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ORIGINAL PAPER

# Behavior of estuarine dolphin, *Sotalia guianensis* (Cetacea, Delphinidae), in controlled boat traffic situation at southern coast of Rio Grande do Norte, Brazil

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**Abstract** Dolphin/whale watching activity represents the major source of income to many local communities, however many studies describe negative effects of this activity on animals' normal behavior. In this paper we describe a behavioral analysis of estuarine dolphins (*Sotalia guianensis*), proximity pattern and breathing synchrony during the first year after the delimitation of a coastal reserve and enforcement of rules to control boat traffic at southern Rio Grande do Norte (Brazil). Different from studies conducted before the delimitation of the coastal reserve, our results show that forage behavior did not decrease and overall activity budget did not change in the presence of boats, although animals would still increase proximity and breathing synchrony during the first semester. We conclude that simple rules for control of boat traffic are effective in minimizing the short term negative impacts on dolphins. However, the enforcement of common rules is a difficult compromise between community needs and vulnerability of dolphin populations.

**Keywords** Activity budget · Dolphin watching · Ecotourism · Estuarine dolphin · *Sotalia guianensis*

Dolphins and whales watching tourism industry has grown considerably over the last 40 years and is currently present in at least 87 countries (Hoyt 2001). According to this author, this industry stimulates a monetary circulation of about one billion dollars a year, composing the major economic activity of many communities throughout the world. Benefits

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related to whale/dolphin watching include economical growth, infra-structure improvements of many local communities (Duffus and Dearden 1993; Hoyt 2001), opportunities for environmental education and changes of predatory attitudes toward the animals (Orams 1995). However, scientific studies regarding the direct and indirect and short and long term impacts on the animals are not growing at the same pace (Constantine et al. 2004). Conservation of animals and the environment were they live while keeping economical and educational benefits of this industry, is one of the greatest challenges to biologists and local politicians (Giannecchini 1993).

Direct short term effects (such as physical injuries) are easier to identify and register. Indirect short term effects (e.g. effects of noise or habitat disturbance on daily feeding success) and indirect long term effects (e.g. effect of noise or visual pollution on reproductive patterns) are harder to discern (Nowacek et al. 2001). Previous researches have documented a series of changes in behavioral patterns (both in sequences of behavior or in overall activity budget), changes in cohesion among individuals and changes in breathing synchrony as a consequence of boat traffic in areas occupied by dolphins. Most common effects of boats on dolphins are: avoidance of boats (Watkins 1986; Janik and Thompson 1996; Moore and Clarke 2002), increase in swimming speed (Nowacek et al. 2001; Moore and Clarke 2002; Jahoda et al. 2003), changes in swimming direction (Nowacek et al. 2001; Lemon et al. 2006), changes in group composition (Bejder et al. 1999), decrease in inter-individual distances (Nowacek et al. 2001), changes in individual breathing intervals (Janik and Thompson 1996; Jahoda et al. 2003), changes in vocalizations types (Lesage et al. 1999), and changes in breathing synchrony (Hastie et al. 2003).

These studies propose the control of number and speed of boats as a solution to minimize the impacts on animals. However, no study was conducted to verify whether the control of boat traffic resulted in a return to the behavioral and proximity pattern of animals (i.e. similar to the periods without the presence of boats).

The estuarine or grey dolphin, Sotalia *guianensis* Monteiro-Filho et al. (2002), is the commonest dolphin in Brazilian shallow waters, occupying protected bays near river mouths. Although the Brazilian federal agency for defense and protection of natural resources classifies the estuarine dolphin as a "data deficient" species (IBAMA 2001), *Sotalia* is the aquatic mammal better studied on the Brazilian coast and researchers are requesting a change in this classification.

The proximity to the coast makes this species vulnerable to anthropic impacts, but also a tourism attraction. Some studies have measured the impacts of boats on this species. Keinert (2006) studying estuarine dolphins at Cananéia (southeast Brazil) found that animals changed the frequency and intensity of their vocalizations in response to the presence of boats. Pereira et al. (2007) in a study conducted at Baía Norte, Santa Catarina, found that dolphins' reactions changed from negative to neutral along a 10 years period.

