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Pattern of use of a small bay in northern Brazil by *Sotalia guianensis* (Cetacea: Delphinidae)

by

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Abstract

The abundance, movements and behaviour of *Sotalia guianensis* were studied between 1999 and 2001 in the Emboraí Bay on the northeastern coast of Pará, Brazil. Dolphins are not distributed regularly around the bay and the population size is estimated to be approximately 150 individuals. Dolphins enter the bay to feed, especially at low tide. Travel, and foraging were, in that order, the behaviours most frequently observed. The potential for the conservation of the dolphins in the Emboraí Bay is good considering the absence of serious threats to the population and the fact that young and infants are regularly present, which shows that the population is reproducing.
Keywords: ***Sotalia guianensis*, *boto-cinza*, abundance, behaviour, northern coast, Brazil.**

Resumo

A abundância, movimentos e comportamento da *Sotalia guianensis* foram estudados entre 1999 e 2001 na Baía do Emboraí no litoral nordestino do Pará, Brasil. Os golfinhos não são distribuídos regularmente ao redor da baía e o tamanho da população é estimado ao redor de 150 indivíduos. Os golfinhos entram na baía para se alimentarem, especialmente na maré baixa. Movimento, e a ação de forragear foram, nessa ordem, os comportamentos mais freqüêntemente observados. O potencial para a conservação dos golfinhos na Baía do Emboraí é bom, considerando a ausência de ameaças sérias à população e pelo fato da presença regular de jovens e filhotes, mostrando que a população está reproduzindo.

Introduction

Cetaceans are commonly seen along the coast of Brazil and are of interest to both scientists and the general public (PALLAZO et al. 1997). However, an increase in shipping traffic may adversely affect populations and there are records of accidental captures of cetaceans all along the Brazilian coast (IBAMA 1997). The rise in popularity of ecotourism, in particular, cetacean-watching has caused concern over the well-being of many populations (IBAMA 1997) since many of these activities are carried out in a disorganised and non-regulated manner. The effects of increasing urbanization and pollution may threaten cetaceans, although studies have shown that large populations may persist even in very polluted waters, such as those around Rio de Janeiro, for example (LODI & HETZEL 1998). Currently Federal Law No. 7.643 (1987) prohibits

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the intentional capture of, or interference with, species of cetaceans in Brazilian waters.

The *boto-cinza*, *Sotalia guianensis* (VAN BÉNÉDEN, 1864), is one of the smallest members of the dolphin family (JEFFERSON et al. 1993) and is distributed along the Atlantic coast from Honduras to southern Brazil (Santa Catarina) (BOROBIA et al. 1991). *S. guianensis* may be distinguished from *S. fluviatilis* (the *tucuxi*), which lives in the Amazonian Basin, by means of skull shape, adult size, habitat, social organization and reproductive strategy, among other characteristics (MONTEIRO-FILHO et al. 2002, and literature cited within). However, according to the IUCN (1996) and the Brazilian wildlife authority IBAMA (1997), insufficient data are available to properly assess the conservation needs of *S. guianensis*. The *boto cinza* is one of several species of cetacean given priority status in an Action Plan created by IBAMA's Aquatic Mammal Special Working Group (Grupo de Trabalho Especial de Mamíferos Aquáticos). The Action Plan (IBAMA 1997) recomends surveys of population abundance, habitat preference, seasonal and daily movements and the evaluation of the impact of fishing activities and tourism, among other studies. Recent studies on the fisheries interactions, population dynamics, and reproduction of *S. guianensis* have been carried out in southern Brazil (ROSAS 2000; ROSAS & MONTEIRO-FILHO 2002). A comprehensive assessment of vocalizations in *S. guianensis* was carried out by MONTEIRO-FILHO & MONTEIRO (2001), again in southern Brazil. There are many records of *S. guianensis* in the south of Brazil and its apparent absence along much of the northern and northeastern coasts is simply the result of a lack of observers in these latter regions (BOROBIA et al. 1991).

