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First insights into the effects of swim-with-dolphin tourism on the behavior, response, and group structure of southern Australian bottlenose dolphins

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During the last two decades, observing wildlife has grown from a rare experience to a mainstream tourism activity. Targeted species range from insects, birds, reptiles, and fish to a great variety of terrestrial and marine mammals, including cetaceans (Tapper 2006). Cetacean tourism, in particular, has developed into a global industry over the last 20 yr. At present it is estimated to generate annual expenditures of approximately US$2.1 billion, with 3,300 operators offering cetacean-related experiences and employing 13,200 people worldwide (O'Connor *et al.* 2009). The tourism activities include land-, air-, and vessel-based cetacean watching, dolphin feeding, and swim-with programs (O'Connor *et al.* 2009). This increasing amount of cetacean tourism has raised concerns about the possible impacts on targeted animals and populations (Spradlin *et al.* 2001). Several recent studies on different species have shown that tourism targeting cetaceans can have a negative effect on individual animals and populations (*e.g.*, Constantine *et al.* 2004, Lusseau 2005, Bejder *et al.* 2006*a*, Neuman and Orams 2006, Dans *et* al. 2008, Martinez *et al.* 2011*a*, *b*).

One effect of disturbance by whale and dolphin watching vessels is a change in the activity budget of the target animals, including decreases in the proportion of time

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spent feeding, resting, and socializing (Lusseau 2003*a*, Williams *et al.* 2006, Dans *et al.* 2008, Stockin *et al.* 2008, Steckenreuter *et al.* 2012). In addition, animals may change group cohesiveness or alter their range to avoid areas where boats operate. Bottlenose dolphins in Sarasota, Florida, as well as in Shark Bay, Western Australia, showed tighter group dispersion in the vicinity of vessels (Nowacek *et al.* 2001, Bejder *et al.* 2006*b*). Bejder *et al.* (2006*a*) also suggested that the bottlenose dolphins in Shark Bay may have shifted their range in response to long-term exposure to commercial tourism vessels. Vessel speed, maneuvering, and angle of approach are important factors in dolphin responses (Constantine 2001, Lusseau 2006), with high-impact approaches (crossing path of the animals, invasive placement of swimmers, boats approaching closely and with high speed) generally resulting in increased disturbance of the animals.

Bottlenose dolphins are often targeted for cetacean tourism due to their coastal distribution and residency in some areas. Reported impacts on these animals include changes in the behavioral budgets, dive patterns, movements, and habitat use (*e.g.*, Constantine *et al.* 2004; Lusseau 2004, 2005; Bejder *et al.* 2006*a*; Lusseau 2006; Stensland and Berggren 2007). Behaviors such as feeding, resting and socializing are crucial for the reproductive success of a population (Bronson 1985), and interruptions of these behaviors could possibly lead to lower reproduction rates and population declines in the medium to long-term (Lusseau 2004, Stensland and Berggren 2007, Dans *et al.* 2008). Nursing of dolphin calves, for example, often takes place while the animals are resting, and therefore a disturbance of resting behavior has been suggested to affect the survival of calves (Bejder *et al.* 2006*a*, Stensland and Berggren 2007). In addition, bottlenose dolphins have been shown to stay in closer proximity to each other when vessels are present than when vessels are not present (Nowacek *et al.* 2001, Bejder *et al.* 2006*b*). Since a group provides enhanced predator detection and vigilance (Elgar 1989), animals seeking close contact to each other could presumably be a sign that they are stressed or sense danger (Johnson and Norris 1986).

In Australia cetacean tourism has been increasing rapidly with an annual growth rate of 8.3% in the last 10 yr (O'Connor *et al.* 2009). In 2008, more than 1.6 million tourists participated in whale and dolphin watching activities in the country, which were provided by 137 operators (O'Connor *et al.* 2009). In 2005 the Australian Commonwealth and state governments jointly developed the "Australian National Guidelines for Whale and Dolphin Watching" to provide clearly defined codes of conduct for all human activities involving wild cetaceans (Department of Sustainability, Environment, Water, Population and Communities 2006). Based on these guidelines, South Australia (SA) has gazetted regulations in December 2010 (Department of Environment and Natural Resources 2010). However, there is no empirical evidence to support these recommendations, and it is likely that impacts of whale and dolphin watching are species, population, and/or site specific (Bejder and Samuels 2003). Since no empirical studies on the effects of cetacean watching on local dolphin populations have been conducted in South Australia, such studies are necessary for the development of robust guidelines and regulations.

In this study we investigated the impacts of cetacean tourism on southern Australian bottlenose dolphins (*Tursiops australis*) inhabiting Adelaide coastal waters, in the Gulf of St. Vincent, South Australia. This species appears to be endemic to southern Australia (Möller *et al.* 2008) and has been recently described (Charlton-Robb *et al.* 2011). In particular, we assessed whether vessel approaches and the presence of swimmers in the water had an effect on the behavior, response, and cohesiveness of bottlenose dolphin groups in Gulf St. Vincent. In addition, we investigated whether these parameters varied depending on dolphin group size and age-class composition.

