THE INFLUENCE OF BOATS TRAFFIC ON *Sotalia guianensis* COMMUNICATION AT BABITONGA BAY, SC, BRAZIL

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Abstract - This work aimed to investigate changes in *Sotalia guianensis* communication patterns caused by boats traffic noise at Babitonga Bay estuary in São Francisco do Sul. The records were done during 2003 and 2005, with the hydrophone placed between 2 and 4m deep. The maximum distance from the animals was of 50m for the recordings, and the engine was turned off. The whistles were separated in segments taking into consideration the segments before, during and after the embarkation crossing. The whistles were quantified and classified according to its types, using the software Avisoft SASLab Pro 4.1. It was established the initial, final, maximum and minimum frequencies and the whistles duration, as well as the maximum and minimum engine frequencies. There were examined 330 whistles and 45 engine records. It was observed that 10 % of the whistles were sent before the embarkation passage; 56 % during and 33 after its passage. The amplitude of the dolphin whistles presented the tendency to reduce during the embarkations passage. The results indicate that the sonic frequency given out by the embarkations engines can induce the *S. guianensis* to increase the quantity of their whistles emission during the embarkations passage.

Keywords: boats traffic, *Sotalia guianensis*, whistle, communication, noise impact.

Introduction

Marine mammals create sounds to communicate each other in the presence of danger, food, other animals, and about their own positioning, identity and territorial or breeding status. When grouped, they produce different types of sounds, with different physical properties, being the whistles the most frequent ones (Richardson et al., 1995).
Besides the natural sources of noise, the marine mammals live more and more together with noises produced by human activities (NRC, 2003). Many human activities produce sounds and one of the main source into the water are the small size boats, as fishing boats, equipped with engines of 3 to 60 Hp (Richardson et al., 1995). The consequence of the human activity impacts along the coast have grown during the last years and the tendency is to increase further. The level of noise coming from the boats traffic can cause strong acoustic impact on the cetacean (NRC, 2003). Noise impacts were reported too for other vertebrate species, like fishes (Picciulin et al. 2005; Sebastianutto et al., 2005; Yan, 2005).

This research analyzed changes in *Sotalia guianensis* whistle patterns caused by boat traffic noise at Babitonga Bay. *S. guianensis*, one of the smallest members of the Delphinidae, is a South American dolphin specimen. At Babitonga Bay (Santa Catarina's northern shore), the specimen occurs along the year, and the population show a significative fidelity to this area (Cremer, 2002; Hardt, 2005).

Study area
Babitonga bay that is the most important estuary in northern Santa Catarina State, located between the geographic coordinates of 26º02'-26º28'S and 48º28'- 48º50'W. It represents a surface area of 160 km2 with an average depth of 6m. It stays sheltered against the waves having calm and tepid water (Ibama, 1998). There it can be found one of the greatest mangrove areas of the southern South America (Fatma, 2002). The area shelters São Francisco do Sul harbor, having an intense tourist and fishing activities too (Ibama, 1998). Therefore, the boat traffic is very intense and represents a potential threat to cetacean populations that live in this area.

Materials and methods
Recordings of *S. guianensis* sounds and of the boats passing through Babitonga bay were made between May 2003 and July 2005. The samplings were done using a boat 5.5 m long equipped with a 60 Hp outboard motor. *S. guianensis* concentration areas in Babitonga bay were searched, so as identified in former studies (Cremer, 2000). The departures for search were done under favorable weather conditions with the sea under Beaufort 2. At each encounter with a dolphin group a C-53 hydrophone, from Cetacean Research Technology (frequency response from 15Hz to 60kHz, and from 100 kHz to 250 kHz) was deployed at 2 to 4m depth and connected to a Sony TCD-5M analog audio tape recorder (frequency response between 20 Hz and 19 kHz). The recordings were done with the boat engine turned off and distant no longer than 50m from the animals. For each session there were registered time, point location (GPS), and the boats presence or not.

The tapes were initially selected for the identification of those containing registers of boat noise interference. Afterward, the acoustic recordings were digitized and spectrograms were generated using Avisoft-SAS Lab Pro, version 4.1 for Windows, software (sampling at 44.1 kHz, 16 bits, FFT size: 512, Hamming window). Categories of 10 minutes before, during and after a boat passage were selected for analysis. When the time interval between two consecutive boat passages was less than 10 min were not analyzed. The upper range of our measurements was 19 kHz, based on the frequency response of the recorder. Whistles exhibiting frequencies above 19 kHz were excluded because the acoustic parameters could be distorted. Whistles exhibiting poor quality were excluded too.

The selected whistles were classified according to the categories defined by Kulevicz (2005): Type I – simple ascending; Type II – simple descending; Type III – modulated; Type IV – concave; Type V – convex; Type VI – regular. The following parameters were measured, according to the type, for each whistle: initial frequency, final frequency, maximum frequency, minimum frequency (in kHz) and duration (in miliseconds). The boats sounds frequency was measured too (maximum and minimum, kHz). Variance analysis was made using the ANOVA test (Statistica 5.0 software).

Results
A total of 4.5 hours of tape registers were analyzed, containing 45 engine sounds and 700 whistles; just 330 whistles (47.14%) were analyzed. From that, 10% (n = 33) were

emitted before, 56.96% (n = 188) during, and 33.03 % (n = 109) after the boats passage. The average sound frequency of motorboats was 5.18 kHz (± 3.25). Simple ascending type whistles (Type I) were the most frequent in all the categories, having appeared in 62.42 % (n = 206) of the registers.