In line with these recommendations, and the fact that few data are available for the north of Brazil, the aim of this study was to provide data on the abundance of a population of *S. guianensis* and its pattern of use of a small bay on the northern coast of Brazil (Fig. 1A, B), as well as assess the possible impact of human activities.

Materials and methods

Between September 1999 and April 2001 eleven expeditions were made to the Emboraí Bay (01°01'39.8"S, 046°27'39.9"W) in the Municipality of Augusto Corrêa on the northeastern coast of the State of Pará, Brazil (Fig. 1B). Much of the bay is protected as a Municipal Conservation Unit (Área de Proteção Ambiental da Costa de Urumajó) with emphasis on the mangrove forest and the scarlet ibis (*Eudocimus ruber*) populations present in the bay. The bay is an important source of income for local fishermen that use small nets from boats, or more commonly, artesanal methods such as the traditional *currais*. These consist of two long walls made of wooden poles driven into the seabed in a "V" shape, at the apex of which is a cage. Fish enter the *curral*, move along the walls and finally enter the cage, from which they are removed at low tide (see BARLETTA et al. (1998) for further details).

Observations were obtained by sighting dolphins from a 5 m long wooden fishing boat with an inboard motor (maximum speed 12 km hr^{-1}), using binoculars along a fixed route (dotted line, Fig. 1C) within the bay between daylight hours. The total number of dolphins in view was counted within a 180° radius from the prow. The boat remained in movement maintaining a distance of at least 5 m. The bay was divided into quadrants (Fig. 1C) and upon sighting dolphins, the location of the boat was noted with respect to the quadrants. Sighting frequency was calculated for each quadrant as the number of visits with sightings of dolphins divided by the total number of visits. Sighting frequencies were classified according to TRUJILLO & BELTRÁN (1995) as very frequent >75 %; frequent 50-75 %; infrequent 25-50 % and rare <25 %.

Tidal conditions were classified as ebbing, low, rising and high, according to local tide tables. Wave types were grouped as separate, those that break with a considerable interval of time between each other, joint, those that break immediately one after another, or no waves, when the sea was completely calm.

Dolphins were identified using size and colour of the body, as well as shape and size of the dorsal fin and head (BELTRÁN-PEDREROS 1999; JEFFERSON et al. 1993; PINEDO et al. 1992). The following group sizes were established: large group (>20 ind.), medium group (11-20), small group (4-10), trio (3), couple/pair (2), and individual (1). Using principally colour and body size, dolphins were classified among the following age categories: adult, young, infant or unknown. Dolphin behaviour was classified into three general categories: travel, foraging, and reproductive activities. Behaviour was observed in intervals of five minutes during a period of 45 min. starting after first sighting the dolphins.

It was not always possible to make observations every month due to bad weather, dangerous sea conditions, mechanical failure, and D.T.'s academic commitments. Therefore, the number of hours of observation varied with each trip and this greatly limited a statistical analysis of the data. However, frequencies of dolphins in different sub-areas, tidal conditions, wave types, and group size categories over the entire study period were analysed for homogeneity across categories.

Results

Numbers of dolphins

The only species seen during the study period was *Sotalia guianensis*. The minimum and maximum number of dolphins seen per day during the study period were 1 and approximately 80 dolphins, respectively. The total number of dolphins seen during the study (209 h of observation) was 508 animals. The greatest number of dolphins seen was in sub-area I (228 ind.), followed by sub-areas II (156 ind.) and IV (122 ind.). The least number of dolphins was seen in sub-area III (02 ind.) (Fig. 2). There is a highly significant departure from homogeneity in frequencies of dolphin among the four sub-areas ($\chi^2 = 210.17$; $p < 0.01$). In sub-area I, the sighting frequency of dolphins was 70 % which corresponds to the category frequent (Fig. 3). In sub-areas II, III, and IV the sighting frequency was low and corresponds to the category rare.