Observations of bottlenose dolphins involved in interactions with swimmers were conducted during the autumn season, between March and May 2010. Gulf St. Vincent is a shallow basin bordered by Yorke Peninsula in the west and Fleurieu Peninsula in the southeast. The vessel-based observations took place in an area of approximately 100 km^2 along the coastline from Henley Beach to Port Stanvac, approximately 25 km alongshore and up to 5 km offshore (Fig. 1). We conducted observations from the tourist vessel *Temptation*, a 58 ft × 32 ft aluminum, high-performance sailing catamaran powered by two 2 × 37.5 hp outboard engines. Currently the dolphin tourism in Adelaide coastal waters consists of only this operator who offers both swim-with dolphin and dolphin watching. The operator runs a maximum of one tour per day, which lasts for approximately three hours. The operator has been conducting commercial trips in this area (Fig. 1) several times a week since January 2002. Commercial trips do not follow a set survey route; therefore the vessel track was not consistent on a daily basis (see Fig. 1).

Observations were only conducted in calm sea conditions (*i.e.*, Beaufort sea state <3 and swell <1 m) between 0730 and 1130. The track of the vessel and the position of each dolphin group sighted were collected using a Garmin Oregon 400c portable Global Positioning System (GPS). We used a 50 m chain rule to define groups, so all individuals in a group were within 50 m of at least one other member of the group; engaging in similar behavior and heading in the same direction when traveling. Groups were considered to be independent as they were sampled on different days. The possibility of pseudoreplication within a given day was low because we were able to visually identify part of the animals in a group either *via* photo-ID or by eye (many animals were visually recognized by the experienced operator and crew based on the dolphins' nicks and notches) and because the boat generally followed a north to south direction of movement along the coast.

Once a group of dolphins was sighted we recorded the time, group size, number of calves and juveniles, predominant behavior (*i.e.*, the behavioral state of ≥50% of the individuals at the surface), response (direction of movement of ≥50% of the individuals at the surface with respect to the vessel) and group cohesiveness. This information was recorded every two minutes using focal group scan sampling (Altmann 1974, Mann 1999). The predominant behavior of a dolphin group was determined using behavioral categories modeled on definitions established by Shane *et al.* (1986) (Table 1). The following definitions were established for group composition: calves (up to one-half body length of an adult and closely accompanied by an adult); juveniles (more than one-half but less than three-quarters the body length of an adult); and adults (individuals approximately 2.5–3 m in body length). Group cohesiveness was defined as either loose (more than one adult body length apart) or tight (less than one adult body length apart). Group size was categorized as either small (1–4 animals) or large (5–15 animals). The response of the dolphins in relation to the vessel was classified into four categories according to defined criteria (Table 2).

Once the dolphins were sighted, the operator approached them slowly up to 50 m and maneuvered the vessel slightly ahead of the group, moving in the same direction as the animals. Vessel speed and type of approach were consistent during the fieldwork period (KJP, personal observation). If the dolphins approached the vessel to less than 30 m, the swimmers were placed in the water holding onto either one of two ropes ("mermaid lines") that were attached to the stern of the vessel.

