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Alteration of Southern Right Whale (*Eubalaena australis*) Behaviour by Human-Induced Disturbance in Bahía San Antonio, Patagonia, Argentina

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Abstract

A study was conducted to assess the behavioural response of southern right whales (*Eubalaena australis*) to human-induced disturbance in Bahía San Antonio, Province of Río Negro, Argentina. Behavioural observations were made from June to October in 2008, 2009, and 2010. Aerial observations carried out in 2010 show that up to one third of the whale groups were mating groups, indicating that the study area is an important reproduction area for the species. The study compares 65.8 h (on a total effort of 120.3 h and 24 groups of whales) of land-based "undisturbed" whale behaviour observations to 43.6 h of boat-based whale behaviour in a "disturbed" state (total effort of 326.1 h and 34 groups of whales). Analysis of the behavioural data show that whales significantly altered their behaviour by cutting social interactions short (on average 13%) when confronted with human short-range presence. At the same time, travelling whales experienced a significant increasing tendency to continue travelling (+21%) instead of starting to rest (-21%). However, social behavioural patterns returned swiftly to normal levels after the approach had ended, with a relative increase in "resting" (+18%) as opposed to "travelling" (-30%) rates.

These data show that whale behaviour is altered by human approaches, pointing out the need for effective conservation measures and mitigation of behavioural impacts in relation to whale-based tourism.

Key Words: southern right whale, *Eubalaena australis*, behaviour, tourism, human-induced disturbance

Introduction

The distribution of the southern right whale (*Eubalaena australis*) ranges from 18° S to 50° S (de Oliveira Santos et al., 2001). Every year, the whales migrate from their Sub-Antarctic summer feeding grounds to the coasts of the southern continents and islands, mainly to calve and mate (Payne, 1976; Whitehead et al., 1986; Payne et al., 1990; Best, 2000; Rowntree et al., 2001). In recent decades, the population of southern right whales is recovering from historical whaling (Best & Underhill, 1990; Payne et al., 1990; Cooke et al., 2001), and historical wintering grounds are gradually being repopulated (de Oliveira Santos et al., 2001; Iñíguez et al., 2003; Piedra et al., 2006). This trend has also been observed in the study area of Bahía San Antonio, Province of Río Negro, Argentina (Failla et al., 2008). This apparent increase in right whale presence in Río Negro consequently led to an increased interest in this species for local whale-based tourism.

In Argentina, the southern right whale was declared a "Natural Monument" in 1984, assigning the maximum national protection status to the species. Over the years, all the Argentine Patagonian provinces also separately assigned protective statuses to this species. As such, in 2006, the province Río Negro declared the southern right whale a "Natural Monument" within the provincial law 4066/06, and they endorsed within this same law whale-based tourism, including both whale-watching and swimming-with-whales activities, the latter being unique in the country.

Boat-based whale-watching, and especially swimming-with-whales, is a touristic activity that has been debated in Argentina for several years. Although legal in Río Negro and being increasingly commercialized, no regulations or conservation measures are in place, and no controlling body has been assigned to ensure the sustainability of the activity. As a consequence, whales are being approached often in a fast and uncontrolled way.

Although the majority of cetacean-based tourism worldwide is boat-based and does not include swimmers entering the water, swimming with large whales occurs in at least 20 locations globally, including areas where it is strictly forbidden (Chubut, Argentina and Azores, Portugal) (Rose et al., 2003; Lundquist et al., 2008). In general, very few studies have examined the behavioural impact of swim-with activities on large whales (e.g., see Valentine et al., 2004), and the few data available are often based on opportunistic interactions under uncontrolled conditions (Ritter & Brederlau, 1999; Kiefner, 2002; Magalhães et al., 2002), making the short- and long-term consequences of this activity hard to estimate. This study aims to determine if southern right whales undergo a change in behaviour in response to controlled human approaches in the study area, both by vessels and swimmers in the water, and whether the initial behaviour of the whale can be used to predict their behavioural reaction. This information seems essential at this time of creating and implementing adequate conservation measurements.

Materials and Methods

Data were collected in Bahía San Antonio, a relatively shallow bay (maximum depth 30 m) located in the northwestern region of the San Matias Gulf (40°50' S, 64°50' W), Rió Negro, Patagonia, Argentina (Figure 1).