Rio Grande do Norte State (RN), extreme northeastern Brazil, is the state with a great increase in "beach and sun" tourism over the last 10 years (Embratur 2006). The southern coast of RN is characterized by zeta bays near river mouths where three areas of occurrence of estuarine dolphins were mapped: Tabatinga bay, Pipa bay and Baía Formosa Bay. Pipa bay, at Tibau do Sul municipality, is an international tourism destiny, with an increasing number of hotels and second houses buildings, and tourism boat traffic. Previous studies on this area detected major changes in dolphins′ behavior during the presence of dolphin watching boats. Carrera (2004) noted a decrease in foraging success during the presence of boats relative to the periods before the arrival and after the departure of boats. Valle and Melo (2006) noted that individuals would come close together during the approach of boats, with a concomitant increase in breathing synchrony. However,Santos Jr et al. (2006) noted behavioral

changes only when dolphins' groups contained two infants or more, but no behavioral change was detected when only adults or groups with only one infant was present in the area.

Ferreira et al. (2005) by doing an overall analysis of four years data proposed the delimitation of a Coastal Reserve on this area, in order to control the number and speed of dolphin watching boats. In accordance to International laws (IBAMA 1996, portaria n°117), from 17 February 2006, only two dolphin watching boats could simultaneously visit the bay, proximity to the dolphins was restricted to a minimum of 50 m and speed was limited to 2 knots. The aim of this paper is to present an analysis of the behavioral, proximity and breathing synchronism patterns of Pipa's bay dolphins during the period after the creation of the municipal reserve. It is hypothesized that if control of boat traffic is successful, then the behavioral changes observed in previous studies shall not be statistically detectable.

## Methodology

### Study areas

The study was conducted on two contiguous areas (Madeiro beach and Curral beach) that together compose the Pipa bay area (6°13′21.16′′ S 35°04′15.91′′ W), located at southern Rio Grande do Norte coast (Fig. 1). Pipa Bay presents a gradually shelving sea-bed, alternately rocky and sandy, with an average depth of 6 m. The bay is encircled by cliffs approximately 30 m in height, having sandy beaches which are heavily strewn in places with beachrocks, forming bays which are sheltered from the prevailing trade wind and ocean currents. Curral area has the remnants of an antique artisanal fishery area, and Madeiro area is frequented by tourists and surfing practitioners.

### Data collection

Direct observations were conducted from a land base (on the cliff side, 25 m high) located at Madeiro and Curral areas, with binoculars (Bushnell 10 × 50), a digital clock, and two specific registers protocols, one for activity budget and another for proximity among individuals and breathing synchrony.

Daily observations lasted for 6 h, during the period of February to December 2006. Accompaniment of dolphins occurred only during dry periods, with no data collections conducted on June, July and August, period of heavy rains.

Although only 5 individuals are identified by natural marks (a photo-id catalog is currently being built), we counted animals based on: size/color, spatial position and intervals of surfacings to breath. Calculated intervals between breathings were of from 24 to 31.48 s for adults and from13 to 23.85 s for immatures (Valle and Melo 2006; Garri 2006). Thus, surfacings occurring in short time intervals (less than 10 s) at the same area or surfacings at slightly longer intervals (20 s) but at distant areas (more than 200 m) were considered as performed by different individuals.

In Pipa bay few individuals used the area simultaneously (in more the 90% of the scans 5 or less individuals used the bay simultaneously). Besides these individuals tend to remain apart (see data below). We, therefore, used two methods of data collection: (i) scan sampling (Altmann 1974; Lehner 1986, pp 205–206) at 2-min intervals for registering the distance among individuals and presence of boats within the bay; (ii) Predominant Activity Sampling (Mann and Smuts 1999) for registering the behavioral state of each dolphin and the occurrence of synchronous breathing. We used the category "unknown" to indicate the

