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The use of auditory stimulants during swim encounters with Hector's dolphins (*Cephalorhynchus hectori hectori*) in Akaroa Harbour, New Zealand

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ABSTRACT

The coastal distribution of Hector's dolphins and their attraction to vessels make them easily accessible to commercial tour operations. For over 25 yr, tour operators have been undertaking view and swim-with-dolphin trips in Akaroa Harbour, New Zealand. Since 2003, auditory stimulants, in particular stones, have been provided during such swim encounters. The potential effects associated with such stimulants have not, until now, been examined. Here, we investigate the effects of stones and other human-induced noise on Hector's dolphin behavior. The use of stones significantly affected how dolphins interacted with swimmers. Specifically, swimmers who used stones had a greater probability of close approaches by dolphins than those who sang or simply floated on the surface of the water. The number of close and sustained approaches was also significantly higher for swimmers using stones. Dolphins were more interactive with active swimmers, approaching closer and engaging for longer than with nonactive swimmers. Dolphins socializing had a tendency to be engaged longer with swimmers. The use of stones as an auditory stimulant to sustain or enhance interactions with dolphins by artificial means may not be in the best interest of an endangered species, which already faces a range of challenges due to human activity.

Key words: Hector's dolphin, *Cephalorhynchus hectori hectori*, swim-with-dolphin, tourism, auditory stimulants, management, Akaroa Harbour, New Zealand.

Marine mammal tourism is a large industry worth an approximated U.S.$2.1 billion in total expenditures (O'Connor *et al*. 2009). On a global scale, the industry has grown at an average rate of 3.7% per annum between 1998 and 2008 (O'Connor *et al*. 2009). However, there is a growing body of evidence, both worldwide and within New Zealand, to suggest that both cetacean-watching and swimming activities are not benign, disturbing targeted animals in the short term (*e.g.*, Janik and Thompson 1996, Bejder *et al*. 1999, Constantine 2001, Nowacek *et al*. 2001, Samuels *et al.* 2003, Lusseau 2003, Constantine *et al.* 2004, Ribeiro *et al.* 2005, Bejder *et al*. 2006*a*, Richter *et al*. 2006, Miller *et al*. 2008, Stockin *et al*. 2008, Williams *et al*. 2009). Recently, research has linked short-term effects of tourism with long-term biological consequences on the viability and fitness of targeted species (*e.g.*, Bejder *et al*. 2006*b*). While published tourism impact studies within New Zealand have focused heavily on the bottlenose dolphin, *Tursiops truncatus* (*e.g.,* Constantine 2001, Lusseau 2003, Constantine *et al*. 2004, Lusseau *et al*. 2006); common dolphin, *Delphinus* sp. (*e.g.*, Constantine and Baker 1997, Neumann and Orams 2006, Stockin *et al*. 2008); dusky dolphin, *Lagenorhynchus obscurus* (Barr and Slooten 1999, Lundquist and Markowitz 2009); and the sperm whale, *Physeter macrocephalus* (Richter *et al*. 2006), considerably less emphasis has recently been placed on the South Island Hector's dolphin, *Cephalorhynchus hectori hectori*, herein referred to as Hector's dolphin (Bejder *et al.* 1999, Nichols *et al.* 2001). This is particularly the case off Banks Peninsula (Nichols *et al*. 2001) on the eastern coast of South Island, New Zealand (Fig. 1). This area has been identified as the main hot spot for this subpopulation (Clement 2005), with Hector's dolphins exhibiting high site fidelity (*e.g.*, Bräger *et al*. 2002, Stone *et al*. 2005, Rayment *et al*. 2009). Akaroa Harbour (43.81°S, 172.97°E) is an important part of the home range for a large number of individual Hector's dolphin found around Banks Peninsula (Bräger *et al*. 2002, Rayment *et al*. 2009), particularly during the austral summer season. This coastal distribution (*e.g.,* Baker 1983, Dawson and Slooten 1988, Bräger *et al.* 2002, Clement 2005, Rayment *et al*. 2009, 2010) and vessel tactic response of Hector's dolphins (Baker 1983, Dawson and Slooten 1988, Dawson *et al*. 2000) make this species attractive and potentially vulnerable to commercial tourism operations. Hector's dolphins are both endemic and endangered (Reeves *et al*. 2008) and already face serious pressures from human activities, mainly fisheries bycatch (*e.g.*, Dawson 1991, Martien *et al.* 1999, Slooten 2007).

Currently within Akaroa Harbour, seven commercial marine mammal tourism permits allow a maximum of 32 trips per day to interact with Hector's dolphins, including 18 daily swim-with-dolphin trips. Both watching and swimming with dolphin tourism occur year round, although most tourism activities coincide with the austral summer season (November to March). During this period, trips operate throughout the day, with the majority of tours occurring between 0900 and 1600. Since 2003, commercial swim-with-dolphin operators in Akaroa Harbour have been encouraging their patrons to use auditory stimulants, in particular stones (brought

Figure 1. Map showing location of Banks Peninsula and Akaroa Harbour in New Zealand.

together under the water to create sounds), to entice dolphins to approach and sustain interaction with swimmers. Other techniques used include, but are not limited to, bubble blowing, singing, tapping on objects, and hitting the surface of the water with hands. The implications of such activities remain unknown and are poorly described within the published literature, although there is a widespread concern about the potential effects of anthropogenic noise on marine mammals and marine ecosystems (see Richardson *et al*. 1995, Nowacek *et al.* 2007 for reviews). Furthermore, the deliberate use of such techniques to create sound underwater in the proximity of dolphins could contravene section 4 of the New Zealand Marine Mammals Protection Act (MMPA, 1978), which stipulates that "no person shall take any marine mammal" and where *take* is considered to include "to take, catch, kill, injure, *attract*, poison, tranquilize, herd, harass, disturb, or possess." The increasing prevalence of such activities and any potential impacts on Hector's dolphins has not, until now, been examined.