Behavioural Observations

Behavioural observations of southern right whales were made during the months of June to October of 2008, 2009, and 2010, both from the shore and from a small boat. Boat-based surveys were carried out from a dedicated research vessel (KIEL zodiac [4.6 m] with a Suzuki 40 hp outboard motor). Land-based observations were made by two observers from a 20-m cliff using Nikon binoculars 8 × 40, a Kowa telescope TSN-822 20-60 × 82, and a Kenko Volare telescope 20 × 50. Undisturbed behavioural data were collected from the land-based observations as it was assured that no vessels were in the water during the survey time.

At all times, whales were chosen for observation based on their visibility and proximity to the observers. All data were noted on standardized observation sheets.

A group of whales was determined as two or more whales at a distance less than three body lengths of an adult whale (approximately 45 m; Cassini & Vila, 1990). When whales were observed, data were recorded on group size and composition using the following categories: (1) *solitary whale*; (2) *mother and calf* (M&C), defined as an adult whale in close association with a whale notably smaller in size with orange-coloured callosities; (3) *Surface Active Group* (SAG), defined by their apparent courtship behaviour (Kraus & Hatch, 2001); and (4) *non-classified groups* (NC groups, including *non-SAG*; Best et al., 2003).

Focal animal observations (Altmann, 1974; Martin & Bateson, 1993) were used to record instantaneous individual point samples of the behavioural patterns of a focal whale every 5 min using three mutually exclusive behavioural states following the assumptions of Lusseau (2003) and as applied previously by Lundquist et al. (2008): (1) *rest* when the animal is motionless in the water; (2) *travel* when the animal is moving from one location to another leaving surface "footprints"; and (3) *socializing and or aerial activity* (social/AA) when the animal is causing white water at the surface by rolling, breaching, tail- or flipper-slapping, or when the focal animal is actively rubbing, touching, or circling around another whale. A behaviour pattern was defined as "not classified" (NC) when it could not be clearly assigned to one of these behavioural states. In the case when a vessel was involved, it was recorded whether the whale approached the boat (orienting and moving in the direction of the vessel), was neutral to the boat (no movement towards or away from the vessel), or avoided the boat (orienting and moving away from the vessel). It was also noted whether the boat approached the whale actively (orienting and moving in the direction of the whale), remained neutral (no movement towards or away from the whale), or moved away from the whale (orienting and moving away from the whale).

During boat-based observations, whales were approached from their side in a slow and controlled way to evaluate the impact of this interaction on their undisturbed behavioural patterns. In case swimmers were involved, they were placed slowly in the water at a maximum distance of 100 m from the whale. At all times, swimmers remained within 50 m of the vessel and stayed in the water until the whale had moved more than 100 m from the swimmer. Behavioural observations were made *before* a boat approaches (BI), *during* a boat approach and/or swimmer interaction (DI), and *after* swimmers exited the water and/or the boat left the area (AI) (adapted from Bejder & Samuels, 2004; Lundquist et al., 2008). *Before* was defined as all activity from the moment behavioural observations started to the moment the boat first approached a distance of 500 m from the animal. *During* began when the boat approached within 500 m of the animal, including the entire time the boat was near the whale and/or the swimmers were in the water, and ended when the boat travelled more than 500 m from the animal. *After* was then defined as when the boat returned to the coast and travelled more than 500 m from the whale. When whales showed an avoidance behaviour as defined above, they were approached no more than two times to exclude cumulative effects of disturbance. Distance between the whale and boat was estimated using a range stick and a trained observer. The behavioural observations were made using Nikon binoculars 8 × 40 when necessary.

The behavioural data were then analysed as a series of time-discrete Markov chains as suggested by Lusseau (2003) and Lundquist et al. (2008). A first-order Markov chain was used to build a matrix of preceding behavioural patterns vs succeeding behavioural patterns for each transition within the BI, DI, and AI chains. Transition probabilities (from preceding to succeeding behavioural pattern) were determined in the BI, DI, and AI chains by dividing the number of times a transition from preceding behavioural pattern *i* to succeeding behavioural pattern *j* was observed by the total amount of times behaviour *i* was seen as the preceding behavioural pattern.