Environmental conditions

The greatest number of dolphins was seen during the ebbing tide (356 ind.), followed by the rising tide (122 ind.) (Fig. 4). During low tide and high tide, equal numbers of dolphins (15 ind.) were observed. Frequencies of dolphins among the four tidal states showed a highly significant departure from homogeneity ($\chi^2 = 610.66$; $p < 0.01$). More dolphins were observed when there were no waves (345 ind.). In the categories separate waves and joint waves, 149 and 14 individuals were observed respectively (Fig. 5). There is a highly significant departure from homogeneity of dolphin frequencies among the three categories of wave type ($\chi^2 = 327.16$; $p < 0.01$). During the ebbing tide and when no waves were present, dolphins were ocasionally seen interacting with fishermen, usually moving in the direction of the boat and, according to the fishermen, driving the schoal of fish towards their nets.

Group size and structure

The most frequently observed group size category was small group (n=20) followed by couple/pair (n=11), trio (n=10) and individual (n=10) (Fig. 6). The categories medium group (n=4) and large group (n=5) were infrequently observed. Dolphin frequencies among the six categories of group size showed a highly significant departure from homogeneity ($\chi^2 = 16.2$; $p < 0.01$). The number of individuals observed of unknown age was greatest (n=219) among the different age categories (Fig. 7). In the adult category, 201 individuals were observed whereas the number of individuals seen in the categories infant (60 ind.) and young (28 ind.) were much lower. A highly significant departure

from homogeneity of dolphin frequencies among age categories was found ($\chi^2 = 222.28$; $p < 0.01$).

Behaviour

Reproductive activity was not observed at all during the entire study. The dolphins spend 100 % of their time foraging during the low tide. During the rising tide, activity was almost equally divided between foraging (52 %) and travel (48 %). During high tide, foraging (77 %) predominated over travel (33 %). In contrast, during the ebbing tide, travel (62 %) was predominant over foraging (38 %). Within the category separate waves, dolphin activities were divided between travel (53 %) and foraging (47 %). With no waves, the most frequently observed activity was travel (64 %), followed by foraging (36 %). Within the category joint waves, foraging (67 %) predominated over travel (33 %). In general, travel (53 %) was slightly more frequently observed than foraging (47 %).

Discussion

In the Emboraí Bay, the dolphins were most abundant in sub-areas I and II, which coincide with localities with the greatest number of *currais*, according to local fishermen. This suggests that the dolphins are aggregating in these areas in search of food. MONTEIRO-FILHO (1995) also showed that *S. guianensis* in the Cananéia Estuary, São Paulo (Brazil) forages in the presence of *currais*. Similarly, LODI & HETZEL (1998) suggested that large gatherings of *S. guianensis* in Ilha Grande Bay at Rio de Janeiro (Brazil) were common and were related to feeding, resting and social activities. EDWARDS & SCHNELL (2001) found that feeding was the predominant activity of *S. guianensis* in the Cayos Misikito Reserve (Nicaragua) and that their distribution was related to the availability of food.

A study in Ceará, northern Brazil (OLIVEIRA et al. 1995) showed that dolphin abundance was greatest between January and June and tended to decrease during the rest of the year. These authors cited the greater abundance of fish during this period as the explanation for the greater abundance of *S. guianensis*. HAYES (unpubl.), in a later survey of the same location, found that the abundance of *S. guianensis* was greatest in March. However, HAYES's (unpubl.) study took place between March and June 1998 and the abundance of *S. guianensis* during the rest of the year was not quantified.

Based on our observations, we estimate that approximately 150 individuals of *S. guianensis* are present in the Emboraí Bay. Observations show that on each visit usually not more than 100 individuals were seen and these may represent repeat sightings of many individuals. In comparison with populations in other regions, the Emboraí Bay population of *S. guianensis* is relatively large. For example, although EDWARDS & SCHNELL (2001) sighted 536 individuals over two years in the Cayos Miskito Reserve, the estimated population size was only 49 dolphins. LODI & HETZEL (1998) recorded the largest known groups of *S. guianensis* which ranged from 150 to 450 individuals in Ilha Grande Bay. Mean numbers of individuals observed by GEISE (1991) in two study periods in 1984 and 1988 in Guanabara Bay at Rio de Janeiro were 417.9 and 398 individuals, respectively. In another study in Guanabara Bay, ANDRADE et al. (1986) recorded 1123 individuals in 186 groups.