The ANOVA results for Type I whistles showed that the initial frequency average tend to increase during the boats passage, diminishing afterwards ($F_{2,203} = 1394.32$; $p<0.05$) (Figure 2). The whistles duration tend to increase during the boats passage, remaining long in the after category ($F_{2,203} = 90.36$; $p<0.05$) (Figure 3).
The minimum frequencies average of Type III whistles showed a tendency to increase during the boats passage, remaining at this same frequency afterwards ($F_{2,57} = 248.10$; $p<0.05$). The same tendency was observed for the maximum frequencies average ($F_{2,57} = 272,31$; $p<0,05$). Whistles duration were prone to reduce during and after the motorboats presence ($F_{2,57} = 87.54$; $p<0.05$).

The initial frequencies average of Type IV whistles had the tendency to increase during the boats passage. For the after category the initial frequencies tended to reduce, showing lower values than in the before category ($F_{2,46} = 372,28$; $p<0,05$). The minimum frequencies showed the tendency to turn down after the boats passage ($F_{2,46} = 290.18$; $p<0.05$). The analysis of duration showed the tendency of whistles to be longer after the boats passage ($F_{2,46} = 228.51$; $p<0.05$).

The initial frequencies of Type VI whistles tended to reduce during the boats passage ($F_{2,4} = 2086.22$; $p<0.05$). The analysis of the whistles duration detected that they tended to be longer during the boats passage and shorter afterwards ($F_{2,4} = 8.00$; $p<0.05$).
For Type II and Type V whistles there were few records to conduct an analysis.
Considering the whistles amplitude (difference between the maximum and minimum frequencies), the results showed that *S. guianensis* tended to reduce the amplitude during boat passage. Before its passage, the average amplitude frequency of the whistles was 5.26 kHz and during the embarkation passage it changed to 4.67 kHz.

Discussion
The results indicated that, within the evaluated parameters, significative changes on *S. guianensis* vocalization patterns occurred in the presence of motorboats. Babitonga bay population presents a tendency to change some characteristics (initial and final frequencies, minimum and maximum frequencies, and duration). It was also observed that the boats produced noise frequencies that overlap the frequency range of some whistles emitted by the specimen.

The observations indicated that the number of whistles emissions increased during and after the passage. Nevertheless, this number may be influenced by the quantity of individuals in the recorded group, and the activity that was being made at the recording time (Monteiro-Filho, 2000; Azevedo and Simão, 2002).

According to Erber and Simão (2004), *S. guianensis* whistles at Sepetiba bay presents the minimum and maximum frequencies average was of 10.52 kHz and 13.31 kHz, respectively. This result suggests that the dolphins of Babitonga's Bay vocalize in higher frequencies (maximum frequency average of 15.01 kHz before boats passage). This difference may be associated to habitat characteristics, like noise frequency and energy variations. The number and type of boats moving through the area (like cargo ships, fishing boats, launches and schooner) can also influence the song patterns of the populations.

In the study conducted by Rezende (2000) with *S. guianensis* in Cananéia, Brazil, it was observed that the boats interference depend on both the displacement velocity and the frequency spectrum reached by its engines. Adversely of what was observed at Babitonga bay the studied animals of Cananéia presented the tendency to reduce their signals emission rates during the embarkations passage. In the same study there are data of acoustic side-stepping and behavioral side-stepping. These studies indicated that the acoustic-behavioral changes of this species are closely connected to boat presence, that emit signals in the same frequency range and with the same energy as well their displacement velocities.

Gonçalves (2003), studying *S. guianensis* in Cananéia estuary too, compared the sounds emitted by the dolphins in the presence of diesel and gas powered boats. It was observed that the frequency produced by diesel boats has less interference in the whistle frequency of *S. guianensis* (that is frequently over than 6 kHz) when compared to the gas powered engine boats.These results fulfill the current study since in both cases there are changes of the specie acoustic behavior that can bring short and long term consequences to the animals. Though the boat traffic at Babitonga bay is intense, in most cases there are momentary disturbances during the boat passage.

These changes in the dolphin's communication patterns can influence the group activities. It is believed that there happens a negative consequence for any situation where the behavioral pattern changes. Since the whistles are sounds of social communication, the change of their patterns can interfere on the effectiveness of this communication, whether it being for fishing strategy, group cohesion or breeding (Richardson et al., 1995; Tyack, 1999; Acevedo-Gutiérrez and Stienesses, 2004). It is important to emphasize the increase in the quantity of whistles emitted during the boat passage, since this result can strengthen the importance of this type of sound in the communication among the individuals of the group. This increase could be assigned to an alert emitted by the animals because of boat presence. Regarding to the ecologic approach, this change in the acoustic pattern can be revealing a stress caused by the sound disturbance over this population, requiring higher energy consumption during the whistles emission.
According to these results it can be noticed that the boat noise, in most cases, interfere in the acoustic behavior of *Sotalia guianensis* at Babitonga bay. To better understand how the nautical activities interfere on cetacean's communication, it is suggested that future studies target the analysis of different engine types and the effect of distance from the source. Cetacean communication patterns are not still well-known. Future studies about cetacean sound, in different geographic regions, are very important for a better understanding about the dolphins' acoustic behavior and the impacts of human noise impact.

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