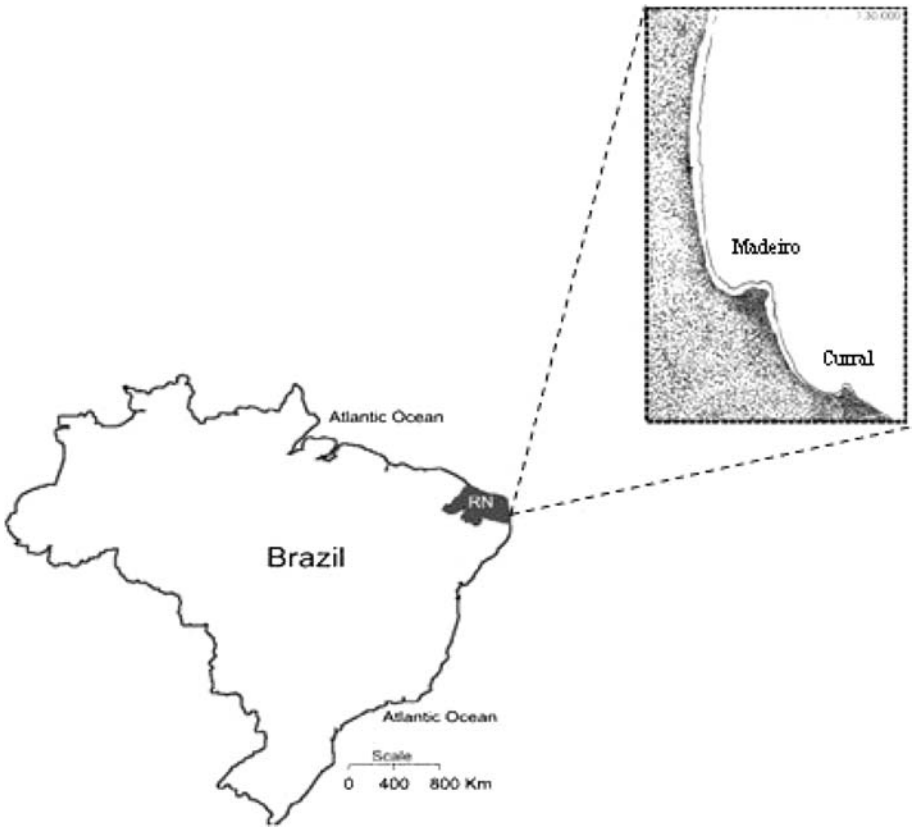


**Fig. 1** Localization of study area: Pipa bay (Curral and Madeiro beach)

sampling intervals when observer was doubtful about the behavioral state of the dolphins. These registers were excluded from analyses.

Behavioral categories used in this work were adapted from many authors, and classified as: 1-Travel: swimming characterized by a uniform directional movement resulting on the change of animals' position from one area to another. It can occurs in different speeds; 2-social behavior: high level activity of the dolphins, where they remain longer on the surface and indulged in intense physical contact (cf. Balance 1992; Mann and Smuts 1999; Lusseau 2003); 3-rest: characterized by a pronounced diminution in one level of activity and very slow rate of swimming, without defined direction (cf. Würsig and Würsig 1980; Gnone et al. 2001; Constantine et al. 2004; Lusseau 2003); 4-Forage: Involved variable directional movement, periodically interrupted by events of persecution and lunges towards a prey. This may or may not result in a successful catch of prey (cf. Norris and Dohl 1980).

Registers of distance between individuals were classified on four categories: at a maximum distance of 20 m, at a maximum distance of 40 m, at a maximum distance of 80 m and above 80 m, regardless of the occurrence of synchrony between individuals.

Breathing synchrony was defined as the breathing surface of two or more individuals at the same moment or within 3 s apart (Hastie et al. 2003). To be considered synchronic at least two breathing surfaces had to occur in sequence. Only one breathing surfacing was considered as a chance event.

At each register interval it was noted the presence of boats, and the moment of entry and departure of bay. Two types of boats circulate on the area (launches with motors of 25 HP and large boats with motors MWM-6).

Data analyses

Data were divided in two periods: before (February to May) and after the rains (September to December). A daily time budget was calculated by dividing the total number of register entries on each behavior category by the total number of register entries each day. The mean of these daily proportions represents the overall activity budget of the animals during each period.

Daily proximity index was calculated by dividing the number of dolphins present in each distance category by the total number of dolphins present within the bay, at each register interval. Daily breathing synchrony index was calculated by dividing the number of individuals in breathing synchrony by the total number of individuals within the bay at each register interval.