The dolphins do not appear to be negatively affected by fishing or other activities carried out by the human population in the Emboraí Bay. One of the reasons for this is

the use of the traditional *curral* for fishing which does not appear to present any danger to the dolphins, and because large monofilament nets are prohibited in the Emboraí Bay. MONTEIRO-FILHO (1995) reports fishermen from the Cananéia Estuary releasing young dolphins from the *curral* after having foraged there. Another reason for the lack of threats to dolphins is that there are very few permanent inhabitants in the Emboraí Bay. Most are fishermen that live for relatively short periods in *ranchos* (temporary dwellings raised above the sea on wooden poles and roofed with palm leaves). LODI & HETZEL (1998) found *S. guianensis* following shrimp-fishing boats around Rio de Janeiro and feeding on the bycatch, demonstrating a positive effect of fishing activities on the dolphin population. Mutual benefits for both dolphins and fishermen have been recorded during fishing activity in southern Paraná, Brazil by MONTEIRO-FILHO et al. (1999). However, the same study showed that negative interactions may also occur, such as when fishing boats chase the dolphins. Between 1997 and 1999, ROSAS (2000) found that 45 individuals of *S. guinanensis* had been accidentally caught during artisanal fishing activities along the coast of Paraná. Surface gill nets (10 cm mesh) and deeper nets (18-20 cm mesh) were responsible for 54.5 and 33.3 % of the accidental catches, respectively (ROSAS 2000). However, the author cautions against dismissing the number accidentally captured as insignificant for the following reasons: the number may be sub-estimated, the reproductive rate of *S. guianensis* is low and the total population size along the Paraná coast is unknown. Another study in Paraná has shown that although accidental captures do occur, the dolphins are not viewed as competitors because they help drive fish into the nets and fishermen even try to attract dolphins by whistling or making noise (PRZBYLSKI & MONTEIRO-FILHO 2001).

In the Emboraí Bay, fishermen have suggested that the dolphins may also help with the fishing effort since, during feeding, they may drive shoals of fish against the walls of the *curral* and some of these fish eventually enter the central trap where they can be collected at low tide by the fishermen (A. ROSÁRIO, pers. comm.). MONTEIRO-FILHO (1995) described in detail different fishing techniques used by *S. guianensis* near *currais* in the Cananéia Estuary. One of these activities is identical to that described by fishermen in the Emboraí Bay in which a dolphin pursues the fish towards the wall of the curral. The dolphin may catch fish close to the wall and, although some escape, many enter the trap at the end of the wall where they may be later retrieved by fishermen. In Rio de Janeiro, *S. guianensis* was observed feeding near *currais* but no mention was made of their possible impact on the capture of fish in the *curral* (ANDRADE et al. 1986). Studies of the diet of *S. guianensis* in the coastal region around the Amazon estuary has shown that these dolphins are highly opportunistic feeders and seasonal variation in certain food items does not seem to affect feeding as other items can be utilised (PANTOJA unpubl.) and the dolphins in her study appear to feed as much on the sea floor as in mid-water.

Feeding was the only activity at low tide in the Emboraí Bay and, according to OLIVEIRA et al. (1995) and MONTEIRO-NETO et al. (1996), feeding during the ebbing tide is explained by the increasing density of fish at this stage in the tidal cycle, as the volume of water lowers. In the state of Rio Grande do Norte (Brazil) numbers of *S. guianensis* increase during the ebbing tide (ARAÚJO & SOUTO 1998). Similarly, HAYES (unpubl.) and OLIVEIRA et al. (1995) recorded the greatest abundance of *S. guianensis* in Ceará between the ebbing tide and low tide. In the absence of waves, the dolphins were more abundant and this was probably due to the fact that, when the sea

is calm, visual observations of dolphin numbers are easier to make.