This analysis was performed on the entire dataset regardless of group composition of the whales. Despite being rather limited, the dataset was fractioned to take into account the interaction type (boat vs boat + swimmers). When comparing the calculated transition probabilities between the BI, DI, and AI chains, a Z-test for proportions (Fleiss, 1981) was used to test whether the interactions had a significant effect on the behavioural patterns of the whales. All statistical analyses were performed using the software *STATISTICA 7.0* (StatSoft, Inc., 2004) and Zar (1996).

Aerial Surveys

Additionally, monthly aerial surveys were conducted in Bahía San Antonio from August to November 2010. These surveys were conducted in the frame of another research topic concerning relative abundance of whales in the area, and only obtained data on group size and composition were used in this study. The aerial transects were designed using *DISTANCE 5.0* (Thomas et al., 2010) and consisted of 14 parallel North-South (up to S 40.9°) transect lines with a 2.5 km separation, covering a total surface of 418 km² (mean coverage probability [CP] = 0.78; Figure 1). Transect length was determined by safety restrictions on the airplane.

Aerial surveys were conducted in good weather conditions and calm sea states (Beaufort 3 or less) using a high-wing Cessna 152 with flat windows. Due to the small size of the aircraft, only one person could travel next to the pilot during each flight. Hence, observations were made to one side only. Average speed and altitude of the aircraft were kept constant during the surveys at 90 kts (166 km/h) and 213 m, respectively.

When a group of one or more whales was sighted, data were recorded on species, location (using a Garmin GPSMap 60CSx; WGS 84), time, and group size.

Results

Aerial Surveys

In total, four aerial surveys were conducted, resulting in a total flight time of 8.2 h. During these surveys, 131 whales (including calves) were observed in 60 groups, which were distributed evenly throughout the entire bay. Individual group sizes ranged from one to five whales with a mean group size of 1.6 animals (SD = 0.83). Most encounters were solitary animals (58%), followed by active mating groups (SAG; 35%), NC groups (5%), and M&C pairs (2%) (Figure 2); these encounters remained relatively constant across the different aerial surveys.

Land-Based Observations

The total land-based observation effort amounted to 120.3 h. This effort resulted in 65.8 h of undisturbed behavioural data of 24 focal whales (chosen

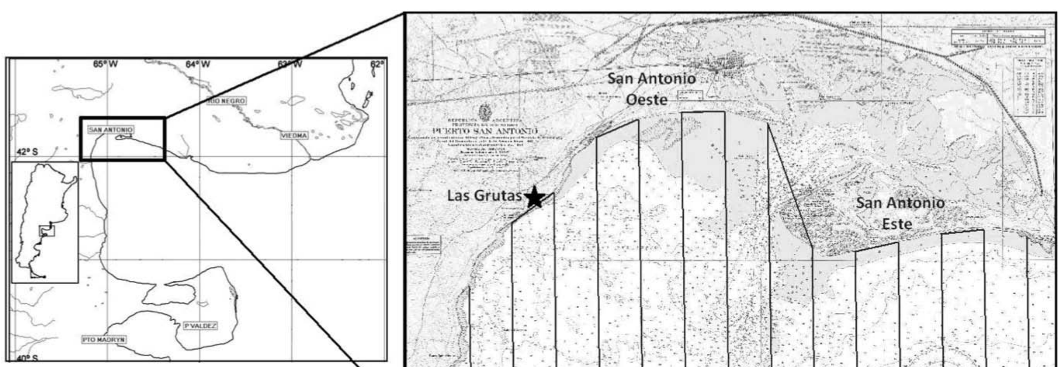

Figure 1. Study area and transect design for aerial surveys; star indicates site of land-based observations.