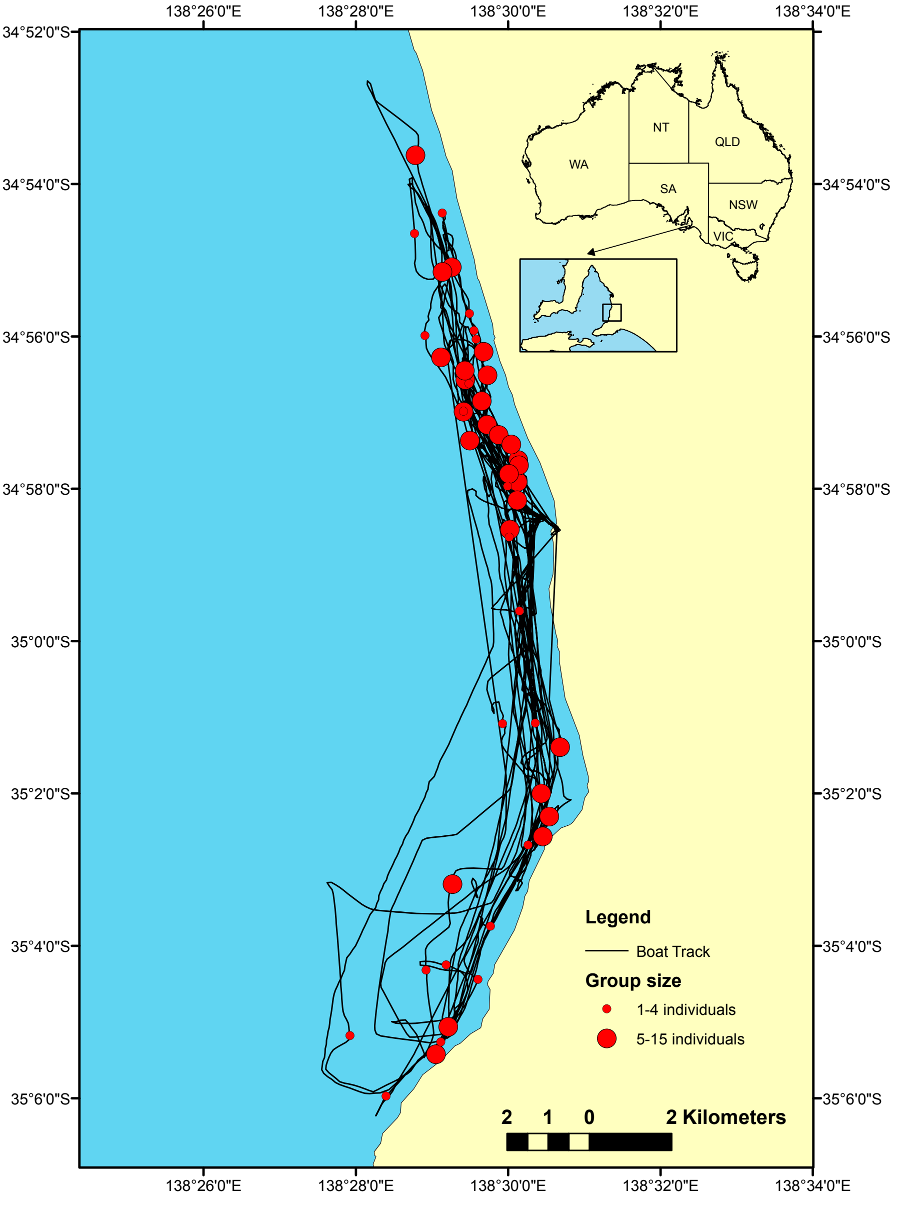

Figure 1. Map showing location of the study area in Adelaide coastal waters, South Australia, with vessel tracks and locations where dolphin groups were initially sighted.

The behavioral sampling was conducted in three stages: (1) before swim (dolphins have been spotted but no swimmers are in the water, (2) during swim (swimmers are in the water with the dolphins, (3) after swim (swimmers are back on board of the vessel but dolphins are still visible). If the sampling stage changed while an interval

Table 1. Behavioral state definitions (adapted from Shane *et al.* 1986).

Behavioral state	Definition
Socializing (S)	Dolphins observed leaping, chasing and engaged in body contact with each other. Involves aspects of play and mating with other dolphins. Serves a social and sexual role.
Feeding (F)	Dolphins involved in any effort to capture and consume prey as evidenced by chasing on the surface, deep diving and circle swimming. Prey is sometimes observed.
Resting (R)	Dolphins engaged in slow movements as a tight group, generally lacking the active components of the other behaviors described.
Traveling (T)	Dolphins engaging in persistent, directional movement.
Milling (M)	Dolphins show frequent changes in heading but stay in one location and usually close to the surface.

Table 2. Definitions for responses of dolphins to vessel and swimmers.

Response	Definition
Approaching swimmers	Dolphins swim within 5 m of the swimmers.
Approaching boat	Dolphins swim within 5 m of the vessel.
No response	Dolphins do not change their direction of movement.
Avoidance	Dolphins actively change their path of travel away from the vessel and the swimmers.

was being recorded, that interval was discarded and a new 2 min interval was started. To avoid bias between different observers, all observations were undertaken by the same observer (KJP) throughout the study period.

To analyze changes in the behavior of the dolphins in relation to swimmers presence and absence, we developed first-order Markov chains. Markov chains measure the dependence of an event on preceding events, and therefore probabilities of transition from one event to another can be calculated (for detailed information see Caswell 2001). Since this method provides insights into the temporal dynamics of the behavioral states, it has been used in several studies investigating the impact of tourism on cetacean behavior (Lusseau 2004, Dans *et al.* 2008, Stockin *et al.* 2008).

Data were arranged in two-way contingency tables as described in Lusseau (2003*a*), including the preceding behavior *vs.* the succeeding behavior. Due to the small frequencies of observed resting behavior ($n = 10$ transitions that involved resting), this behavioral state was excluded from the analysis. One table with data of the sighting stage "during swim" was classified as "impact" table, data of the stages "before swim" and "after swim" were tallied into "before impact" and "after impact" tables. The transition probabilities (from preceding to succeeding behavior) were calculated for all three chains as:

$$p_{ij} = \frac{a_{ij}}{\sum_{j=1}^{4} a_{ij}}, \quad \sum_{j=1}^{4} = 1$$

where $p_{ij}$is the transition probability from preceding behavior i to succeeding behavior j and a_{ij} is the number observed transitions from behavior i to behavior j. Transition probabilities were compared using a z-test for proportions (Zar 1996). To calculate the activity budgets, we arranged the transition probabilities in three stochastic matrices (one for each stage). We then estimated the behavioral budgets for each stage from the left eigenvectors of the dominant eigenvalues of the transition probability matrices (for details see Caswell 2001 and Lusseau 2004). Eigenanalyses were conducted using the PopTools add-in for Excel version 3.2.5 (Hood 2010). We then compared the budgets of the stages "before impact" and "impact" and "before impact" and "after impact" using a z-test for proportions (Zar 1996).

To analyze the differences in group cohesiveness, data were arranged in contingency tables including the different sighting stages and group cohesiveness. In order to minimize pseudoreplication, data for each group at each stage were characterized as the predominant (>50% of the 2 min observation intervals) group cohesiveness. When no predominance was obtainable, that stage/group was excluded from analysis of group cohesiveness. To compare group cohesiveness between the three stages we used a z-test for proportions (Zar 1996).

We analyzed the stage "during swim" separately to assess differences in the response of the dolphins to boat and swimmers dependent on groups size and calf presence. Predominant data for each group were obtained as explained above. Response was compared between small and large groups and groups with and without calves using Fisher's exact test for proportions (Fleiss 1981). Analyses of group cohesiveness and response were conducted using IBM SPSS Statistics 19 software.