Social interactions among dolphins during foraging were commonly observed in the Emboraí Bay. In other studies, activities including leaping, tail-splashing (HAYES unpubl.) and even kleptoparasitism (LODI & HETZEL 1998) were observed during feeding. Although noted by other authors (ANDRADE et al. 1986; MONTEIRO-FILHO 1992; LODI & HETZEL 1998), interactions between dolphins, birds or other animals were not observed in this study, despite the presence of seagulls and terns in the Emboraí Bay.

Our observations of dolphin numbers, movements and behaviour over a period of two and a half years, suggest a repeating pattern of use of the Emboraí Bay. During the ebbing tide, large numbers of dolphins enter the bay and begin to feed in sub-areas I and II. At low tide the dolphins appear to be spread around the bay and feeding is the only activity observed. With the rising tide the dolphins continue feeding and afterwards leave the bay in large numbers. During high tide, some dolphins remain foraging. A similar pattern was observed by SICILIANO et al. (1987) in a study in Guanabara Bay at Rio de Janeiro, in which dolphins were seen to enter the bay to feed and afterwards leave in the direction of the ocean. Outside the area of the bay, the destination and behaviour of these dolphins and those of the Emboraí Bay are unknown. Most observations of dolphin behaviour are purely visual and cannot take into account more complex interactions based on vocalizations. A long-term study by MONTEIRO-FILHO & MONTEIRO (2001) has shown that vocalizations are associated with different activities and social structure. For example, calls are emitted about 5 % of the time when dolphins are travelling but this increases to 95 % of the time during fishing activities, especially when fishing in schools, when a high degree of communication is necessary (MONTEIRO-FILHO & MONTEIRO 2001).

The group size category most commonly observed was small group (4-10 ind.), however pairs and individuals were relatively common. Similarly, MONTEIRO-NETO et al. (1996) found the small group to be the most frequently observed category. MONTEIRO-FILHO (2000) found the family unit, all combinations of male, female and calf, to be the most frequently observed group in Cananéia Estuary. SICILIANO et al. (1987), in their study of *S. guianensis* in Guanabara Bay, found that the couple/pair was the most frequently observed category and that small groups were observed travelling across the bay whereas large groups were seen engaged in fishing activities. GEISE (1991) noted that the most common group size was 2 individuals and that individuals or groups of 2-5 animals are more common when dolphins are travelling. In contrast, groups of 6 or more individuals were commonly seen when dolphins were feeding (GEISE 1991). EDWARDS & SCHNELL (2001) recorded a mean group size of three individuals in the Cayos Miskito Reserve (Nicaragua).

The lack of observations of sexual behaviour leads us to believe that the Emboraí Bay is used exclusively for feeding. Similarly, ANDRADE et al. (1986) did not observe sexual behaviour but the presence of infants and young was noted throughout their study. In the Emboraí Bay, infant dolphins were easily identified, usually by their small size and proximity to an adult (assumed to be the mother). The large number of infants and young dolphins found during this study is a remarkably positive feature and indicates that the population is reproducing and that survival of new-borns is high. In Ceará, a reduction in numbers of dolphins was noted and has been attributed to fishing activities (MONTEIRO-NETO et al. 1996; HAYES unpubl.). If the current environmental

conditions and levels of human activity remain unchanged in the Emboraí Bay, the prospects for the survival of the population of *S. guianensis* are very good indeed.

