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The response of marine tucuxis (Sotalia fluviatilis) towards tourist boats involves avoidance behaviour and a reduction in foraging

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Abstract

*Marine ecotourism has undergone worldwide expansion in recent years, leading to increased concern regarding the impact on the environment. Despite this, however, few studies into the potential effect of tourist boats on dolphin welfare, have been carried out. In order to evaluate the impact of these activities on the presence and foraging behaviour of the threatened marine tucuxis (*Sotalia fluviatilis*), we observed them: 1) prior to the arrival of a boat in the bay; 2) for the duration of a vessel's stay in the bay and 3) after the boat's departure: ie pre-exposure, exposure and post-exposure phases. Both the average number of dolphins and the foraging activity were significantly reduced while a vessel was in the bay. Marine tucuxis are exclusively coastal and show fidelity to the site where they choose to live which makes any environmental disturbance of particular importance. Moreover, our findings are further evidence of the need for motorboat activity to be regulated and monitored to protect marine tucuxis as well as other coastal and estuarine dolphins.*

Keywords: *animal welfare, ecotourism, human disturbance, marine tucuxi,* Sotalia fluviatilis*, tourist boats*

Introduction

In recent years the marine environment has become a particular attraction of the ecotourism trade (Cater & Cater 2001; Scarpaci *et al* 2004; Bejder *et al* 2006b). However, marine tourism has not only brought economic change to many areas but also increased concerns regarding the impact it may have on marine mammals (Constantine 1999). As dolphins are often targeted by marine tourists, studies that focus on the extent to which tourist vessels influence these animals, play a significant role in their protection.

Concerns regarding the level of disturbance that boats cause to dolphins is reflected in the increasing number of publications on this matter. Much of the emphasis of this work has been on the influence vessels have on the behaviour of bottlenose dolphins (*Tursiops* spp). Some of these studies have shown that the presence of boats causes these dolphins to increase diving intervals (Nowacek *et al* 2001), to change their swimming speed (Nowacek *et al* 2001), disrupts their social and resting behaviours (Lusseau 2003), affects their foraging activity (Constantine *et al* 2004) and, as a long-term effect, causes a decline in their abundance (Bejder *et al* 2006b). Studies on other dolphins are less well documented. It is known, for instance, that Hector's dolphin (*Cephalorhynchus hectori*) avoids approaching boats (Bejder *et al* 1999) and the Chinese white dolphin (*Sousa chinensis*) communicates differently in the presence of boats (van Parijs & Corkeron 2001). It seems clear that more work on different species is required to support specific management plans. Moreover, with the exception of Bejder *et al* (2006b), all the other above studies reflect the short-term effects of boats on dolphins' behaviour. Although information based on key short-term effects can be crucial and may help avoid critical or irreversible situations, from a conservation perspective short-term behavioural disturbances must be interpreted with caution (Bejder *et al* 2006a, b); ultimately it is the preservation of biodiversity which is of uppermost concern and, hence, the long-term effects take priority over short term. Despite this, however, from a welfare point-of-view, unnecessary human disturbance (whether short term or otherwise) should be limited to regulate or remove their impact on animals. Animal welfare relies strongly on the promotion of ethical and societal values, aimed at minimising fear, pain, stress and suffering, with the ultimate intention of treating non-human wild and domestic individuals with respect and dignity (AVMA 2007). This study is concerned, chiefly, with the promotion of welfare.

In the waters of Baía dos Golfinhos (Dolphin Bay), Northeast Brazil, the highly vulnerable marine tucuxis (*Sotalia fluviatilis*) (Di Beneditto & Ramos 2004; CITES 2005) has been commonly observed. Since 2001, three motorised vessels have been transporting dozens of tourists on unrestricted daily excursions into the bay.

The main objective of this study was to evaluate the disturbance caused by these tourist boats to the tucuxis in Baía

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dos Golfinhos. To accomplish this task we monitored the influence of tourist boats on the presence of the dolphins and also on a particular foraging activity known as 'chasing' behaviour. Our findings provide additional information on the effects of boat activities on the marine tucuxis and might also be helpful with regard to other coastal and estuarine dolphins.