A total of 63.72 h of survey time was spent in the field over 19 d of study. Surveys were conducted always between 0730 and 1130, ranging between 2.5 h and 3 h a day. During this time a total of 106 dolphin groups were sighted in the study area and approached by the commercial operator (Fig. 1, Table 3). Groups that were only observed for one interval (2 min), or for one sighting stage, were excluded from the analysis (n = 11). If the commercial operator started a second swim with the same group during the same sighting, the data for the second swim were not included in the analysis. In 16 cases the operator decided not to conduct a swim because the spotted group turned out to be a single animal or a single female with a small calf. Both of these situations have been proven to be very unlikely to result in interaction and thus the operator does not try to conduct a swim with these animals. Consequently, data for these approaches were excluded from the analysis. We observed few dolphin groups resting (n = 6), therefore changes in this state could not be assessed. It is possible that by the time we were close enough to the dolphins to determine their behavior, the dolphins had already changed their behavior from resting to another state due to the approaching boat. Additionally, the time of the day our surveys took place may not be a usual resting time for the dolphins of this population. In this case, the chance of observing this behavior would be very low.

Seventy-nine approaches resulted in swim attempts and were included in the analysis. Dolphins were exposed to the swimmers between 1 and 41 min (mean = 8 min, SD = 47.64).

Seventy-two groups were observed for a minimum of two observation intervals in at least one of the sighting stages and could thus be included in the analysis using Markov chains. A total of 285 transitions were recorded including 47 transitions of "before impact" and 174 transitions of "during impact," as well as 55 transitions of "after impact." Behavioral transition probabilities are presented in Figure 2. At any sampling stage (before, during, and after impact), regardless of the preceding behavior, animals were most likely to continue with the same behavior, with the exception

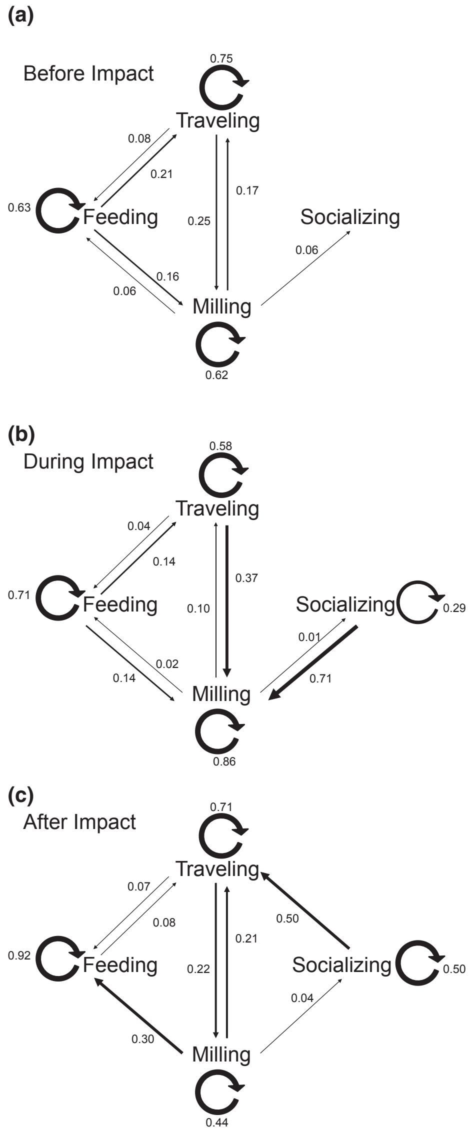

Figure 2. Transition probabilities in before impact (a), during impact (b) and after impact (c) chains. Behavioral states are defined in Table 1. Values are transition probabilities represented by the thickness of arrows.

of socializing "during impact" (Fig. 2). Differences between transition probabilities were not statistically tested given the small sample sizes.

The behavioral budget for traveling, milling, and feeding differed significantly between the three sampling stages (Table 4). The time budget for traveling decreased from "before impact" to "during impact" as well as from "before impact" to "after impact" ($z = 6.35$, $P < 0.001$ and $z = 3.61$, $P < 0.001$, respectively). The time

Table 3. Number of groups/day and dolphins/group encountered during the fieldwork period.

Date	# Groups/day	# Dolphins/ group
2 March 2010	3	3, 3, 2
3 March 2010	3	2, 6, 4
4 March 2010	3	7, 3, 5
5 March 2010	2	6, 11
10 March 2010	4	7, 3, 4, 5
11 March 2010	3	2, 4, 7
12 March 2010	4	2, 7, 8, 2
13 March 2010	2	13, 9
15 March 2010	3	7, 8, 10
16 March 2010	4	13, 2, 5, 9
17 March 2010	5	5, 9, 4, 10, 4
18 March 2010	2	6, 4
24 March 2010	5	9, 3, 6, 8, 7
25 March 2010	3	2, 6, 10
26 March 2010	4	3, 8, 9, 9
30 March 2010	5	2, 4, 4, 2, 5
31 March 2010	8	3, 1, 2, 4, 2, 4, 1, 6
2 April 2010	7	5, 2, 1, 2, 6, 8, 4
18 May 2010	2	9, 5

Table 4. Time budget for behavioral states in the three impact stages.