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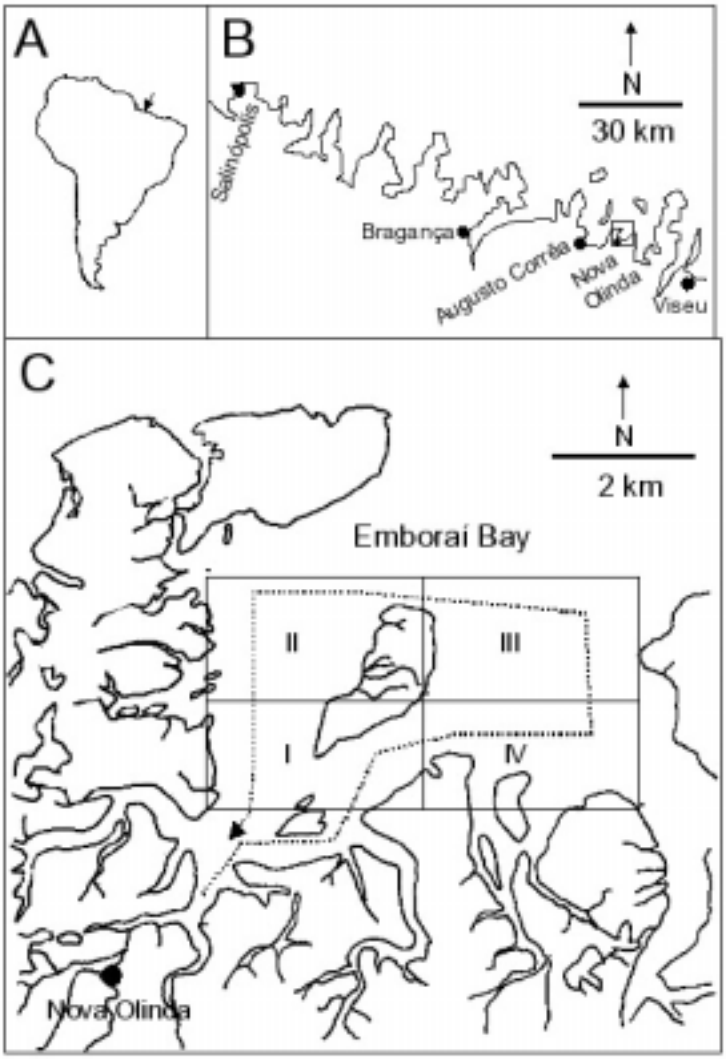

Fig. 1:
Map showing (**A**, **B**) the location of the Emboraí Bay on the northeastern coast of Pará State, and (**C**) the sub-areas and survey route (dotted line) used in the study.

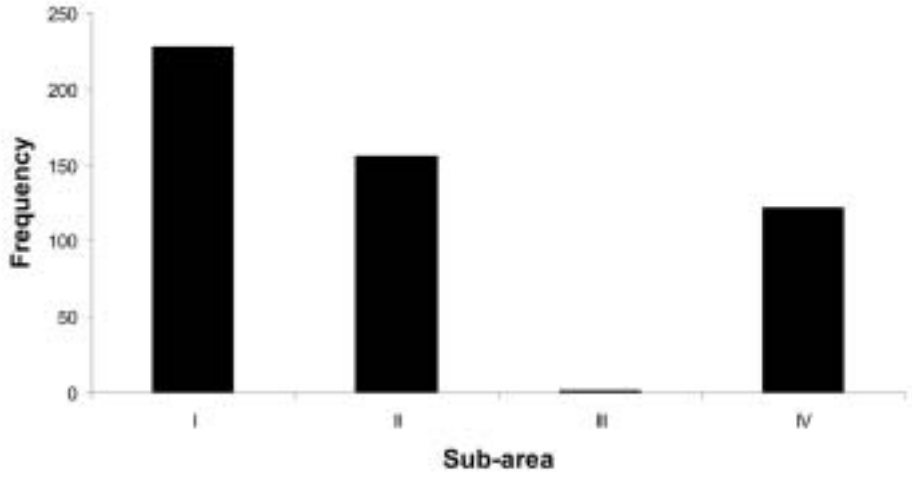

Fig. 2:
Total number of dolphins *S. guianensis* observed in each sub-area (I-IV) in the Emboraí Bay.