Materials and methods

Animals

Marine tucuxis, also known as Guiana or estuarine dolphins, inhabit the tropical and sub-tropical Atlantic coasts of South and Central America. Sightings have been made from Honduras in the north (15º58N, 85º42W) (da Silva & Best 1996) to the southern region of Brazil (27º35S, 48º34W) (Borobia *et al* 1991). They are relatively short (approximately 2.0 m in length), stout, grey, torpedo-shaped dolphins that are exclusively coastal (Borobia *et al* 1991). This species does not typically follow boats and tend to die from stress-related illnesses when kept in captivity (Hetzel & Lodi 1993). They show a preference for bays (Borobia *et al* 1991; Flores 2002) and site fidelity (Hetzel & Lodi 1993; Flores 1999; Santos *et al* 2001). The interval between breaths is relatively short: 11 to 90 s, with an average of 40 s (Edwards & Schnell 2001) and the number of dolphins at any given time in the study site varies between one and eight individuals (Araújo *et al* 2001). Moreover, dolphins use the study site for mainly foraging (Hetzel & Lodi 1993; Araújo *et al* 2001) and possibly resting purposes (Araújo *et al* 2001). Their diet consists mainly of fish (Hetzel & Lodi 1993).

Study site

Baía dos Golfinhos (Dolphin Bay) also known as enseada do Curral, is located in Tibau do Sul County (6º10'S, 35º05'W), Rio Grande do Norte State, Brazil, 80 km south of the capital, Natal. It is a bay approximately 0.4 km^2 in area which is surrounded by cliffs and has rocky outcroppings at both ends. The waters are at their deepest (5–7 m) at the mouth of the bay (Garri 2006). The water is turbid, due probably to a combination of the small particle composition of the substrate, the relatively shallow depth of the water, the erosion inflicted by the waves when they reach the cliff walls (mainly composed of clay, sandstone and limonite) and the estuarine complex of the Tibau do Sul. Visibility is no greater than 1 m (Feitosa 2006). The water temperature ranges from 19 to 28ºC, whilst salinity ranges from 36 to 37% (Araújo *et al* 2001). Tourism growth can be inferred by increasing numbers of small hotels to be found close to the boat trip embarkation point, at the village of Pipa (approximately 2 km south of Baía dos Golfinhos) ie from one in 1987, to approximately 40 in 2002 (A Souto personal observation 2002).

General procedure

The presence or absence of dolphins, the arrival and departure of boats as well as the 'chase' behaviour were recorded on a notepad and a digital watch was used to register the time at which the observed behaviour and boat activity occurred. The three fishing boats observed in this study measured between 15 and 18 m, were motorised with a single six-cylinder diesel motor and adapted to cater for tourists. Each boat could transport up to 60 passengers in one trip and these were the only active boats in the bay.

Marine tucuxis behaviour was monitored from a viewpoint on the side of a cliff, approximately 20 m above the beach. This enabled accurate recording of the dolphins' activities.

Preliminary observations (Lehner 1996; Martin & Bateson 2000) were made during the months of August and September of 2001 (30 h). These were important to allow familiarity with the behaviour of the animals and to define the time of the day at which the boats were active. These observations revealed that boats operated daily between 1100 and 1300h.

Observations were carried out from 0900 to 1500h (distributed over 60 days from the 30th of October 2001 to the 15th of February 2002). Data used for the statistical analysis involved 48 encounters between boats and dolphins during a total of 32 h and 10 min. A number of the encounters were discarded (see following section) which explains the discrepancy between the observational days (60) and encounters (48).

