was 2.4 \pm 0.08 individuals, ranging from two to five individuals (n = 98). Groups composed of two individuals were more frequent, present in 66.3% of the records (n = 65). Eight different group compositions were recorded, which generally included adults/juveniles or adults/juveniles and calves. The most frequent group composition was two adults/juveniles, followed by one female and one calf. Groups with five individuals were rare (Table 1). Groups of Guiana dolphins were recorded in every year of the study (Fig. 2) and calves were observed regularly in the company of adults/juveniles (Table 2, Fig. 3, Fig. 4). Groups containing at least one calf were recorded in 53.7% of the sampling days, and calves were present in 35.7% of the groups (Table 1). Between 2013 and 2019, we obtained photoidentification of 17 Guiana dolphins accompanied by calves. The dolphins named R2, R4, R8, R10, and R18 were accompanied by calves in three or more study years (Table 2 and Fig. 3).

Table 1. Group composition of Guiana dolphins, *Sotalia guianensis*, registered between 2013–2019 at the Tibau do Sul Coastal Wildlife Reserve (REFAUTS), Brazil

Group composition	N° of groups registered	Frequency (%)
2adju	42	42.9
3adju	18	18.4
4adju	2	2.0
5adju	1	1.0
1fe1ca	23	23.5
2adju1ca	6	6.1
3adju1ca	5	5.1
4adju1ca	1	1.0
Total	98	100

adju: adult/juvenile, ca: calf, fe: female

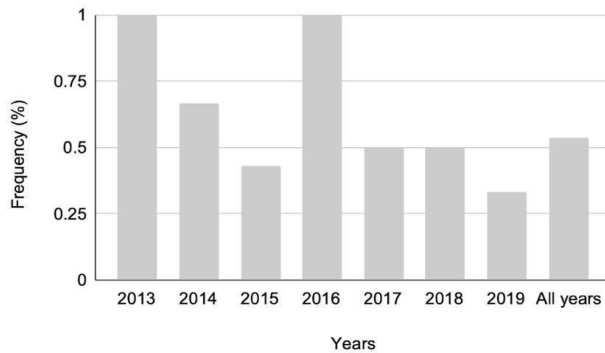


Fig. 2. Relative frequency (%) of sampling days in which groups of adults/juveniles in the company of calves Guiana dolphin, *Sotalia guianensis*, were recorded in the Tibau do Sul Coastal Wildlife Reserve, Brazil, between 2013–2019

Table 2. Adults/juveniles Guiana dolphins *Sotalia guianensis* in the company of calves registered between 2013–2019 at the Tibau do Sul Coastal Wildlife Reserve (REFAUTS), Brazil. Letter R accompanied by a number indicates the individual photoidentification of an adult/juvenile

Year	Guiana dolphin registered in the companion of a calf
2013	R1, R2, R4, R5
2014	R2, R4, R8, R10
2015	R1, R2, R4, R5, R8, R9, R10, R18, R21, R22
2016	R4
2017	R8, R10, R18, R20
2018	R24, R25, R40, R38
2019	R10, R18, R21, R34, R40, R45

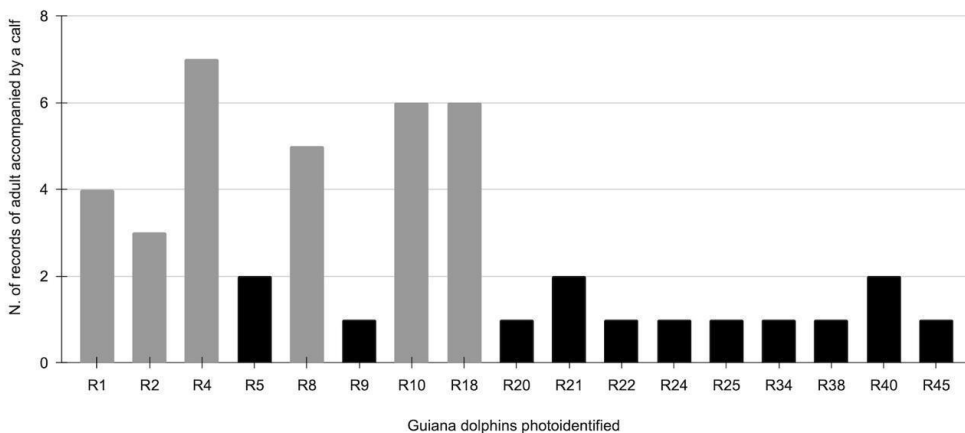


Fig. 3. Number of records of adults Guiana dolphins, *Sotalia guianensis*, in the company of calves in the Tibau do Sul Coastal Wildlife Reserve, Brazil, between 2013–2019. Letter R accompanied by a number indicates the individual photoidentification of an adult. Black bars represent adults in the company of a calf registered up to twice and gray bars three times or more

Guiana dolphins exhibit a fission-fusion social system, where individuals form groups or move away from one another dynamically and fluidly, according to specific interests and needs

[19]. Group size is an important component in population studies and likely one of the most studied parameters. We recorded groups of Guiana dolphins composed of two to five individuals, but primarily of the former. A study conducted in the REFAUTS before 2013 recorded Guiana dolphin groups of up to 19 individuals [19]. The decline in the number of individuals per group may indicate a possible reduction in the population size of Guiana dolphins in the REFAUTS in the last decade, resulting in a disordered increase in dolphin-watching tours [23-25]. Factors such as a significant rise in the number of Guiana dolphin-watching tour boats and noncompliance with the maritime transport guidelines [23-25] may threaten parental care [26] and contribute to their leaving the area [27]. Unfortunately, in this protected marine area, there is evidence to suggest that a calf was being run over and killed by a tour boat [28], which may not be an isolated event. Thus, monitoring programs and dolphin-watching control, associated with monitoring the Guiana dolphin population by photoidentification, are essential strategies that may contribute to the conservation of this threatened species.