	Time budget (%)			*z*-test	*z*-test
Activity	Before impact	During impact	After impact	Before-during	Before-after
Traveling	50	20	27	6.35, $P < 0.001$	3.61, $P < 0.001$
Milling	31	70	11	6.65, $P < 0.001$	3.12, $P < 0.002$
Socializing	2	1	1	0.27, $P > 0.5$	0.50, $P > 0.5$
Feeding	17	8	61	2.31, $P < 0.5$	6.93, $P < 0.001$

budget for milling increased from "before impact" to "during impact" ($z = 6.65$, $P < 0.001$) and decreased from "before impact" to "after impact" ($z = 3.12$, $P < 0.002$). Comparing the time budget of feeding "before impact" and "after impact," there was a significant increase in the time the dolphins spent feeding "after impact" ($z = 6.93$, $P < 0.001$).

No significant difference was found in the proportion of time dolphin groups were "loose" or "tight" in the three sampling stages (before/during impact: $z = 0.74$, $P < 0.5$, before/after impact: $z = 0.56$, $P > 0.5$). Response was different between large and small groups (Fisher's exact test = 7.759, $P = 0.030$) (Fig. 3). Large groups were more likely to approach the swimmers rather than the boat while small groups were more likely to approach the boat and not the swimmers. Calf presence did not influence the response of the dolphins (Fisher's exact test = 2.548, $P = 0.537$).

Our results indicate that bottlenose dolphins in Adelaide's coastal waters change their behavior significantly when they are exposed to swim-with-dolphin tourism

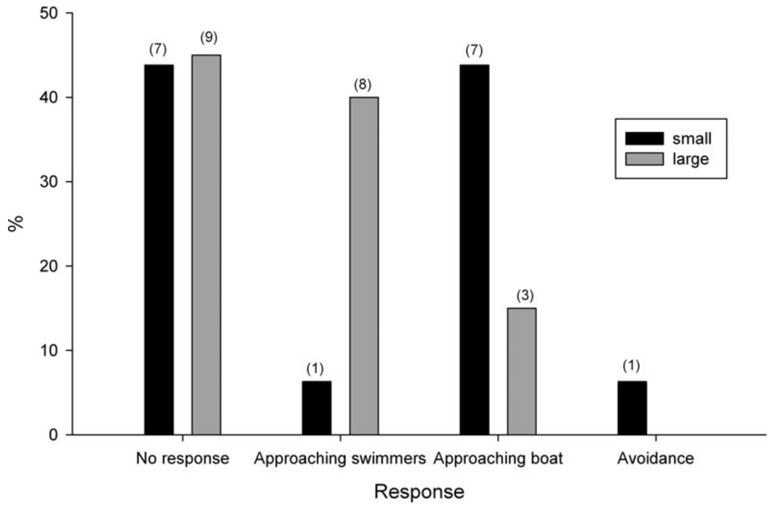

Figure 3. Predominant response of southern Australian bottlenose dolphins "during impact" for the two group size categories (small: 1–4 animals, large: 5–15), *n* is given in brackets.

activities. The shifts in the behavioral budgets show that even after the swimmers exited the water, the behavioral budgets did not return to the same levels they were before the interaction.

Most noticeable is an increase in the amount of milling during the impact stage, while the budgets for the other behaviors decreased during this stage. Therefore, during the impact stage, the involved animals appear to switch from their before impact behavior to milling. This has implications especially for essential behaviors such as feeding, socializing, and resting, since frequent interruptions of these behaviors can have important consequences (see below for further discussion). After the impact, feeding increased to levels higher than before the impact, while milling decreased compared to other stages, and travelling did not return to before impact levels. This suggests that the interaction with the tourist vessel and swimmers altered the dolphins' behavior not only during the time of approach but continued after the boat had left. Since post-impact observation times were usually short, perhaps there has not been sufficient time for the dolphins to regain their before impact activity. Further research is needed to support this.

Similar shifts in behavior have been found in previous studies on impacts of dolphin watching without swim programs. For example, common dolphins (*Delphinus* sp.), dusky dolphins (*Lagenorynchus obscurus*), and bottlenose dolphins (*Tursiops* spp.), showed a decrease in foraging, feeding, resting, and socializing behaviors in the presence of tourism vessels (Lusseau 2003*a*, Dans *et al.* 2008, Stockin *et al.* 2008). These short-term behavioral changes can, if persistent over time, lead to permanent changes in behavioral budgets of the dolphins (Hastie *et al.* 2003, Lusseau 2003*b*) and therefore alter their energy expenditure (Williams *et al.* 2006) and also lead to changes in habitat use (Lusseau 2004, 2005) which can possibly result in changes in population density (Bejder *et al.* 2006*a*). Therefore, although of short-term effect, the aforementioned behavioral changes can transform into long-term alterations that may be harmful to the targeted population.