Disturbance evaluation procedure

Disturbance to dolphins' foraging activity as a result of tourist boats was measured via the frequency of chase behaviour. Chase behaviour is defined as the fast pursuit of fish at, or close to, the surface of the water (Araújo *et al* 2001; Valle & Vaz 2005; Souto *et al* 2006). In accordance with the work of Constantine *et al* (2004), fish were frequently observed during the foraging pursuit and, sometimes, afterwards, in the dolphin's mouth. For dolphins, chase behaviour is the predominant activity in Baía dos Golfinhos (Araújo *et al* 2001) as well as in other locations (eg Rossi-Santos 2006; Araújo *et al* 2007; Daura-Jorge *et al* 2007). The high frequency of this behaviour in Baía dos Golfinhos is possibly associated with the great prevalence of mullets in the Rio Grande do Norte region (Hetzel & Lodi 1993). Mullets are extremely agile fish and it takes considerable effort by predators to capture them (Daura-Jorge *et al* 2007).

One of us (MLC) recorded changes in the observed number of chase events, irrespective of the individual performing it. By recording only one single behaviour we sought to avoid the main drawback of utilising *ad libitum* observations when the objective is to perform comparisons between rates or frequencies. By definition *ad libitum* means recording all events and states that are perceived by the observer, regardless of the animal's identity (Altmann 1974). When observing different types of behaviour, performed by different animals (recorded at the same time), the researcher might tend to record those forms of behaviour that are more conspicuous, biasing the data sampling (Altmann 1974; Mann 1999).

To test whether the presence of boats affects either the chase behaviour or the number of dolphins in the bay, we divided

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the observations into three phases: pre-exposure, exposure and post-exposure to the boats. During the pre- and post-exposure no boats were in the bay. The period of time in which boats remained in the bay varied from day-to-day. To maintain uniformity between the phases we used the time of exposure in a certain day to serve as a duration parameter to the pre- and post-exposure on that same day. For example, assuming that on day one the exposure length was 25 min, all data obtained 25 min prior to the arrival of a boat (the pre-exposure period), and all data obtained in the 25 minutes following the departure of the boat (the post-exposure period) was used. This was possible because continuous recordings started at 0900h and ended at 1500h (sufficient time to cover the 1100–1300h maximum range of the boats' excursions). The exposure phase consisted of the period of time in which one (or more) boats were visiting the bay, ie when one boat was passing the mouth of the bay. We considered a sequence of boats when one was leaving the bay whilst another was entering. When two boats were in the bay at the same time data were discarded. We considered a single boat visit when either 1) it was the only boat entering the bay or 2) the second boat arrived after a period of time equal to or longer than the exposure phase, allowing us to build all three phases with the same time length. In the case of the latter, only the data from the first boat was used and data from the subsequent boat (or boats) were discarded. Data were also discarded in two other situations; 1) when the first boat was still in the bay and another entered (ie to avoid overlapping stimuli) and 2) after the first boat had left the bay and another had entered but with a time interval that was insufficient for building a post-exposure phase (ie for the first boat). With these procedures we assumed that the visit of one boat or a sequence of them represented a single stimulus (the exposure phase).

As the number of dolphins in the bay can influence the number of chases in a particular phase, we divided the chase displays by the average number of dolphins during the same phase. The counting of dolphins was carried out by one of us (EGPF). Although eight individuals were readily identifiable via differences in dorsal fins, a precise identification could only be guaranteed with certain light angles and/or dolphin body positions. Such difficulties were caused, to a certain extent, by the height (20 m) of the vantage point and subtle variations between five of the eight individuals. Moreover, identities would often need to be reset once dolphins submerged as it was not generally possible to follow the progress of an individual underwater. The reason we chose this vantage point, as opposed to relocating to the beach or to a boat of our own, though, was due to the fact that tucuxis are only ever seen in relatively small numbers, have a very brief interval between breaths and the bay is relatively small. From our fixed viewpoint the observer had a privileged visual sweep of the study site. Moreover, the shallow waters of the bay seemed to make long dives unnecessary. These points taken together made the likelihood of counting the same individual multiple times extremely unlikely. Counting never took longer than two minutes.

The average number of dolphins in a phase was the sum of the separate counts divided by the number of scans in that phase (for example: three consecutive visual scans spotted initially two, then one, and again one dolphin, giving a result of 1.33 dolphins during that phase).