In the REFAUTS, adults with calves were frequent. Although there is no genetic information on these animals, they are likely females accompanied by their offspring, since delphinids recorded in coastal areas are typically female-calf pairs [6-8]. Female delphinids can occupy different areas, based on their reproductive status. In these areas, there is likely a space shared by females for delivery, nursing and offspring care that forms part of the total habitat denominated nursing area [10].

In polygamous species, such as delphinids, males are expected to maximize their reproductive success, leaving their place of birth and moving among sexually receptive females [29]. Males tend to travel to larger areas to increase mating opportunities with reproductive females [30]. On the other hand, females tend to be more philopatric in their home area [7].

Guiana dolphin calves in the REFAUTS are always observed beside at least one adult, which may indicate that mothers keep their offspring close to monitor them visually or acoustically [30]. Ideal habitat conditions at birth may determine offspring survival in the first days of life and guarantee reproductive success [31]. Continuous monitoring by the mother in the first year of an offspring's life may be associated with the latter's dependence on obtaining food and learning social behaviors [3].

Variables such as salinity, water temperature, and the availability of food resources, influence small cetaceans' selection of a particular habitat [31, 32]. The frequent occurrence of offspring in Dolphin and Madeiro bays in the REFAUTS is related to the environmental characteristics of this reserve, which include shallow water, protection from strong winds and maritime currents, and an average temperature of 27.8°C [33]. Shallow water habitats may allow mothers and offspring to detect and more easily avoid predators. Coastal waters less than 20 m deep are a refuge for females, especially for parental care [5], and prey density may be greater in shallow water [34], particularly if adjacent to a highly productive area such as Guaraíras lagoon [35]. Given that it is a protected marine area with commercial fishing restrictions, there may be a greater concentration of schools of fish in this area, when compared to unprotected waters. Thus, in addition to being an area favorable to offspring care, Dolphin and Madeiro bays are also important feeding areas for Guiana dolphins [19].

In several parts of the world, dolphin-watching is considered beneficial, since it provides jobs and income to local communities and may promote environmental conservation through educational experiences that encourage sustainable environmental behavior [36, 37]. However, dolphin-watching may also harm the key species. It has been widely reported that tourist boats may cause behavioral changes in small cetaceans [38, 39] and the demography and dynamics of populations [40, 41].



Fig. 4. Guiana dolphins, *Sotalia guianensis*, calves registered in the Tibau do Sul Coastal Wildlife Reserve, Brazil, between 2013–2019 (A–O).

The presence of boats in coastal habitats may have a negative influence on the reproduction rate of small cetaceans. In areas of intense tourist boat activities, reproduction rates

are typically lower than in areas with less boat traffic [42]. Conservation strategies to recover endangered species generally concentrate on reproductive success, such as the number of offspring and survival rate [40]. As such, to establish the best management options for vulnerable species, factors that compromise survival rates and the viability of coastal dolphins must be eliminated or minimized [39].

Offspring are especially vulnerable to disturbances due to their small size and poorly developed survival skills [7]. Parental care can vary according to environmental risks. In hostile environments, females tend to protect their offspring from possible dangers, including predators, fishing nets, and boat traffic [7]. The intense tourist boat traffic in the REFAUTS [23] may affect the well-being and survival of Guiana dolphins, including offspring [28]. In the restricted use zone, these dolphins share their habitat with tourist boats, swimmers, surfers, and kayaks. In 2018, the municipality of Tibau do Sul was classified as a class A tourist destination, reaching the top of the national tourism ranking, due to the increase in four economic performance indicators: number of jobs and tourist accommodations, and number of domestic and international tourists [43].

The REFAUTS is a sustainable use marine protected area, whose law n. 349/2007 that regulates tourist boats [44] is not complied with or enforced. In this reserve, the absence of control, monitoring, and continuing education for boat operators has contributed to violations of the aforementioned law. In the long term, these violations may threaten the Guiana dolphin, including reducing the local population or inducing them to leave the area, as occurred in Guanabara Bay on the coast of Rio de Janeiro [45]. Nursery areas are strategic locations that must be effectively protected, given their importance in guaranteeing offspring survival and the continuity of behaviors such as nursing. Promoting more restrictive measures in tourist and fishing activities in the REFAUTS may contribute to the long-term survival of Guiana dolphins in this reserve.

Conclusions

This study presents three pieces of evidence that corroborate the classification of the REFAUTS as a nursery area for Guiana dolphins, a threatened species on the Brazilian coast: calves were regularly observed in this area over time; groups of adults/juveniles and calves were common; and Guiana dolphins with a high degree of site fidelity were accompanied by calves. Monitoring a coastal species such as the Guiana dolphin from a fixed point on the coast was quite effective and low cost, in addition to not causing any behavioral changes in these cetaceans. Identifying nursery areas for threatened species such as the Guiana dolphin is highly relevant given that it may support, through public policies, the implementation of tourist activity monitoring and enforcement programs. Guiana dolphin conservation strategies should prioritize the protection of their nursery areas, to allow these animals to continue providing parental care and increasing their chances of survival.

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