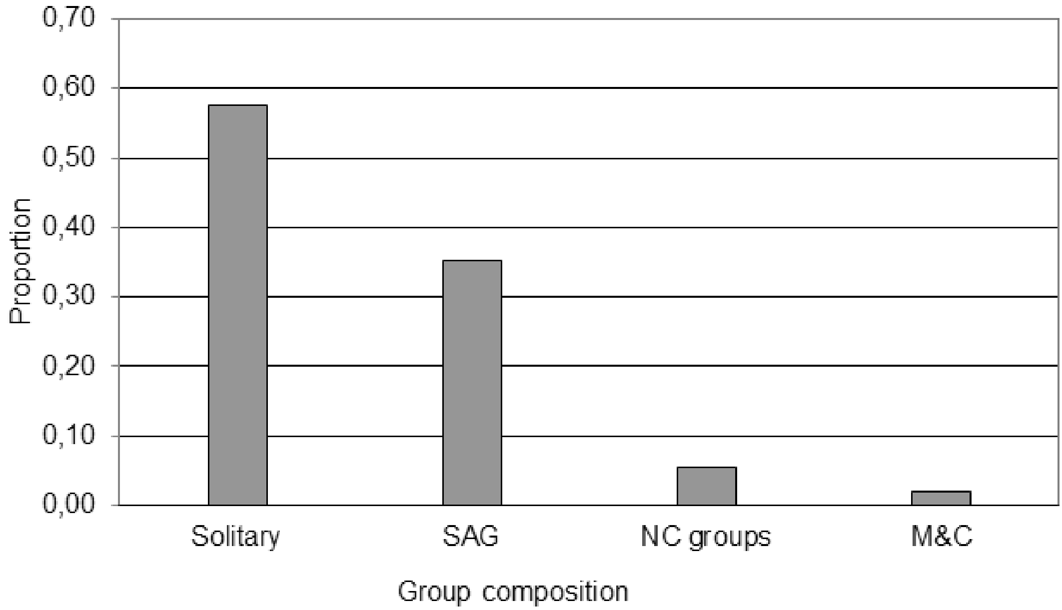

Figure 2. Group composition of southern right whales in the study area (aerial surveys 2010; N = 60); SAG = Surface Active Group, NC = not classified, and M&C = mother and calf.

by proximity to observation point) consisting of solitary whales (46%), focal whales in SAGs (33%), and NC groups (21%). No M&C pairs were seen from land. Results indicated that the undisturbed time-budget of these whales included mainly social/AA behavioural pattern (42% of their time-budget) and travel (41%), whereas resting accounted only for 11% (the other 6% of the behavioural patterns could not be classified accurately due to the large distance).

Boat-Based Observations

Boat-based observation effort amounted to 326.1 h (or 2,145 km) of which 77.6 h was spent in the presence of 74 focal whales, chosen based on visibility and proximity to the boat. Focal whales were solitary in 35% of the encounters, whereas 42% were found in a SAG, 21% in an NC group, and only 1% was a female with an associated calf. As only a very low number of M&C pairs (n = 1) were observed, and previous studies already indicated that M&C pairs are most affected by interactions with humans (Payne, 1986; Lundquist et al., 2008), they were disregarded here for further analysis. All other data were further analysed regardless of group composition and age class of the focal whale.

Behavioural Response to Human Approaches

To ensure the quality of the data, observations were selected that included at least 15 min in each of the BI, DI, and AI segments, resulting in a total of 43.6 h of behavioural data of 34 whale groups for analysis (9.6 h BI; 25.3 h DI; 8.7 h AI). Out of these whale groups, 20 were approached only by a boat and 14 with a boat and one or more swimmers. The time-budget of these whales before interaction included mostly social/AA behavioural patterns (66%), with the other 34% equally divided between resting and travelling. This time-budget was altered during an interaction and returned more or less to previous levels immediately after the interaction had ended (distance to whale > 500 m) (Figure 3).

To test whether the behavioural data in the BI chain could be used as "undisturbed" behaviour, a comparison was made between the transition probabilities resulting from the behavioural data of land-based observations (without vessels in the water and, thus, without impact) and the ones of boat-based observations at a distance > 500 m (BI). As no significant differences could be found in the transition probabilities resulting from both types of observations, it was suggested that the BI chain could be used as "undisturbed" behavioural data to measure the impact of anthropogenic approaches on the behavioural state of the whales.