Statistical analysis

Studying free-living dolphins is a difficult task and researchers are faced with a multitude of problems (Bejder & Samuels 2003). The problems associated with identifying individuals are further compounded with displays of behavioural activity and when this is to be carried out in murky waters it becomes almost impossible. This is reflected in the statistics; as marine tucuxis show site fidelity, it may well be that the data obtained from this study originates from the same animals exposed to the influence of boats on different days. Thus, these results should be interpreted cautiously. They are adequate for the dolphins of Baía dos Golfinhos but other groups may respond differently. In truth, this advice could be applied to a host of behavioural (Weary & Fraser 1998; Rook 1999; Mundry & Sommer 2007) and ecological (Johnson 1999; Wedekind *et al* 2007) studies. At present the best way of remedying this is through the implementation of other similar studies by different researchers in different locations (Johnson 1999). Therefore, despite being statistically limited, this study should still make a significant contribution to our understanding of this complex subject.

To test whether or not chase behaviour rate differed between the three situations (pre-exposure, exposure and post-exposure) we employed the Friedman two-way analysis of variance by ranks (Siegel & Castellan 1988). If the Friedman test detected a significant result, multiple comparisons between groups were carried out to find where the differences occurred (Siegel & Castellan 1988). Differences were taken as being significant when $P \leq 0.05$ (two-tailed).

Results

Boat activities and time spent in the bay

As a boat entered the bay it would always head straight towards the dolphins and motors were kept running continuously. The total mean time boats spent in the bay was 40.33 (± 3.57) min (n = 48).

Number of individuals

The number of individuals differed significantly in at least one of the comparisons between the three phases (Freedman: n = 48, $Fr = 7.8$, df = 2, $P < 0.05$). The mean number of individuals in the bay before the arrival of boats (*Pre*) was 3.30 (± 0.18). This was significantly higher than when the boats were present (*E*) 2.77 (± 0.17) (multiple comparison test: n = 48, $[R_{Pre}–R_E] = 26.5$, $P < 0.05$). As the boats left the bay (post-exposure or *Post*) the mean number of individuals increased slightly, reaching 2.92 (± 0.21). No significant differences were seen between the post and the exposure situations (multiple comparison test: n = 48, $[R_{Post}–R_E] = 11.5$, ns). Similarly, there was no

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statistical difference between the pre- and the post-exposure phases (multiple comparison test: n = 48, $[R_{Pre}–R_{Post}]$ = 15, ns; Figure 1).

Effects of boats on chase rate

The number of chase displays differed significantly for at least one of the comparisons between the phases (Friedman: n = 48, Fr = 12.61, $P < 0.01$). The number of chases displayed per individual in the exposure phase (0.51 [± 0.11]) was significantly reduced compared with the preceding period (1.09 [± 0.24]) (multiple comparison test: n = 48, $[R_{Pre}–R_{E}]$ = 27.5, $P < 0.05$). As the boats left the site, no statistical significance was attained when this phase was compared with the exposure phase (0.84 [± 0.15], and 0.51 displays per individual, respectively) (multiple comparison test: n = 48, $[R_{Post}–R_{E}]$ = 16, ns). Similarly, no significant difference was seen in the number of chase displays between the post- and the exposure phases (multiple comparison test: n = 48, $[R_{Pre}–R_{Post}]$ = 11.5, ns; Figure 2).

Discussion

The present study shows that marine tucuxis in the Baía dos Golfinhos respond to the presence of boats by moving away from the boats and leaving the bay and by showing a reduction in foraging behaviour. It may well be that motor noise is the cause of such disruption (van Parijs & Corkeron 2001). We assume that dolphins are expending time and energy avoiding vessels at the expense of continuing their foraging activities, ie in keeping with the findings of Bejder *et al* (1999) and their work with Hector's dolphins. It would seem they are in danger of losing control over their interactions with the environment; a recognised indicator of poor welfare (Broom 2001). Welfare is particularly compromised by disruption to feeding patterns (Kirkwood *et al* 1994; Knierim *et al* 2001).