The type of vessel approach and the swimmer behavior may influence the response of dolphins to dolphin-swim interactions (Constantine 2001, Lusseau 2003*b*, Neuman and Orams 2006, Stensland and Berggren 2007, Martinez *et al.* 2011*b*). In Doubtful Sound, New Zealand, violations of tour-vessel guidelines by dolphin watching operators caused female bottlenose dolphins (*Tursiops* sp.) to increase their dive intervals (Lusseau 2003*b*). Similarly, changes in dive patterns as a response to erratic movements of swimmers and/or vessels were observed for Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) off the south coast of Zanzibar, East Africa (Stensland and Berggren 2007). In the Bay of Islands, New Zealand, it was shown that the type of vessel approach and the placement of swimmers had an effect on the response of common bottlenose dolphins (*T. truncatus*) to the activity (Constantine 2001). Avoidance of vessel and swimmers increased when the operator placed the swimmers directly in the dolphins' path of travel (Constantine 2001). There was also a difference in the response depending on the age of the dolphins, with juveniles more likely to interact with the swimmers than adult dolphins (Constantine 2001). By contrast, in Porpoise Bay, New Zealand, presence of swimmers did not cause a significant change in the direction of movement of Hector's dolphins (*Cephalorhynchus hectori*) (Bejder *et al.* 1999).

In the present study, large dolphin groups were more likely to approach the swimmers than small groups. This could be due to larger groups generally containing juveniles, which have previously been reported to be more interactive with vessels and swimmers (Constantine 2001). In addition, larger group sizes may enhance protection through increased vigilance, predator detection, and group defense (Elgar 1989). As predation and nonlethal human disturbance stimuli create similar trade-offs (Frid and Dill 2002), the level of perceived risk from an approaching tourist vessel may be lower for dolphins in larger group sizes.

We did not find a significant difference in group cohesiveness among the different sampling stages. Several studies have reported that dolphin groups are found in tighter group formation during the presence of tourism vessels (Blane and Jaakson 1994, Bejder *et al.* 1999, Nowacek *et al.* 2001). However, in Porpoise Bay, New Zealand, the presence of swimmers did not appear to influence the cohesiveness of Hector's dolphin groups (*C. hectori*) (Bejder *et al.* 1999).We could not test for the effect of vessel presence (vessel was present during all sampling stages) on group cohesiveness. It is therefore possible that the groups are less tight while the tourist vessel is absent. Nevertheless our results indicate that the dolphins do not perceive the swimmers as a threat, and therefore do not appear to seek enhanced group protection by decreasing interanimal distance. In our study area, the operator approached the dolphins side on, slightly ahead of their path of travel in all observations. This method, called "line abreast" or "parallel approach," has been proposed as the least invasive type of approach during dolphin-swim activities (Constantine 2001, Scarpaci *et al.* 2003), and may explain the lack of change in group cohesiveness in our study during the exposure to swimmers. Furthermore, the use of "mermaid lines" by the operator prevents swimmers from swimming freely towards the dolphins, and therefore allows the dolphins to determine whether a close interaction occurs. This may reduce the level of perceived risk associated with the interaction, potentially leading to lower stress levels and impact on the animals (Moberg 2000). Consequently this may possibly result in closer and longer approaches of dolphins to the swimmers.

When animals are exposed to a stimulus over time, they can develop behavioral habituation or sensitization (Bejder *et al.* 2009). Habituation, defined as a response reduction due to the learning process of the animals that the stimulus is neither harmful nor beneficial (Thorpe 1963), is often considered a positive outcome (Bejder *et al.* 2009). Sensitization, in contrast, is defined as a response increase due to the animals' learning process that the stimulus does have significant consequences for them (Richardson *et al.* 1995). Sensitization to swim-with tourism has been reported for bottlenose dolphins in the Bay of Islands, New Zealand (Constantine 2001). Over time these dolphins increasingly showed avoidance behavior with an increase in the levels of tourism in the area (Constantine 2001). Bottlenose dolphins off Adelaide have been exposed to tourism since 2002. It is unknown whether the dolphins' reactions towards the tourist vessel and behavioral activities have changed over time due to the lack of baseline data without any exposure to tourist vessel or from earlier years of tourism activities.

Interaction times of swimmers with dolphin groups in Adelaide waters are usually short, with a maximum recorded of 41 min and an average of 8 min per group. Compared to other locations, this level of tourism is extremely low. In the Bay of Islands, for example, dolphins are targeted by up to 70 permitted tours a week, with up to 20 tourism vessels at a time, all year round (Constantine *et al.* 2004, O'Connor *et al.* 2009). In Akaroa Harbour, New Zealand, Hector's dolphins are exposed to a permitted maximum of 32 trips per day, including 18 swim-with-dolphin tours (Martinez *et al.* 2011*a*). It is possible that the relatively low exposure situation observed in our study could change in the future. The impact on the coastal dolphin population may be higher if the number of operators in the area increases or if the operator changes the number and length of tours and swimmer interactions. In Shark Bay, long-term studies on tourism impacts have shown a declining trend in bottlenose dolphin abundance in the tour area with an increase from one to two tourism operators (Bejder *et al.* 2006*a*). As this example shows, even a small increase in tourism intensity could have significant impacts on the target animals. Furthermore, a change in the methods of boat approach and/or type of swimmer placement could also result in increased disturbance to the animals. All these factors have been shown to influence impacts of vessel-based tourism on bottlenose dolphins elsewhere (Constantine 2001, Lusseau 2004, Bejder *et al.* 2006*a*). Furthermore, the disturbance by anthropogenic noise produced by boats and swimmers (*e.g.*, the use of auditory stimulants, for details see Martinez *et al.,* 2011*b*) is an important issue (Richardson *et al.* 1995, Lusseau 2006, Nowacek *et al.* 2007), and is likely to increase with tourism intensity.

