



Interaction of spinner dolphins (*Stenella longirostris*) (Cetacea, Delphinidae) with boats at the Archipelago of Fernando de Noronha, Brazil

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Abstract. Dolphin watching in Fernando de Noronha is one of the most attractive activities for those who are visiting the Archipelago. Due to a new pattern in area of occupancy of the spinner dolphins in the archipelago of Fernando de Noronha and an increasing occupation at the region of Santo Antônio Bay and Entre Ilhas area, this research aims to describe the interaction between dolphins and the nautical tourism of that region. Recently the principal meeting area between spinner dolphins and vessels is the Entre Ilhas area and the nautical tourism in Fernando de Noronha is an impact agent on this population. The spinner dolphins use the archipelago of Fernando de Noronha to rest, mate and take care of the calves, making the animals susceptible to impacts caused by the passing by of tourism vessels in places where the dolphins gather; this may compromise behavioral patterns and species occurrence.

Keywords: behavior, dolphin watching, impact, tourism

Resumo. Missing abstract in Portuguese. Missing abstract in Portuguese. Missing abstract in Portuguese. O turismo de observação de golfinhos-rotadores em Fernando de Noronha é uma das atividades mais procuradas pelos turistas que visitam o arquipélago. Em função do estabelecimento de um novo padrão de ocupação de área dos golfinhos-rotadores no Arquipélago de Fernando de Noronha, com crescente ocupação na região da Baía de Santo Antônio/Entre Ilhas, este trabalho objetivou descrever as interações dos golfinhos com o turismo náutico na região. Atualmente a principal área de encontro das embarcações com os rotadores é a Região Entre Ilhas e o turismo náutico em Fernando de Noronha se mostrou um agente de impacto sobre esta população. Os golfinhos-rotadores em Fernando de Noronha utilizam o arquipélago para descanso, reprodução e cuidado parental, tornando os animais susceptíveis aos impactos causados pelas passagens de embarcações de turismo nos locais em que se concentram; podendo comprometer tanto padrões de comportamento e ocorrência da espécie.

Palavras chaves: comportamento, impacto, observação de golfinhos, turismo

Introduction

Tourism based on cetaceans watching has become one of the most important economic activities for some coastal communities. This harmless interaction with cetaceans is an important way of raising awareness of environmental issues among participants (IFAW 1997). It is an effective source of information for researchers as well, thus becoming a tool of preserving and protecting marine life. However, if there is no control, this activity

may cause negative impacts on these animals (Coscarella *et al.* 2003).

Studies around the world have evaluated the impact of anthropic activities on cetacean populations. In New Zealand, studies have shown that the presence of boats or swimmers can affect the behavior of bottlenose dolphins (Constantine *et al.* 2004) and hector dolphins (Bedjer *et al.* 1999). Humpback whales in Australia are also affected by the presence of vessels during migration (Stamation

et al. 2010). At the Equator the same species increased movement speed when boats approached (Scheidat *et al.* 2004). In Brazil, guiana dolphins (*Sotalia guianensis*) at Pipa beach, Rio Grande do Norte State, changed their movement patterns, moved away, and reduced foraging activity when boats approached (Santos-Jr. *et al.* 2006). Concerning some species in the Baía Norte in Brazil, Pereira *et al.* (2007) registered negative reactions, where long dives, moved away and group cohesion were more common. More serious situations may occur such as changes in habitat utilization patterns in areas previously occupied by the animals (Lusseau 2005). Lusseau & Bedjer (2007) explain that disruptions previously considered immediate and short-term disturbances may cause long-term consequences, affecting the dynamic and survival of animals exposed to boat-related activities.

Spinner dolphin watching has been taking place on Fernando de Noronha since the seventies. However, growth in visitor numbers has led to a rise in number of tour boats at the archipelago, increasing boat traffic for dolphin watching. Vessels have been forbidden to get into Dolphin's Bay since 1989. Encounters between boats and dolphin groups occur in other areas of the Inner Sea, including Santo Antônio Bay and Entre Ilhas area.