The results obtained in this study are based on daily boat incursions lasting approximately 40 min and for these no significant differences were found between post-exposure and exposure phases. It may well be that this is a consequence of the conservative Friedman test (Siegel & Castellan 1988) rather than a failure to restore levels to those of pre-exposure. Due to methodological limitations, most studies that deal with cetaceans and motorboat disturbances are only able to demonstrate short-term effects (see Bejder & Samuels 2003 for a review). It tends not to be clear whether or not these have a cumulative effect, leading, ultimately, to prolonged changes (Bejder & Samuels 2003; Lemon *et al* 2006). However, a recent longitudinal study by Bejder *et al* (2006b) has shown that the number of *Tursiops* spp decreases as the number of tourist boats increases.

The boat incursions into the Baía dos Golfinhos confer no benefits to the dolphins and are responsible for considerable behavioural disruption. Our aim, therefore, must be to alleviate these types of disturbance, thereby improving welfare. It is worth noting that the expected growth in ecotourism (Santana 2001; Bejder *et al* 2006b) will almost certainly be reflected in increasing numbers of boats and, consequently, greater periods of occupancy in the bay; as observed in other countries (eg Orams 1997). This expected growth increases welfare concerns as well as highlighting overall worries regarding the conservation of a species such as the marine tucuxis. Marine tucuxis are not only exclusively coastal dolphins (Flores 1999; Santos *et al* 2001) but also demonstrate site fidelity (Borobia *et al* 1991; Hetzel & Lodi 1993; Flores 2002). These characteristics, taken together, make them one of the most vulnerable cetacean species (Di Beneditto & Ramos 2004).

While our study showed that motorboats disturb the activities of marine tucuxis, it was unable to give precise information on how boats could operate without causing any disruption. However, given the displacement and evident reduction in foraging behaviour we suggest the implementation of precautionary approach to avoid behavioural disturbances (eg Bejder *et al* 2006b).

Many studies have shown that maintaining a discrete distance from feeding or reproduction sites is fundamental to avoiding wildlife disturbance (eg Cassini 2001; Thomas *et al* 2003). As a preliminarily step towards improved welfare and conservation, we recommend the prevention of motorised boats from entering the Baía dos Golfinhos for any commercial or recreational pursuits. Permission should only be granted for access to boats for points close to the mouth of the bay. Given the disturbance imposed by boats, this is a realistic recommendation. Moreover, as the bay is relatively small, viewing dolphins from this proposed location is still possible. It is also worth noting that marine tucuxi can be easily seen from the beach, as they tend to stay close to shore, perhaps as it is easier to fish in shallow waters (eg Oliveira *et al* 1995) and, as such, the use of boats could be classed as unnecessary.

After the implementation of these preliminary guidelines we would urge that future studies closely monitor the interaction between motorboats and marine tucuxis. This would provide data on the effectiveness of the above measures and be of great importance in adjusting and/or creating new regulations on motorboat activities.

We would hope this study will help contribute to better management of the interaction between marine tucuxis and tourist boats and, in a broader sense, similar interactions between boats and other cetaceans, especially those inhabiting coastal and estuarine habitats.

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Figure 1

Number of marine tucuxis in relation to the presence or absence of tourist boats in the Bay. Data are presented as means (± SEM). Statistics: multiple comparison test (two-tailed); * $P \leq 0.05$.