The decrease in the proportion of time a whale spent in a social/AA behavioural pattern during an interaction shown in Figure 3 was also reflected in a decrease of the transition probability between the BI and DI segments (-13%; $p < 0.05$). Furthermore,

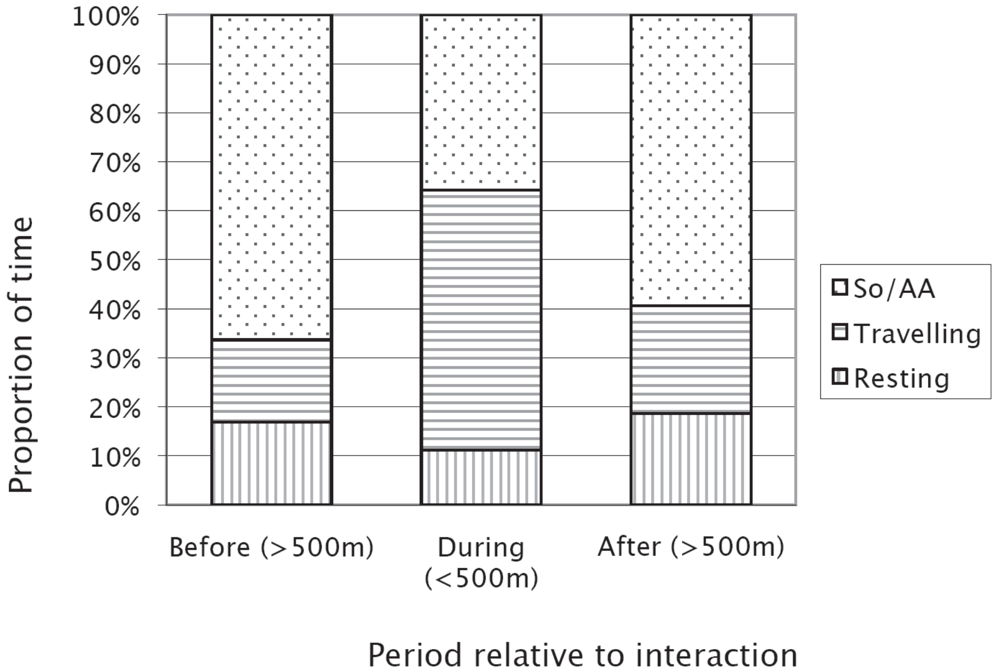

Figure 3. Proportion of time spent in each behavioural state before, during, and after an interaction in Bahía San Antonio (n = 34 focal whales)

the probability of a travelling whale starting to rest during an interaction decreased significantly (-21%; $p < 0.05$), whereas the probability of it continuing to travel at that time increased significantly by 21% ($p < 0.05$) (Figure 4). A comparison between the DI and AI chains showed a significant increase in the transition probability from travel to rest (+18%) and a significant decrease in the transition from travel to travel (-30%). Comparing the BI and AI chains showed no significant alterations of the behavioural patterns after an interaction had ended ($p > 0.05$ on all transitions).

Although sample sizes were relatively small, the transition probabilities of BI and DI were analysed separately for interactions with only boat vs boat + swimmer. When whales were approached by only boats (n = 20 focal whales), a significant decrease was seen in the probability of a whale remaining in a social/AA behaviour (-11%; $p < 0.05$) and altering their behaviour from travelling to resting (-29%; $p < 0.05$). When swimmers were also involved in the interaction, a stronger decrease could be found in the probability of a whale remaining in a social/AA behavioural pattern (-32%), but this change did not test as significant, possibly due to a small sample size (n = 14 focal whales; $p = 0.07$).

The reaction of whales (n = 74 focal whales) was analysed in relation to the activity of the boat (either actively approaching the whale, remaining still with the engine off, or moving away from the whale) and the distance of the boat to the whale. Most of the time, whales neither approached nor avoided the boat actively (NC in 80% of the samples). Most avoidance behaviour was recorded when the boat came closer than 500 m to the whale while approaching the animal. The whales hardly ever approached the boat (6% of the time) and, if so, only when the boat was still with the engine turned off at < 100 m (Figure 5).

Discussion

Although overall most of the commercial whale-based tourism does not involve swimmers entering the water (Hoyt, 2001), this "adventurous" form of ecotourism is increasing globally (Bejder & Samuels, 2004). Most of these swim-with activities are based on small cetaceans, but nonetheless, swimming with large whales occurs in at least 20 locations globally (e.g., with dwarf minke whales [*Balaenoptera acutorostrata*] in Australia [Arnold & Birtles, 1999] and humpback whales [*Megaptera novaeangliae*] in the South Pacific [Constantine, 1998; Orams, 1999]).