Spinner dolphin watching on Fernando de Noronha is one of the most attractive activities for those who are visiting the archipelago. Watching them from Mirante dos Golfinhos, which is an outlook from land, does not affect these animals. On the other hand, boat trips conducted improperly may cause negative impacts on spinner dolphins. However, it is of knowledge that this activity is profitable for the archipelago. In 2009 around 70,000 visitors spent approximately US\$ 2,625,000 on the island and it was exclusively due to dolphin watching (Silva-Jr. 2010).

A nautical study called Estudo de Capacidade de Suporte Náutico made for the Marine National Park of Fernando de Noronha (Luis-Jr. 2009) suggests the boats for dolphin watching follow some procedures to avoid the impact on spinner populations. One of its goals to propose the adequate management to conserve the animal's ecological status plus the economical viability. Therefore, the aim of this study was to describe interactions between spinner dolphins and vessels in the Santo Antônio Bay and Entre Ilhas area of Fernando de Noronha's Archipelago in Brazil. This study tested the hypothesis that the traffic of tourism vessels, when done improperly, changes the behavioral patterns of the spinner dolphins.

Materials and methods

Study Site

The study site is located on Fernando de Noronha Archipelago (3°50'S 32°24'W) which belongs to the State of Pernambuco and is located 545 km from Recife. It consists of one main island and 17 small others ones (Silva-Jr. 2010), with a total area of 26km².

Due to differences between the two sides of the archipelago they were named "Inner Sea" and "Outer Sea". The first one on the northeast side, faces South America and is protected from ocean winds and currents. On the South, or Southeastern coast, is the "Outer Sea" facing the African continent; receiving winds and waves year-round (Linsker 2003).

The study site consists of Santo Antônio Bay and Entre Ilhas area (Figure 1). The former is characterized by an open water bay where the only port is located on the archipelago. It is bordered in the Southeast by Morro de Fora and in the northeast by the Viuvinha, Cuscuz and São José Islands. On the other side of São José Island there are Ilhas Secundárias connected to Santo Antônio Bay only during high tide. The area between Ilhas Secundárias named Rasa and Sela Ginete comprise the Entre Ilhas area (Silva-Jr. 2010). The fixed observation point was established at Nossa Senhora dos Remédios Fort, situated 45 meters above sea level, with a wide view of the entire study site.

The Archipelago consist of two Federal Conservation Units: Fernando de Noronha Marine National Reserve (PARNAMAR-FN) (FUNATURA/IBAMA 1990); and Fernando de Noronha – Rocas - São Pedro and São Paulo Environmental Protection Area (APA) (IBAMA 2005).

As the study site comprises part of APA-FN and PARNAMAR-FN boat traffic is constant throughout the day, receiving tourist operators licensed to navigate within the two Conservation Units. Santo Antônio Bay and Entre Ilhas area are the main meeting points between these vessels and dolphin groups. Each Conservation Unit rules the flow of boat traffic within its boundaries as part of their Management Plan. Throughout APA - FN, all visitors and island vessels are allowed to freely transit. On the other hand very few vessels are authorized within PARNAMAR - FN, and speedboats are strictly prohibited. All vessels in all areas of the archipelago are required to comply with the current legislation, which specifics among other guidelines norms for the encounter between boats and dolphins.