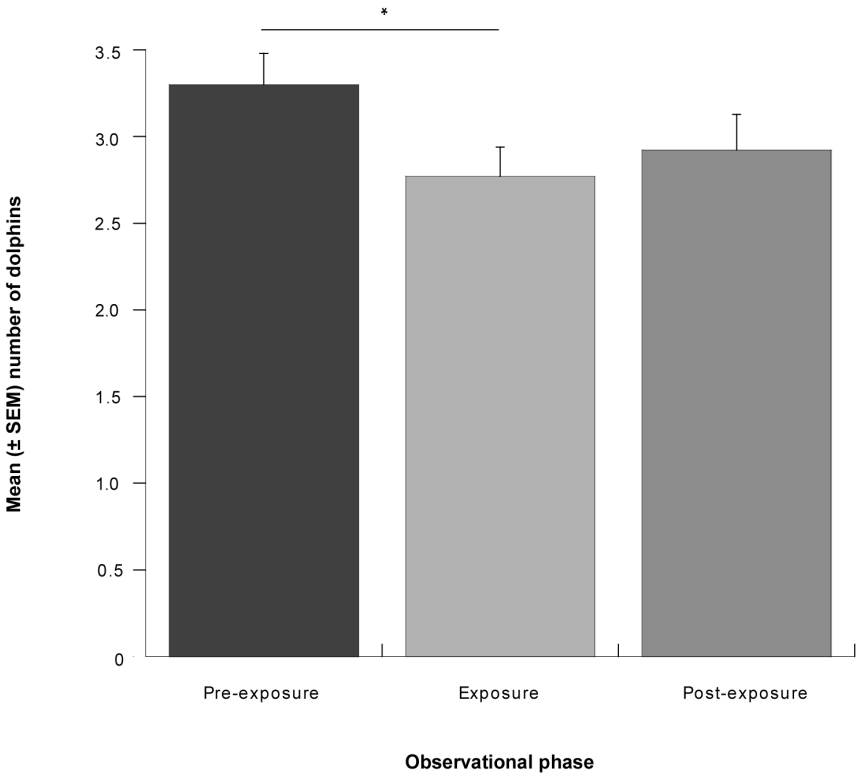
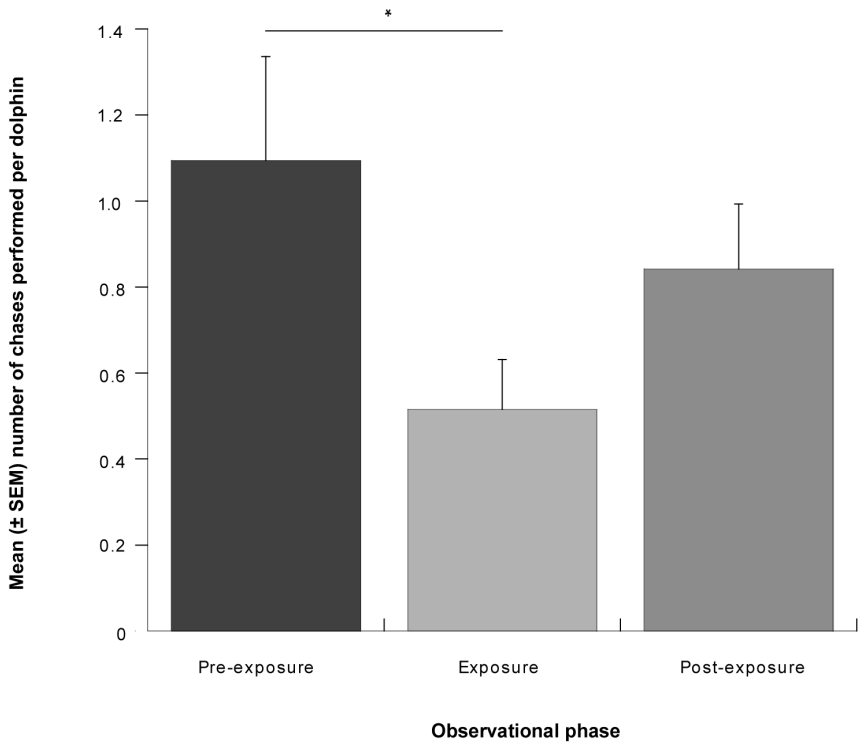


Figure 2

Foraging behaviour (number of chases per dolphin) in accordance with the exposure to tourist boats. Data are presented as means (± SEM). Statistics: multiple comparison test (two-tailed); * $P \leq 0.05$.



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