To verify the influence of boat traffic these daily indexes (time budget, proximity and breathing synchrony) were calculated separating the registers with the presence and without the presence of boats within the bay.

Data were analyzed using SPSS 10.0. When data were normally distributed T paired test was used, otherwise, Wilcoxon test for related samples was used. Significance value was set to 5% ($P \leq 0.05$) (Zar 1996).

## Results

A total of 76 days of field effort and 70 days of effective data collection was accomplished, resulting in a total of 414.9 h of field effort and 197.12 h (47.5% success) of effective data collection. From these, 222.2 h of field effort or 88.66 h of effective data collection (39.9% success) occurred during the period 1 (before the rains), and 192.7 h of field effort and 110.46 h of effective data collection (57.3% success) on period 2 (after the rains).

Time budget

*Period 1*

Although travel and social behaviors increased and rest and forage behaviors decreased on the presence of boats, these differences were not statistically significant: Travel ($t = -1{,}319$; $n = 27$; $P = 0.199$), Social ($z = -0.087$; $n = 27$; $P = 0.931$), Rest ($z = -1.161$; $n = 27$; $P = 0.245$) and Forage ($t = 1.254$; $n = 27$; $P = 0.221$) (Fig. 2a).

*Period 2*

Again no statistical differences were found on the mean daily proportions of each behavioral category on the presence or absence of tourism boats within the bays: Travel ($t = -0.238$; $n = 29$; $P = 0.813$), Social ($z = -0.229$; $n = 29$; $P = 0.819$), Rest ($z = -1.537$; $n = 29$; $P = 0.124$) and Forage ($t = -0.425$; $n = 29$; $P = 0.674$) (Fig. 2b).