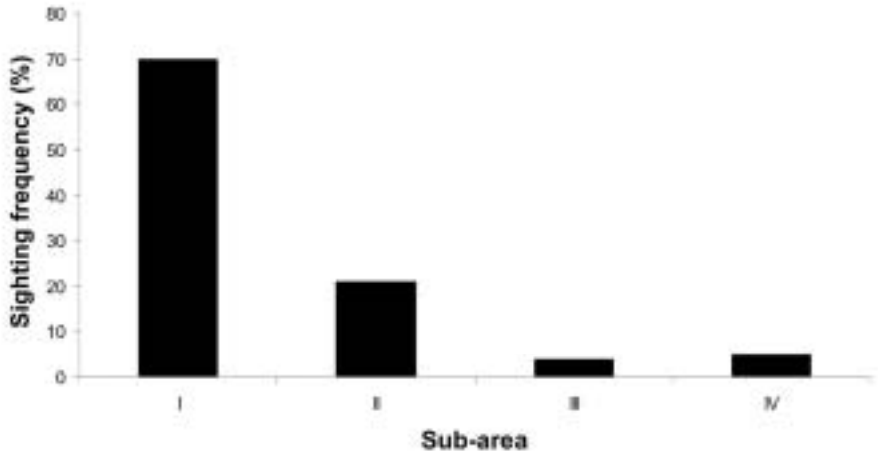

Fig. 3:
Sighting frequency of dolphins *S. guianensis* in each sub-area (I-IV) in the Emboraí Bay.

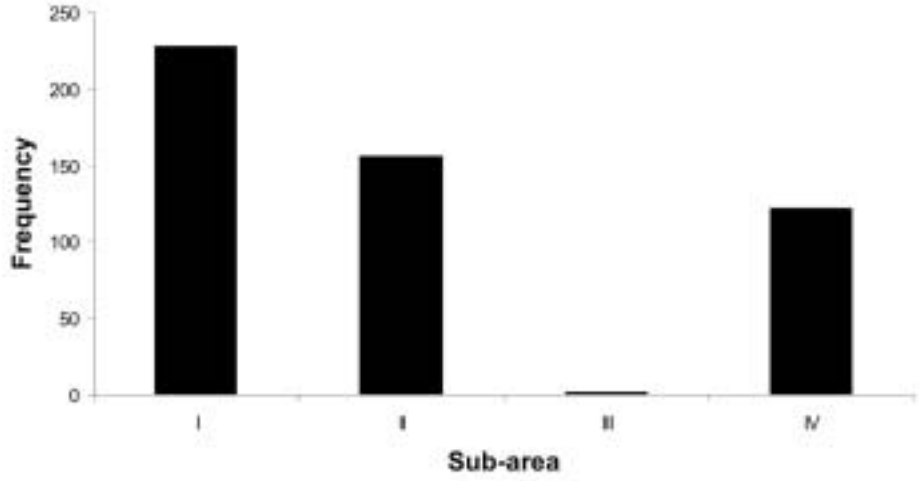

Fig. 4:
Overall frequency of dolphins *S. guianensis* in relation to the four tidal states.