Generally, previous studies on swim-with activities have demonstrated changes in behaviour of the cetaceans involved, including increase

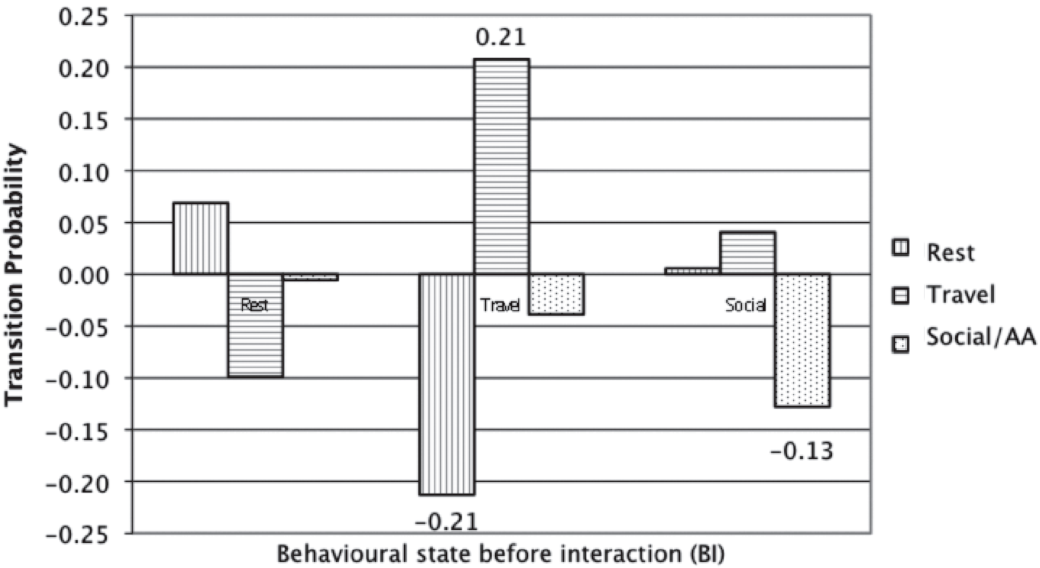

Figure 4. Difference in transition probability of three exclusive behavioural states between BI (x-axis) and DI (categories in legend) segments (n = 34 focal whales); values are only given for the significant changes in transition probabilities (p < 0.05).

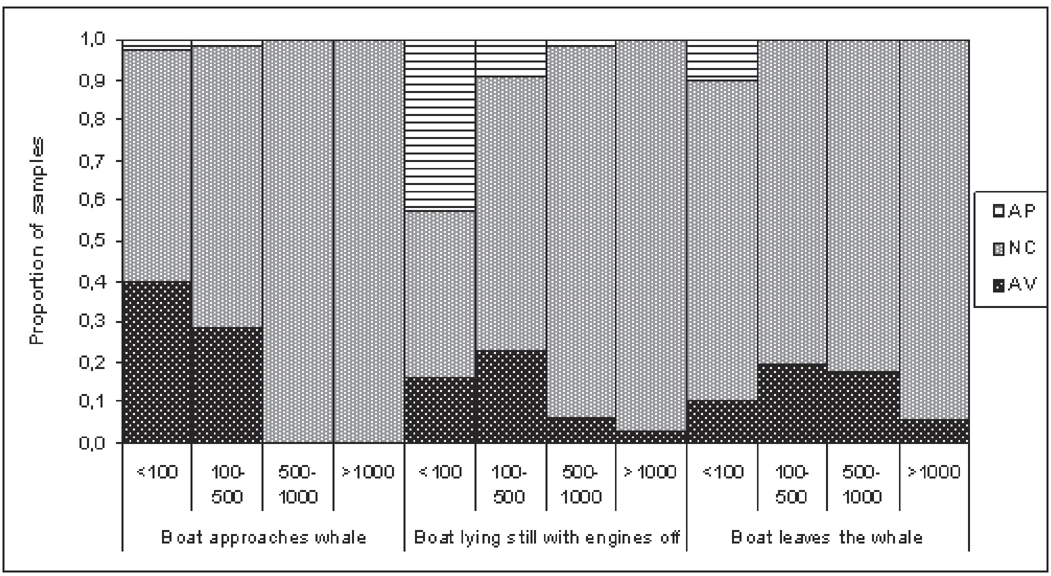

Figure 5. Response of southern right whales in relation to boat activity and distance (n = 74 focal whales); Legend: AP = whale approaches boat, NC = not classified/neutral, and AV = whale avoids boat.