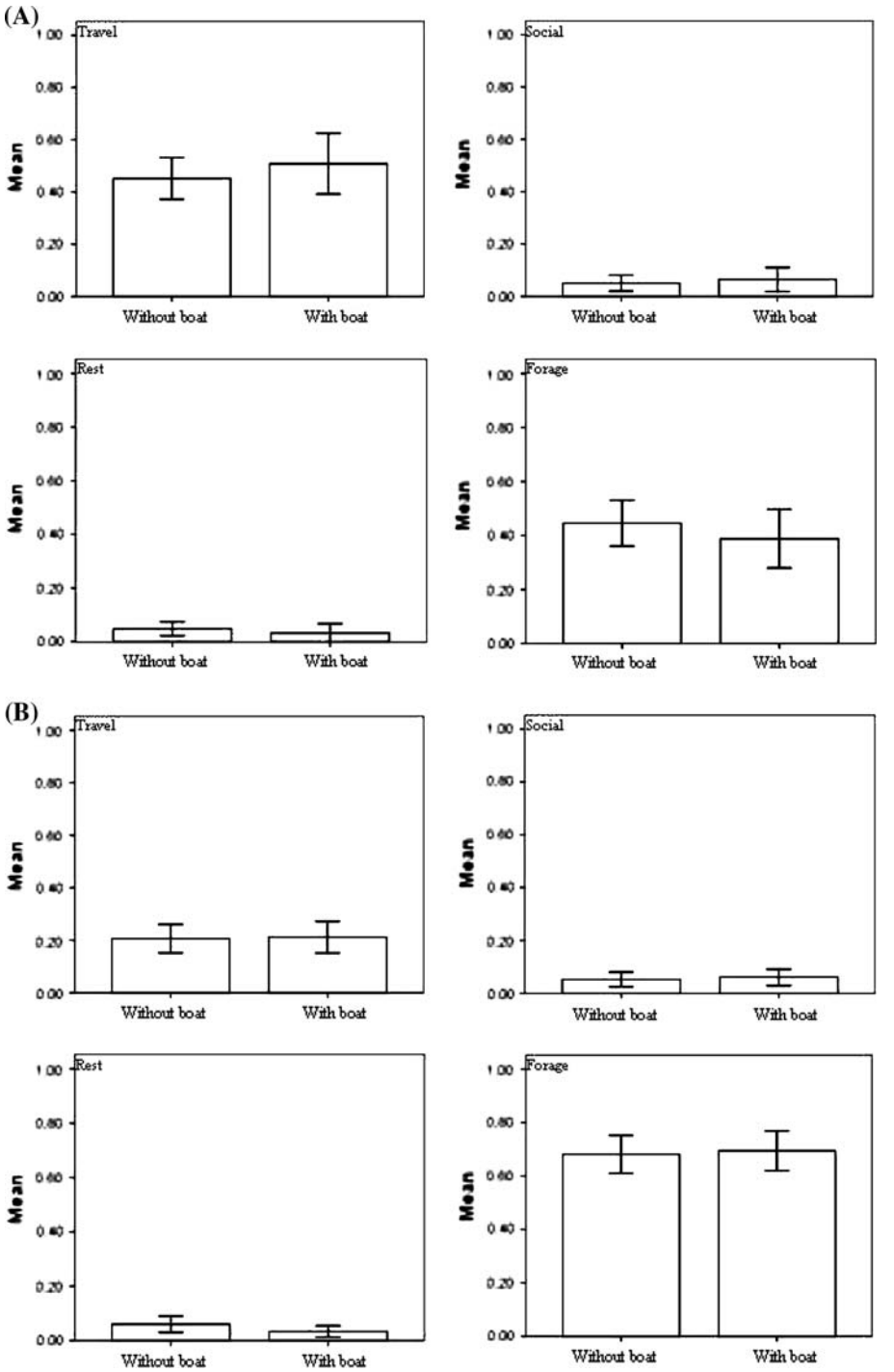


**Fig. 2** Mean daily proportion of behavioral states, with and without the presence of boats within the bay. (**a**) period 1: before the rains; (**b**) period 2: after the rains

Proximity among dolphins

*Period 1*

During this first period, dolphins increased proximity during the presence of tourism boats. This increase in proximity was significant at all distance categories: up to 20 m ($t = -1.984$; $n = 27$; $P = 0.058$), up to 40 m ($z = -2.691$; $n = 27$; $P = 0.007$) and up to 80 m ($z = -2.103$; $n = 27$; $P = 0.035$) (Fig. 3a).

*Period 2*

Different from the first period, on the period after the rains no significant increase in proximity among the individuals during the moment with boats relative to the moments without boats was found: up to 20 m ($t = -0.073$; $n = 28$; $P = 0.942$), up to 40 m ($t = -0,786$; $n = 28$; $P = 0.439$) and up to 80 m ($t = -1.544$; $n = 28$; $P = 0.134$) (Fig. 3b).

Breathing synchrony

*Period 1*

Dolphins increased breathing synchrony during the moments with boats. However, this increase was only observed when dolphins were in Travel behavior and a boat entered the bay ($t = -2.241$; $n = 25$; $P = 0.035$). When individuals were in another behavioral state and boats entered the bay, no increase in breathing synchrony was observed: Social ($z = -1.604$; $n = 8$; $P = 0.109$), Rest ($z = 0.000$; $n = 6$; $P = 1.00$) and Forage ($t = -0.475$; $n = 21$; $P = 0.640$; Fig. 4a).

*Period 2*

On periods after the rains no increase in breathing synchrony was observed during the presence of tourism boats relative to the moments without the presence of boats: Travel ($t = 0.743$; $n = 24$; $P = 0.465$), Social ($z = -0.141$; $n = 12$; $P = 0.888$), Rest ($z = -1.069$; $n = 0.8$; $P = 0.285$), Forage ($t = 0.290$; $n = 28$; $P = 0.774$) (Fig. 4b).

## Discussion

Our analyses show that boats are not influencing the overall activity budget of the dolphins, but that an increase in proximity and breathing synchrony during the presence of boats occurred during the first half of the year (Period 1).

Before the delimitation of the coastal reserve, Carrera (2004) in a study conducted on the same place found a decrease in foraging activities during the presence of boats within the bay. There are two possible explanations for this difference in results. First, Carrera (2004) used a different methodology, registering all observable foraging events on moments with and without boats. Our analyses did not consider foraging events but foraging states. Thus, it is still possible that, despite maintain the same overall behavioral state, the actual foraging success was decreased by the presence of boats.