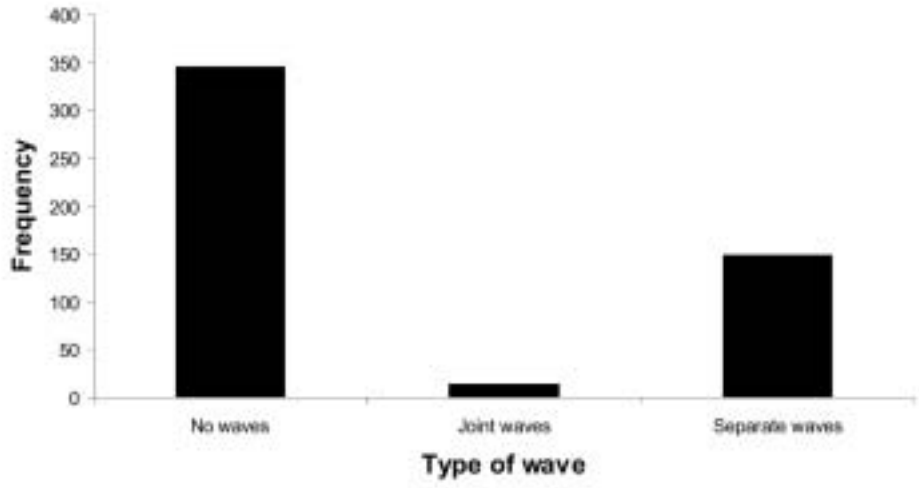

Fig. 5:
Overall frequency of dolphins *S. guianensis* in relation to the three wave types.

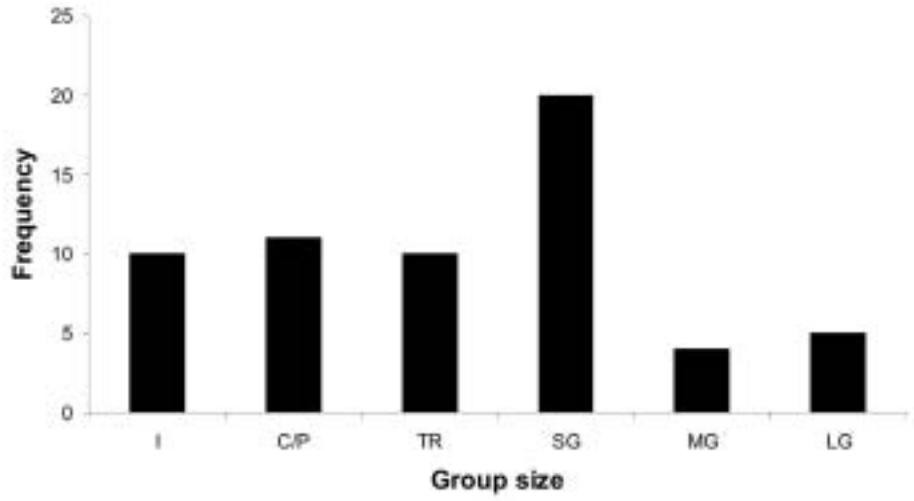

Fig. 6:
Group size frequency distribution of *S. guianensis* in the Emboraí Bay.

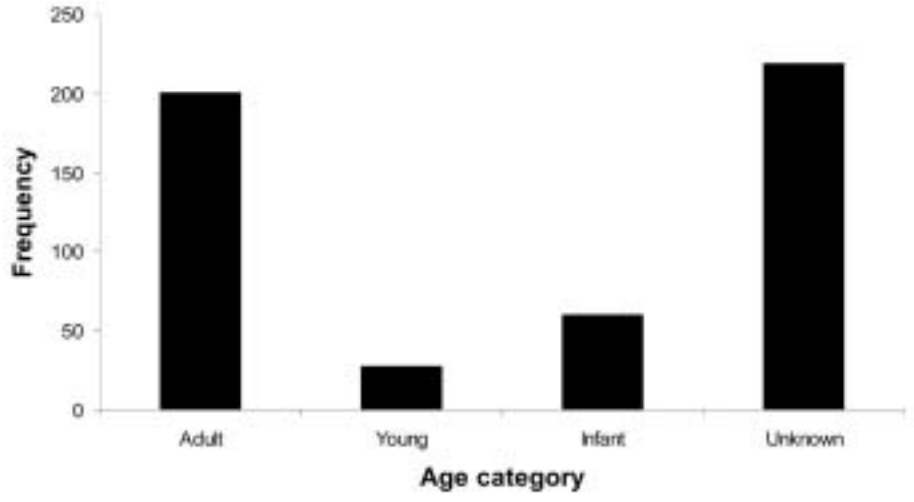

Fig. 7:
Age frequency distribution of *S. guianensis* in the Emboraí Bay.