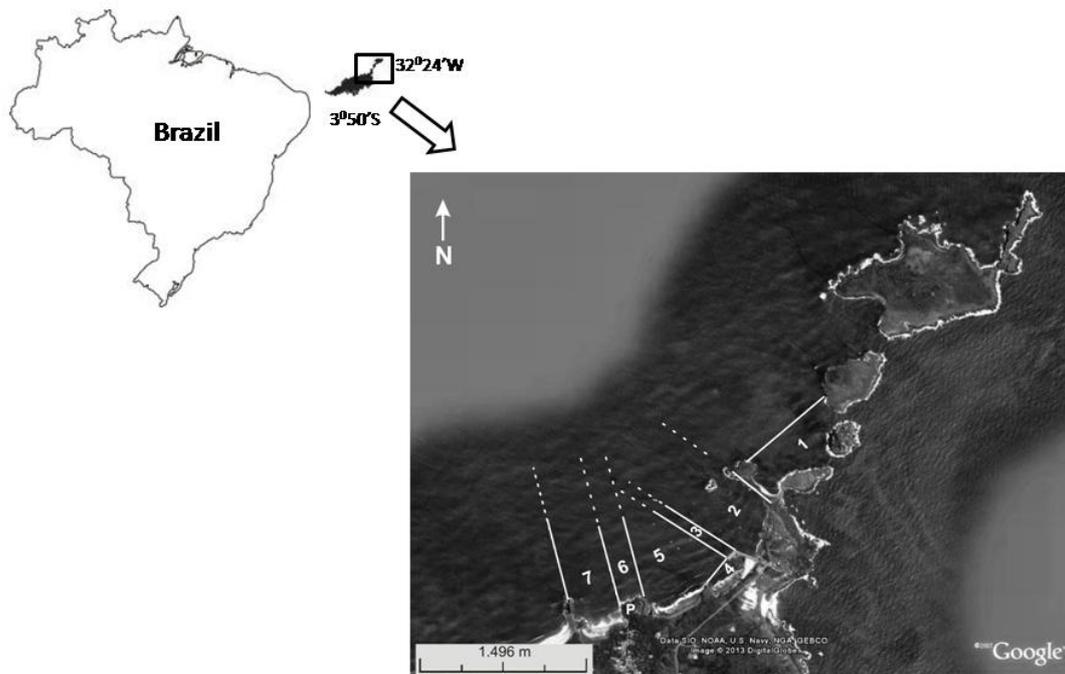


Figure 1. Study area. Santo Antônio Bay and Entre Ilhas area. Fernando de Noronha, PE, Brazil.

Data collection

Observations were carried out from January 2008 to December 2009 five days a week from a fixed point on Nossa Senhora dos Remédios Fort. Data were collected from 5.30am to 1pm, or until the last dolphin group left the study area. This area was divided into seven subareas, defined using coastal reference points. Subarea 1 (Entre Ilhas) is the only area within PARNAMAR – FN. Areas 2 to 7 (Santo Antônio Bay) are within APA – FN.

Data were gathered using 10x50 binoculars with Rongda XBZ 30x-260x-160 Zoom lenses, mechanical counter meters and spreadsheets. Interaction between spinner dolphin groups and boats was recorded by *ad libitum* with a continuous register (Altmann 1974). It was analyzed considering the presence/absence of vessels near dolphin groups, number of boats, their compliance with legislation, their speed, and dolphin behavior in their presence or absence. All vessels coming within 50 meters of dolphin groups were recorded, whether fishing boats (inboard or speedboats), tourism vessels (tours, scuba diving or towing, as well as inflatable dinghies used as support for sailboats) or cargo ships.

Dolphin groups frequently got together in a subarea of the studied region. When this occurred, it was registered as a new group, since the composition and number of individuals changed.

Definitions used for data collection on spinner

dolphins, were the following:

1. Behavioral state:

- stationary – absence of direct and constant movement between subareas;
- movement – direct and constant movement of dolphins from one subarea to another;

2. Following:

- following – the group or some individuals swim in the bow of vessels;
- not following – even when boats passed through dolphin groups, no individuals were seen swimming in their bow.

This variable was recorded once per each occurrence of dolphins in the subarea, not for each vessel close to the group.

3. Direction of movement:

- Rata Island – Northeastern end of the archipelago.
- Sapata Point – Southeastern end of the archipelago.

4. Speed of movement:

- slow – movement where only the dorsal fin is visible on the surface at the moment of breathing;
- fast – movement exposing almost the whole body when breathing;
- “porpoising” – high speed movement characterized by jumps out of the water, exposing the entire body.

Definitions used to register vessels.

1. Type of vessel:

- inboard engine – situated below the boat, not visible above the surface;
- outboard engine – located on the stern of the

vessel, visible.

2. Vessel conduct:

- legal – complying with legislation and guideline for dolphin protection.
- illegal – non-compliance with dolphin protection laws or guidelines.