Differences in results when using different methodologies have already been reported elsewhere. Lusseau (2003), for example, using Markov chains technique found that the

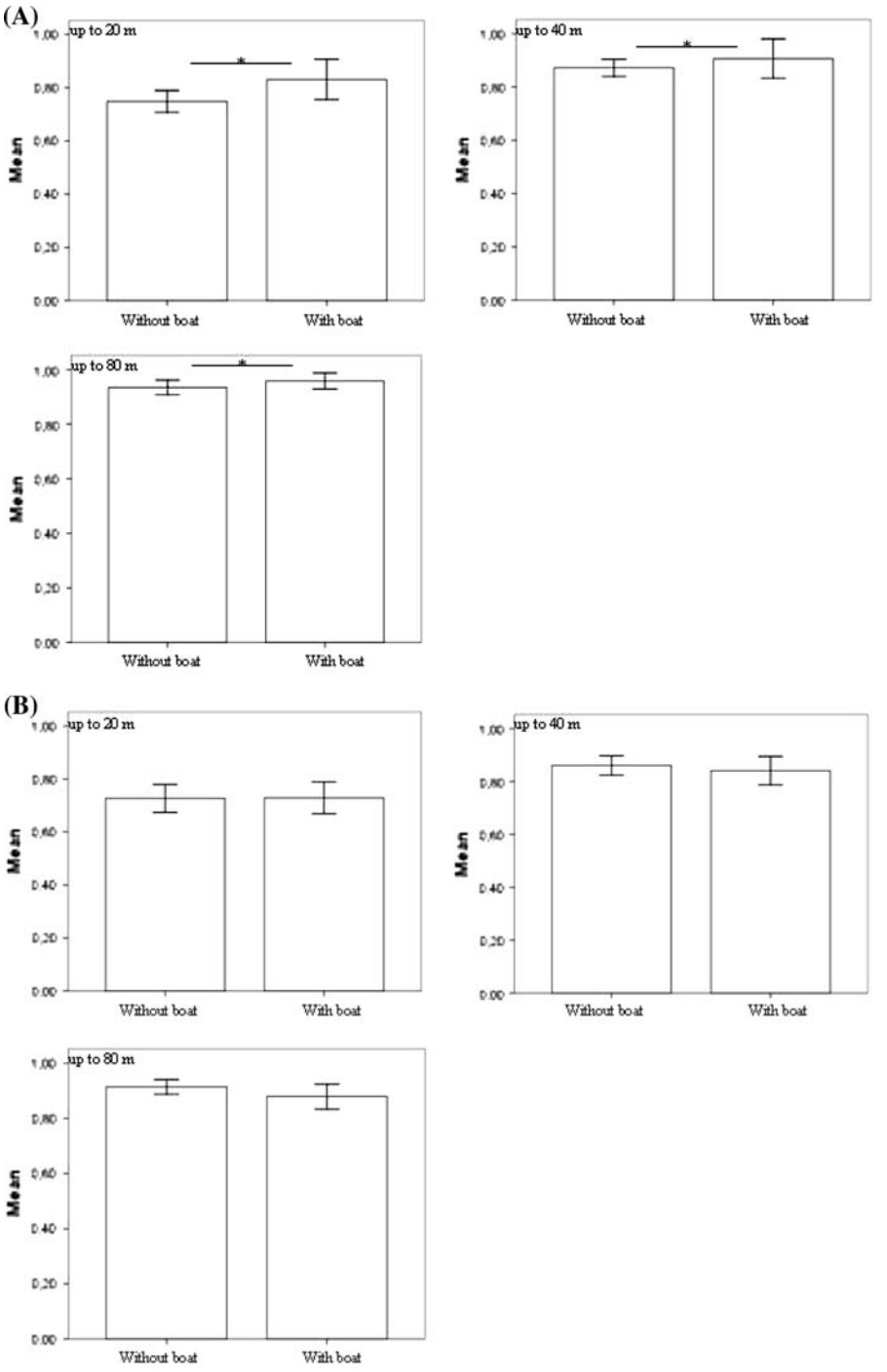


**Fig. 3** Mean values of proximity among dolphins, with and without the the presence of boats within the bay (Cumulative values). (**a**) period 1: before the rains; (**b**) period 2: after the rains. * significative diferences