The cetacean watch industry is a fast growing tourism sector in Australia. As such it is possible that dolphins in Adelaide's coastal waters will be exposed to additional operators in the near future. In order to ensure the long-term sustainability of tourist interactions with dolphins in Adelaide coastal waters, a systematic management of this industry is urgently needed (for a framework model see Higham *et al*. 2008). Further research of this population will help to clarify whether potential inter-seasonal or long-term impacts of these activities occur on the dolphins that inhabit this region. One major limitation of our study is that we were not able to collect data without the presence of the tourist boat. Due to the excellent sound transmission underwater, approaching boats can be audible from a far distance (Nowacek *et al.* 2007). It is possible that we missed reactions from dolphin groups that avoided the tourist vessel before we could observe their presence. This leaves the chance that disturbance of dolphins by swim-with-dolphin tourism in Adelaide coastal waters may be even higher than detected in the present study, which underlines the importance of future research. We suggest that future studies are conducted from an independent research vessel for obtaining prolonged observations of the behavioral budget of dolphins in the absence of the tourism vessel and swimmers, which can be used as a control data set. Furthermore, data on other critical biological parameters such as population estimates (*via* photo ID), reproductive rates, and habitat usage are needed. Through this approach, short and long-term shifts in behavior due to the presence of commercial vessels and swimmers could be recognized by comparing the dolphins' behavioral budgets during impact and control situations, enhancing our understanding of the impacts of dolphin swim interactions. Based on the results of this study, and to follow a precautionary approach, we recommend that the legislation for marine mammal watching in South Australia restricts the number of daily tours and/or operators to minimize impacts on this dolphin population. Given the findings of Bejder *et al.* (2006*a*), we suggest a restriction to one operator per site with a limit of one tour per day for Adelaide coastal waters until more is known about the impacts of swim-with dolphin tourism in this area.

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Literature Cited

Altmann, J. 1974. Observational study of behavior: Sampling methods. Behaviour 49:227–267.

Bejder, L., and A. Samuels. 2003. Evaluating the effects of nature-based tourism on cetaceans. Pages 229–256 *in* N. Gales, M. Hindell and R. Kirkwood, eds. Marine mammals: Fisheries, tourism and management issues. CSIRO Publishing, Collingwood, Victoria, Australia.

Bejder, L., S. M. Dawson and J. A. Harraway. 1999. Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. Marine Mammal Science 15:738–750.

Bejder, L., A. Samuels, H. Whitehead, *et al.* 2006*a*. Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. Conservation Biology 20: 1791–1798.

Bejder, L., A. Samuels, H. Whitehead and N. Gales. 2006*b*. Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. Animal Behaviour 72:1149–1158.

Bejder, L., A. Samuels, H. Whitehead, H. Finn and S. Allen. 2009. Impact assessment research: Use and misuse of habituation, sensitisation and tolerance in describing wildlife responses to anthropogenic stimuli. Marine Ecology Progress Series 395:177–185.

Blane, J. M., and R. Jaakson. 1994. The impact of ecotourism boats on the Saint Lawrence beluga whales. Environmental Conservation 21:267–269.

Bronson, F. H. 1985. Mammalian reproduction—an ecological perspective. Biology of Reproduction 32:1–26.

Charlton-Robb, K., L.-A. Gershwin, R. Thompson, J. Austin, K. Owen and S. McKechnie. 2011. A new dolphin species, the Burrunan dolphin *Tursiops australis* sp. nov., endemic to southern Australian coastal waters. PlosOne 6:e24047. doi:10.1371/journal.pone.0024047.

Caswell, H. 2001. Matrix population models: Construction, analysis, and interpretation. 2nd edition. Sinauer Associates Inc., Sunderland, MA.

Constantine, R. 2001. Increased avoidance of swimmers by wild bottlenose dolphins (*Tursiops truncatus*) due to long-term exposure to swim-with-dolphin tourism. Marine Mammal Science 17:689–702.

Constantine, R., D. H. Brunton and T. Dennis. 2004. Dolphin-watching tour boats change bottlenose dolphin (*Tursiops truncatus*) behaviour. Biological Conservation 117:299–307.

Dans, S. L., E. A. Crespo, S. N. Pedraza, M. Degrati and G. V. Garaffo. 2008. Dusky dolphin and tourist interaction: Effect on diurnal feeding behavior. Marine Ecology Progress Series 369:287–296.

Department of Environment and Natural Resources. 2010. National Parks and Wildlife (Protected Animals—Marine Mammals) Regulations 2010. Government of South Australia. Available at http://www.legislation.sa.gov.au.

Department of Sustainability, Environment, Water, Population and Communities 2006. Australian national guidelines for whale and dolphin watching 2005. Department of the Environment and Heritage, Australian Government. Available at http://www.environment.gov.au.

Elgar, M. A. 1989. Predator vigilance and group size in mammals and birds: A critical review of the empirical evidence. Biological Review 64:13–33.

Fleiss, J. L. 1981. Statistical methods for rates and proportions. John Wiley and Sons, New York, NY.

Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6. Available at http://www.ecologyandsociety.org/vol6/iss1/art11/.

Hastie, G. D., B. Wilson, L. H. Tufft and P. M. Thompson. 2003. Bottlenose dolphins increase breathing synchrony in response to boat traffic. Marine Mammal Science 19:74–84.