3. Vessel speed:

- slow – this does not produce trace on the water surface near the stern of the vessel, maximum 5 knots (speed defined by legislation for encounters between boats and dolphins);
- fast – over 5 knots. The vessel produces a foaming trace on the water.

Data analysis

Data were analyzed with PASW Statistics 18 software based on non-parametric statistical tests, since some of variables did not exhibit normal distribution (Siegel & Castellan 2006). The chi-square test was applied to analyze the behavior and movement speed of boats. The same test was also used to study interactions involving the following or not of vessels and their speed and behavior, as well as boat variables (conduct and speed) and dolphin behavior.

A Mann-Whitney U test was employed to investigate interaction related to the period of time

vessels spent in proximity to dolphins, whether animals followed the boats or not, and dolphin behavior. The same test was applied for the number of boats according to behavior of spinner dolphins.

A significance level of 5% ($\alpha = 0.05$) was adopted for all statistical analyses.

In order to assess differences between length of stay by boats in proximity to dolphins among subareas, a Kruskal Wallis test was applied with pairwise Mann-Whitney post-hoc analysis. Bonferroni correction was used for significance.

Results

Observations were carried from January 2008 to December 2009 from a land point for over 490 days, totalizing 4,121 hours of sampling effort. Animal residence time in the area was 1,873h and 55mins, during that time 2,861 occurrences of dolphins and boats in the same subarea were recorded.

The subarea that displayed the longest time spent by vessels near the dolphins was the Entre Ilhas area (Table I). In this area boats spent significantly more time close to dolphin pods when compared with other subareas (Kruskal Wallis test, $H=540.847$; $gl=6$; $p=0.001$).

Table I. Distribution of time spent by vessels close to the spinner dolphins in each subarea at Fernando de Noronha.

Subarea	Time	N
1	134h 05min	1565
2	5h 51min	137
3	8h 41min	160
4	9min	6
5	33h 32min	568
6	12h 38min	295
7	6h 08min	130
TOTAL	201h 04min	2861

No significant differences were found on the time spent by boats equipped with inboard or outboard engines in the proximity of dolphin groups (Mann-Whitney test U; $U=323721.0$; $z=-0.839$; $p=0.402$).

Vessel speed

Among the 2,814 encounters between dolphins and boats on which the vessel speed could be determined, animals were significantly more likely ($\chi^2=2285.464$; $p=0.001$) to move slowly (95%) than at high speed (5%). Similarly, slow

speed was recorded at 96% ($n= 2,413$) of inboard engine vessels and 91% ($n= 240$) of outboard engine boats.

Vessel behavior

Of the 2,839 encounters with cetacean recorded, 89.7% boats followed the protection rules. This is significantly higher ($\chi^2=1791.132$; $p=0.001$) than encounters registered in illegal behavior (10.3%).

Illegal behavior occurred in 8% ($n= 214$) of the encounters with inboard engine boats and 25%

(n=68) of those registered for outboard motor-boats. Compliance with legislation was 92% (n=2334) and 75% (n=200) for inboard and outboard motor-boats, respectively (n= 200).

Interaction between dolphins and boats

Following the vessels

On 993 occasions when dolphins and tour boats were recorded in the same subarea, vessels were accompanied by dolphins in 35.4% of these cases, significantly less ($\chi^2=84.110$; $p=0.001$) than when they were not followed by the animals (64.6%).

No significant difference was noticed between the time boats spent near dolphins when the following behavior was recorded (Mann-Whitney test U; $U=101356.0$; $z=-2.147$; $p=0.32$) (20h 21min, median 2min.) in subareas, compared to occasions when this behavior did not occur (43h 11min, median 2min).

Compliance with protection laws was significantly greater ($\chi^2=297.535$; $p=0.001$) than non-compliance, both in following (n=340) and non-following situations. Only 5% of events recorded following behavior of dolphins occurred when vessels were not following the protection rules. While in 15% of these cases when dolphins were not following, boats were behaving illegally.

Slow-moving vessels (n=341) were significantly more common than those traveling at high speed (n=11) when dolphins accompanied boats ($\chi^2=309.375$; $p=0.001$). The same occurred when the animals did not follow vessels ($\chi^2=454.582$; $p=0.001$), with 584 slow and 48 fast boats recorded.