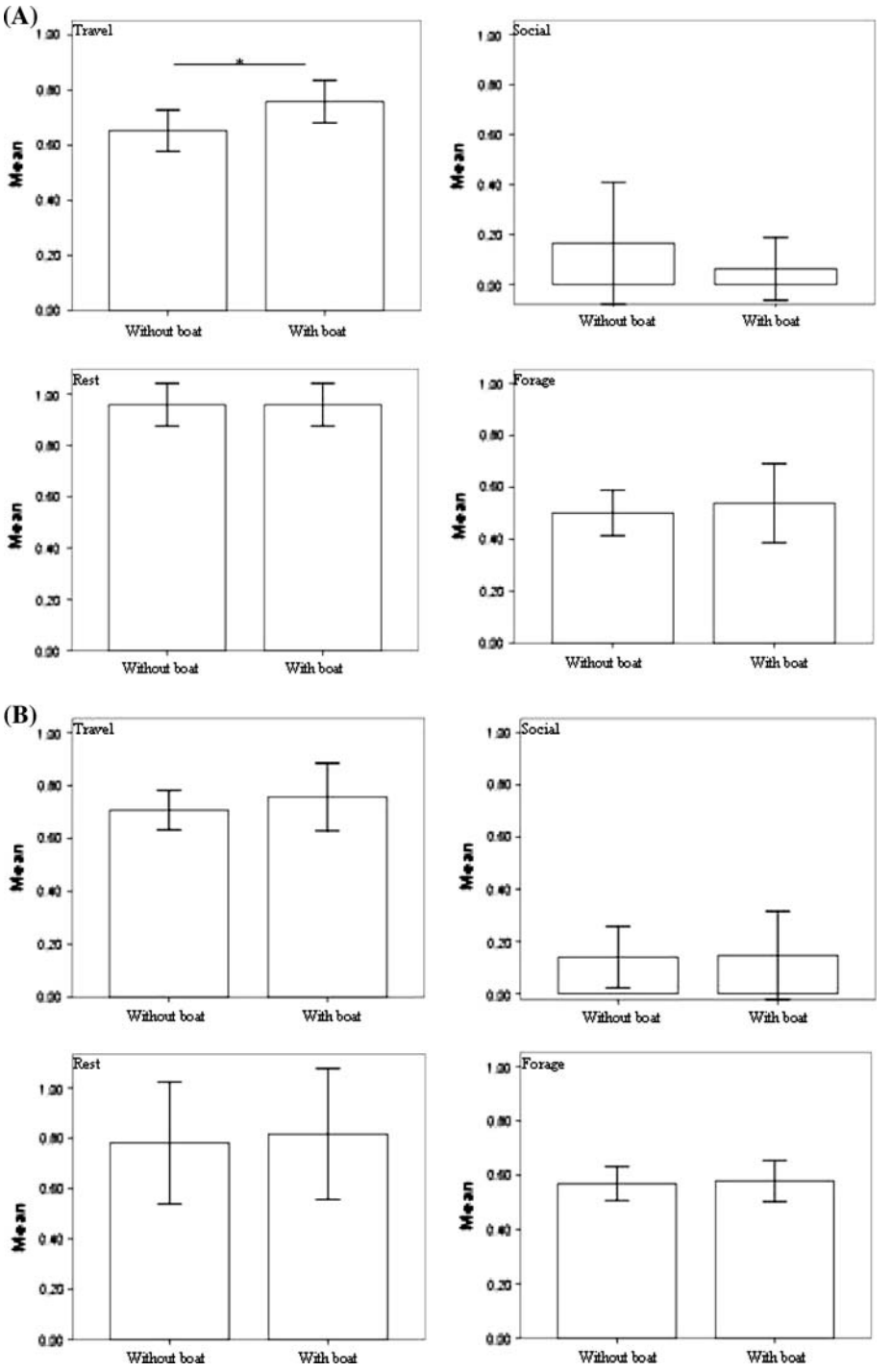


**Fig. 4** Mean values of breathing synchrony, with and without the the presence of boats within the bay. (**a**) period 1: before the rains; (**b**) period 2: after the rains. * significative diferences

sequence of New Zeeland's *T. Truncatus'* behaviors changes during the presence of boats, although the overall activity budget is maintained (see also Stockin et al. 2008). Similarly, Acevedo (1991) found no changes on La Paz (México) dolphins' behavior during the presence of boats, although they could be alarmed during the first moments of boats approach. The fact that presence of boats may change the behavioral sequence but the overall activity pattern is maintained, led us to the discussion of what is an immediate effect, what is a short, medium or long term effect, and in which level can we assert that the continuity of the population in an area is at risk (Nowacek et al. 2001).