of avoidance (Constantine et al., 2003), increased risk of injury or death due to food provisioning (Samuels & Bejder, 2004), and increased communication and echolocation (Scarpaci et al., 2000). Nevertheless, most of these data come from studies on small cetaceans (Valentine et al., 2004), and although data for other cetacean species may apply to large whales, the behavioural differences between small and large cetaceans are enough to require further investigation on the impact on larger whales specifically (Lundquist, 2007). Data presented in this study are therefore of high importance as they might give a clearer insight on the reaction of larger whales to this upcoming form of "adventurous whale-based tourism."

This study indicated that the initial behavioural pattern of the southern right whales can be used as a tool to predict the whales' behavioural reactions towards anthropogenic approaches. Data reconfirmed that whales are affected in their social/AA behavioural patterns when approached by a vessel (Cammareri & Vermeulen, 2010), and the data further suggest that whales will significantly increase their tendency to continue travelling rather than starting to rest when an interaction occurs. Although social behavioural patterns fell back to normal levels after an interaction had ended, travelling whales then significantly increased their resting behaviour and decreased travelling, raising questions on the existence of a long-term impact of the activity. Overall, previous studies in Argentina have described short-term impacts of human interactions on the behavioural patterns of southern right whales (Rivarola et al., 2001; Lundquist et al., 2008), and dusky and Commerson's dolphins (*Lagenorhynchus obscurus* and *Cephalorhynchus commersonii*, respectively; Coscarella et al., 2003), but up to today, the long-term effects remain unclear (Rivarola et al., 2001). In this evaluation, however, it is essential to consider that in this study whales were approached in a slow and controlled way by one small research vessel; and when a whale avoided the boat, not more than two approach attempts were made. Therefore, it is crucial to take into account that no data are available yet on possible cumulative effects of repetitive and uncontrolled human-induced impacts.

As for a determination of an "impact-zone," whales did not appear to respond (e.g., avoid or approach the boat actively) until the boat entered a 500-m zone from the animal, after which most avoidance behaviour started to occur. These findings, combined with the absence of significant differences between the transition probabilities of the control data from land-based observations and the BI chain (> 500 m), suggest that impacts begin to occur at distances of 500 m.

It was assumed that the presence of swimmers would increase the impact on the whale's behavioural patterns due to increased disturbance as was suggested previously by Lundquist et al. (2008). In swimming-with-whales activities, boats must approach the whales closely and quickly enough to get the swimmers in the water close to the whales, thus generating more disturbance for the whales. The recorded impacts of interactions with swimmers were not significantly stronger but were most likely due to the small sample size.

General data for the study area indicated that one-third of the whale encounters were mating groups, suggesting that the area is important for the reproduction of southern right whales (Cammareri & Vermeulen, 2008, 2010). The data further showed that few M&C pairs were present in the study area, indicating that Bahía San Antonio is not a calving nor nursing ground. According to Payne (1986), M&C pairs are the most vulnerable demographic component, but due to their very low presence in the study area, no data could be gathered on their specific reaction towards human approaches. Nevertheless, a similar research study conducted in Argentina recently reconfirmed their particular vulnerability towards anthropogenic approaches and suggested that these whale groups should be excluded from whale-based tourism at all times (Lundquist et al., 2008). Furthermore, having indicated the significant effect of human disturbance on the social behaviour found mainly in mating groups, and understanding the importance of this behaviour in the reproduction and social learning of juvenile animals (Sironi, 2004), it seems important that the interaction with mating groups is limited and should be controlled in regulations and practice.

Generally, the commercialization and execution of whale-watching activities, with or without swimmer interactions, should remain under regulation. They need to be monitored and controlled in order to minimize their impact on the whales in the region. Doing so, potential long-term impacts can be kept to a minimum, especially when considering the possible importance of the region for the reproduction of the species. Therefore, continuous research seems vital to determine more accurately the influence of group composition, age class, and interaction type (whale-watching vs swim-with-whales activities) as well as the degree of impact (e.g., cumulative effects) the whale experiences when affected by human approaches.

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