Dolphin behavior

The number of boats was significantly higher when dolphins remained in a subarea than when they kept moving to other subareas (Mann-Whitney test U; $U=70716.00$; $z=-12.775$; $p=0.001$).

Vessels spent significantly more time in close proximity to dolphins when the animals were static (43h and 17min, median 4min) in a subarea than when they were moving (20h 11min, median 2min) (Mann-Whitney test U; $U=98509.50$; $z=-4.965$; $p=0.001$).

When dolphins remained static in a subarea, vessels compliance with protection laws was significantly higher (n=497) ($\chi^2=338.506$, $p=0.001$) than recorded violations (n=62). The same occurred when pods were moving from one subarea to another ($\chi^2=317.438$, $p=0.001$) ($n_{\text{legal}}=409$, $n_{\text{illegal}}=34$). However, disregard for regulations was significantly greater when the animals were stationary in a region (n=66) than when moving

from one subarea to another (n=33) ($\chi^2=11.000$, $p=0.001$).

In addition, the number of boats moving slowly was substantially higher when among traveling (n=406) and stationary pods (n= 534) than fast-moving vessels, which exhibited n=33 ($\chi^2=316.923$; $p=0.001$) and n= 25 ($\chi^2=463.472$; $p=0.001$) in the presence of traveling and stationary groups, respectively.

When boats moved slowly during dolphin encounters, the animals followed suit (71,85%), significantly more so than performing rapid (27,29%) or "porpoising" movements (0,86%) ($X^2=318.543$; $p= -0.001$). Furthermore, the frequency of the fast traveling of the dolphins increased from 27,29% when the vessels were traveling slow, to 47% when the vessels were at high speed.

Discussion

Since the nineties the Spinner Dolphin Project has conducted research to evaluate the impact of nautical tourism on the dolphin population (Silva-Jr. 2010). None of these investigations included the Santo Antônio Bay and Entre Ilhas area, target site of the present study and currently the region with the most recorded interactions between spinner dolphins and tour boats at the archipelago. In previous studies undertaken by the same Project, the most frequent animal response to the presence of these vessels was to accompany them and increase jumping. Boats that disregarded guidelines regulating this activity promoted increased movement speed and submersion times among the dolphins (Silva-Jr. 2010). This investigation found higher frequencies on slow-moving vessels when encountering dolphins, both when the animals followed boats and when they did not. Awareness and compliance with legislation may be the result that boat operators acquired through environmental education programs organized by the Spinner Dolphin Project, as well as years of enforcement by the institutions responsible for watching the law.

Courbis & Timmel (2009) studied the effects of boats and swimmers on the behavior of spinner dolphins in three Hawaiian coves. They found no correlation between the number of aerial movements performed by the animals and boat traffic or time of day in any of the three coves. However, a reduction in aerial behavior patterns was recorded in relation to previous research, suggesting anthropic activities may have reached sufficient levels to affect the daily pattern of spinner dolphin activities.

Since spinner dolphins were more likely to follow slow-moving boats mindful of regulations, this investigation shows that compliance with legislation, particularly in regard to speed, is efficient in whale-watching tourism, increasing proximity between tourists and dolphins. When vessels disregarded norms, following behavior recorded was less frequent.

Prevalence of slow dolphin movement recorded in this study in the presence of boats at low speed demonstrates that compliance with current laws in Fernando de Noronha is efficient in minimizing the impact caused by the constant presence of boats in close proximity to dolphins. Nevertheless, enforcement and environmental education must be intensified since high speed boats among dolphin pods prompted faster movement by the animals, suggesting escape tactics.

Following behavior by spinner dolphins in the wake of boats in Hawaii was described by Norris & Dohl (1980) as a form of diversion, allowing the main group to escape. Low frequencies were reported for this behavior in the present study when dolphins and boats were in the same subarea together.