A second possible explanation for the differences in results of this and Carreras's (2004) study is that the limitations of boats on the area to two boats simultaneously using the bay may in fact resulting in a minimization of impacts on the dolphins, since that at Carrera′s period, up to six boats were registered simultaneously within the bay.

Regarding proximity among individuals, on the first period we could detect a statistically significant increase in proximity among individuals during the presence of boats. This result is similar to that found by Valle and Melo (2006), reporting data relative to the years of 2004 and 2005. As the increase in proximity is normally related to a defense strategy (Nowacek et al. 2001), our results indicates that, despite control of number, proximity and distance, tourism boats were still affecting dolphins normal pattern during this period.

However, no such statistically significant increase in proximity was observed during the second half of the year. Again, some non mutually alternative explanations may be tried. Firstly, it was noted in previous studies (Guilherme-Silveira and Lima 2007; Tosi 2007) that the period after the rains is characterized by an increase in foraging behavior. This increase is probably related to a decrease in food availability as a consequence of the carrying of sewage to the shallow waters (less than 50% of the municipality has a proper treatment of sewage - SMA 2002). Thus, it is possible to suppose that dolphins are keeping their foraging effort despite the presence of boats on the area, due to scarcity of food on this period.

A second possibility regards the increased control of boat traffic during the second half of the year. There are reports that during the first semester after the delimitation of the coastal reserve, boat owners were not neatly fulfilling the guides of boat traffic within the bay, during the days that the observer was not collecting data. During the second semester there was an increasing enforcement of boat traffic rules. Therefore, it is possible to suppose that with a greater and continuous control of boat traffic, the effects on proximity patters tends to disappear, similar to what was described by Pereira et al. (2007).

Increases in dolphins′ breathing synchrony during the presence of boats are also related to defense strategies, although the results regarding increases in breathing synchrony during the presences of boats are still controversial. Hastie et al. (2003) studying *T. truncatus* at Scotland reported that only 30,5% of their group samples showed increased breathing synchrony but that 69.5% of dolphins groups did not increased their breathing synchrony during the presence of boats. Our results are similar to that of Hastie et al. (2003), in the fact that only dolphins groups in travel showed an increase in breathing synchrony. Moreover, this increase was only observed during the first half of the year. Suggestions similar to that of proximity can be done, regarding the increase breathing synchrony during the first period and lack of increased breathing synchrony during the second period.

At scientific literature, we can find several examples of negative impacts of boats as well as positive impacts (e.g. bow riding—Simões-Lopes 2005, p. 88), and no effects of boats on cetaceans behavior and populations (Acevedo 1991). This variation can be related to a diversity of factors such as: habits of species under study (cosmopolitan or restricted distribution), food availability on the area and in nearby areas, prey behavior, and number, type

and procedures of boats in the area. *S. guianensis* is a species with dietary flexibility occurring all along South American coast, occupying different areas and subject to different anthropic factors.

Despite methodological differences, our results show that a simple control of traffic can minimize the impacts of tourism boats on dolphins' behavior (at least in a short term horizon). Strikingly behavioral changes could not be detected as in previous studies, and we attribute this difference to a greater control of boat traffic within the bays. The fact that changes in dolphins normal activity patterns are still noted, warns us for the need to continuous enforcement and refinement of traffic rules, and continuous monitoring of dolphins behavior along many years, preferentially with the same methodological procedures. Rules of number, type, speed, distance and other attitudes of tourism boat traffic must be defined locally, and the task of achieving a sustainable development of local communities vis a vis the conservation of species is a difficult compromise between community needs and vulnerability of dolphin populations.

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