Higham, J. E. S., L. Bejder and D. Lusseau. 2008. An integrated and adaptive management model to address the long-term sustainability of tourist interactions with cetaceans. Environmental Conservation 35:294–302.

Hood, G. M. 2010. PopTools version 3.2.5. Available at http://www.poptools.org.

Johnson, M. C., and K. S. Norris. 1986. Delphinid social organisation and social behaviour. Pages 335–346 *in* R. J. Schustermann, J. A. Thomas and F. G. Wood, eds. Dolphin cognition and behaviour: A comparative approach. Lawrence Erlbaum Associates, Hillsdale, NJ.

Lusseau, D. 2003*a*. Effects of tour boats on the behavior of bottlenose dolphins: Using Markov chains to model anthropogenic impacts. Conservation Biology 17:1785–1793.

Lusseau, D. 2003*b*. Male and female bottlenose dolphins *Tursiops* spp. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. Marine Ecology-Progress Series 257:267–274.

Lusseau, D. 2004. The hidden cost of tourism: Detecting long-term effects of tourism using behavioral information. Ecology and Society 9. Available at http://www.ecologyandsociety.org/vol9/iss1/art2/.

Lusseau, D. 2005. Residency pattern of bottlenose dolphins *Tursiops* spp. in Milford Sound, New Zealand, is related to boat traffic. Marine Ecology Progress Series 295:265–272.

Lusseau, D. 2006. The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. Marine Mammal Science 22:802–818.

Mann, J. 1999. Behavioral sampling methods for cetaceans: A review and critique. Marine Mammal Science 15:102–122.

Martinez, E., M. B. Orams and K. A. Stockin. 2011*a*. Swimming with an endemic and endangered species: Effects of tourism on Hector's dolphins in Akaroa Harbour, New Zealand. Tourism Review International 14:99–115.

Martinez, E., M. B. Orams, M. D. M. Pawley and K. A. Stockin. 2011*b*. The use of auditory stimulants during swim encounters with Hector's dolphins (*Cephalorhynchus hectori hectori*) in Akaroa Harbour, New Zealand. Marine Mammal Science 28:E295–E315.

Möller, L. M., K. Bilgmann, K. Charlton-Robb and L. B. Beheregaray. 2008. Multi-gene evidence for a new bottlenose dolphin species in southern Australia. Molecular Phylogenetics and Evolution 49:674–681.

Moberg, G. 2000. Biological response to stress: Implications for animal welfare. Pages 1–21 *in* G. P. Moberg and J. A. Mench, eds. The biology of animal stress: Basic principles and implications for animal welfare. CABI Publishing, Wallingford, U.K.

Neumann, D., and M. Orams. 2006. Impacts of ecotourism on short-beaked common dolphins (*Delphinus delphis*) in Mercury Bay, New Zealand. Aquatic Mammals 32:1–9.

Nowacek, S. M., R. S. Wells and A. R. Solow. 2001. Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. Marine Mammal Science 17:673–688.

Nowacek, D. P., L. H. Thorne, D. W. Johnston and P. L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37:81–115.

O'Connor, S., R. Campbell, H. Cortez and T. Knowles. 2009. Whale watching worldwide: Tourism numbers, expenditures and expanding economic benefits. International Fund for Animal Welfare, Yarmouth, MA. 295 pp.

Richardson, W. J., C. R. J. Greene, C. I. Malme and D. H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego, CA.

Scarpaci, C., N. Dayanthi and P. J. Corkeron. 2003. Compliance with regulations by "swim-with-dolphins" operations in Port Phillip Bay, Victoria, Australia. Environmental Management 31:342–347.

Shane, S. H., R. S. Wells and B. Würsig. 1986. Ecology, behavior and social-organization of the bottlenose dolphin: A review. Marine Mammal Science 2:34–63.

Spradlin, T. R., L. M. Barre, J. K. Lewandowski and E. T. Nitta. 2001. Too close for comfort: Concern about the growing trend in public interactions with wild marine mammals. Society for Marine Mammalogy Newsletter 9(3):3–5.

Steckenreuter, A., L. Moller and R. Harcourt. 2012. How does Australia's largest dolphin-watching industry affect the behaviour of a small and resident population of Indo-Pacific bottlenose dolphins? Journal of Environmental Management 97:14–21.

Stensland, E., and P. Berggren. 2007. Behavioural changes in female Indo-Pacific bottlenose dolphins in response to boat-based tourism. Marine Ecology Progress Series 332:225–0234.

Stockin, K. A., D. Lusseau, V. Binedell, N. Wiseman and M. B. Orams. 2008. Tourism affects the behavioural budget of the common dolphin *Delphinus* sp. in the Hauraki Gulf, New Zealand. Marine Ecology Progress Series 355:287–295.

Tapper, R. 2006. Wildlife watching and tourism: A study on the benefits and risks of a fast growing tourism activity and its impacts on species. UNEP/CMS Secretariat, Bonn, Germany. 68 pp.

Thorpe, W. H. 1963. Learning and instinct in animals. Methuen and Coltd, London, U.K.

Williams, R., D. Lusseau and P. S. Hammond. 2006. Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). Biological Conservation 133:301–311.

Zar, J. H. 1996. Biostatistical analysis. 3rd edition. Prentice Hall, Upper Saddle River, NJ.

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