Most of the high speed vessels recorded in APA-FN are outboard motor-boats, producing noise more disruptive to cetaceans than inboard engines (Silva-Jr. 2010). The former are also more likely to run over dolphins, as reported by Camargo & Bellini (2007) who found an adult *S. longirostris* wounded as a result of collision with a boat.

There are a number of differences between inboard engine and outboard motor-boats. When studying the impact of different engines on humpback whale (*Megaptera novaengliae*) behavior, Au & Green (2000) found that the rotations required per minute (RPM) for an outboard motor-boat to reach a specific pressure level are much higher than the RPM needed for inboard engine vessels, which have larger propellers.

Boat tours for dolphin watching in Fernando de Noronha follow two fixed routes. Vessels authorized to enter PARNAMAR-FN, all with inboard engine, leave from Santo Antônio, pass through the secondary islands and into the "Inner Sea" to the opposite end of the archipelago, Sapata point, returning the same way. This trip lasts an average of 3 hours and takes place in the morning and afternoon. Boats unable to enter PARNAMAR-FN, are typically involved in tow diving and travel mostly within Santo Antônio Bay.

Since dolphins are present in Baía dos Golfinhos 95% of the year, generally leave in the afternoon traveling east towards the "Inner Sea"

(Silva-Jr. 1996), and of 90% in Santo Antônio Bay and Entre Ilhas area, chances of boat meeting the animals is high. This may explain the lack of significant differences when analyzing time and number of boats close to dolphins they were or were not following these vessels. This meetings are common so that boat operators do not need to increase the number of trips or spend more time in close proximity to the animals to please the tourists. Moreover, nautical tourism is the main attraction on Fernando de Noronha and includes boat trips, tow diving, scuba diving, fishing and sunset cruises. As a result, tourists rarely travel by boat only once during their stay, giving them several opportunities to meet dolphins during these activities.

The results of this study revealed that the main meeting point between spinner dolphins and boats at Fernando de Noronha is currently the entre Ilhas area, followed by area 5 (Biboca) according to Tischer (2011), and therefore as dolphins spend more time in the above region it is also expected that boats also spend more time near the dolphins in this area. The different sizes of subareas did not affect the analysis. At Biboca, which belongs to the APA-FN, primary impacts were related to high levels of boat traffic in the unit, among them speedboats were frequently observed at high speeds.

The outboard motor-boats would spend more time in close proximity to dolphins since they have greater flexibility in routes and tour times and cannot enter PARNAMAR-FN. Inboard engine vessels usually conduct tours within the "Inner Sea" based on established routes and tour duration times and are authorized to travel in the Entre Ilhas area, where meeting with dolphins is likely. Nevertheless, no significant difference was recorded. This may be due to the behavior of outboard motor-boats, which are more prone to disregarding legislation, primarily in relation to speed when passing spinner dolphin pods, possibly causing dolphins to distance themselves.

Spinner dolphins at Fernando de Noronha show behaviors that are biologically significant in maintaining population stability, including resting, reproduction and parental care (Silva-Jr. 2010). If this stability is altered as a result of anthropic activities, spinner dolphin pods regularly visiting archipelago will be under serious threat. According to Silva-Jr. (1996), the more time and energy dolphins spend interacting with boats, the less they rest and reproduce, which may result in long-term decrease of dolphin populations observed on Fernando de Noronha.

A nautical study called made for the Marine National Park of Fernando de Noronha (Luis-Jr.

2009) recommends closing the Entre Ilhas area to boat traffic and scuba diving and placing signal buoys in the prohibited zone in order to minimize the impact of nautical tourism on the spinner dolphin population in Fernando de Noronha.

Concluding, the present study confirms that nautical tourism in Fernando de Noronha has an impact on the spinner dolphin population. However, dolphin watching for the archipelago can be sustainable and its effects could be minimized if the recommendations of the nautical study Estudo de Capacidade de Suporte Náutico-PARNAMAR-FN regarding spinner dolphins were implemented and regulations laid out in the APA-FN Management Plan were met; permanent environmental education programs were implemented for tourists and boat operators; as well legislation protecting cetaceans at Fernando de Noronha were rigorously enforced and infractions penalized and tour-boat operators complied with these protection laws.

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