The New Zealand Marine Mammals Protection Regulations (MMPR, 1992) do not provide many specific guidelines on swim-with-dolphin activities *per se*. However, section 18(i) states that "no person shall disturb or harass any marine mammal," where *harass* is defined under section 2 as "any act that disrupts significantly or is likely to disrupt significantly the normal behavior patterns of any marine mammal." Moreover, section 20(d) also states that "no person shall make any loud or disturbing noise near dolphins." These sections of the regulations do, therefore, raise the issue about whether enticing and maintaining Hector's dolphin interactions with stones (or any other deliberate creation of sound) may cause disruption to a sufficient level to be considered detrimental.

Here, we examine whether the use of human-made noise affects swim interactions with Hector's dolphins. Particularly, we assess whether banging stones under the water increases the frequency of Hector's dolphins approaching swimmers and whether the amount of time that dolphins spend interacting with people is affected by the use of stones. We also consider whether any potential changes in dolphin behavior related to the use of sound by swimmers could further disrupt dolphin activity patterns and be of detriment to Hector's dolphins in Akaroa Harbour.

Materials and Methods

Data Collection

Opportunistic observations were conducted in Akaroa Harbour, Banks Peninsula, South Island New Zealand (Fig. 1) between 10 November and 7 December 2008. This time period corresponds to the start of the austral summer tourism season and was chosen to (1) reduce any potential effect of increasing vessel traffic throughout the season on the swim experiences given that Hector's dolphins show signs of sensitization to interaction between January and February (Martinez 2010), and (2) ensure opportunities were maximized to record data from as many trips as possible. Weather permitting (Beaufort sea state $\leq$3), data were collected daily during trips commencing at 0900, 1200, 1400, and 1600. Observations were primarily conducted from onboard the commercial swim-with-dolphin vessel, *Cat2*, operated by the *Black Cat Group.* This purpose-built 12.5 m long catamaran was powered by twin powered jet units (Yanmar 350 hp) and could carry a maximum of 30 passengers, including 10 permitted swimmers.

Sampling Protocol

An independent sampling session started when a dolphin group was sighted. An encounter, which typically consisted of several interactions (Table 1), was judged to have commenced when the first swimmer entered the water and ended when the last swimmer climbed back onboard the vessel. The end of the session typically occurred because the dolphins had left the vicinity, the weather conditions deteriorated and were judged unsafe for the swimmers, or because the maximum time allowed with the dolphins had been reached (45 min under the current permit conditions).

Table 1. Definitions of sampling protocol terms used in the present study.

Term	Definition
Swim attempt or encounter	Total time swimmers present in the water irrespective of the presence of dolphins. A trip could consist of several swim attempts.
Interaction	From the time, one or several dolphins swim within less than two dolphin body lengths of any swimmer. During that time, a swimmer might not necessarily be approached (see definition below) by one or several dolphins. A typical swim attempt consists of several interactions unevenly spaced out and of varying duration.
Approach	One or several dolphins swimming past a swimmer and within less than one dolphin body length of a swimmer. Underwater approaches were not taken into account due to low visibility.
First approach	Time when one or several dolphins first swim toward the group of swimmers at a distance of less than one dolphin body length.
Sustained approach	When a dolphin is swimming around a swimmer but without forming a complete circle.
Circle approach	When a dolphin is swimming around a swimmer and forming one or more complete circles. This type of approach is sustained and can also be categorized as a close approach (see definition above).
Tail slap	When a dolphin raises its fluke out of the water and then slaps it on the surface of the water, producing a clearly audible sound.

Once a group of Hector's dolphins was located, swimmers entered the water and were asked to form a circle keeping a distance of 2–3 m between them so that dolphins could swim between and among them. Swimmers were also encouraged to let the dolphins approach them and not swim after them. The skipper or guide gave two stones to a swimmer and asked that person to be positioned in the middle of the circle or group of swimmers. This swimmer was encouraged to bang the stones both when dolphins were already present around the vessel and also when dolphins were not in close proximity. For example, when the dolphins had not approached the group of swimmers for a few minutes, the skipper asked the person with the stones to use them, with no particular instructions regarding the rhythm. Other swimmers were free to float, be active, and could also be encouraged to create noise to make their presence known to the dolphins. The stones were often swapped between swimmers during the course of the swim, especially to a swimmer who had not had the chance to see the dolphins at close range.

At the start of an encounter, the number of individual dolphins within the group, time of initial sighting, Beaufort sea state, and the number of swimmers were recorded. In addition, the predominant dolphin group behavior was also determined and recorded after an instantaneous focal group sampling (Altmann 1974, Mann 1999). The initial predominant behavior was defined as the behavioral state in which 50% or more of the animals were simultaneously engaged. Widely accepted categories of behavioral state, derived from Shane (1990), were adopted (Table 2). Discrete behavioral events (*e.g.,* aerial, sexual) previously described for Hector's dolphin (Slooten 1994) were also incorporated in the behavioral state definitions used within the present study. "Wave surfing," although a behavioral event, was included for

Table 2. Definitions of behavioral state categories used in the present study (derived from Shane 1990, Slooten 1994).

Term	Definition
Traveling	Dolphins engaged in persistent, directional movement, swimming with short, relatively constant dive intervals. Group spacing varies.
Wave surfing (boat included)	Dolphins engaged in riding surf of waves, including those created by boats (bow and stern wake, or wakes from other vessels in the vicinity), resulting in a net movement in the direction of the wave. Group spacing varied.
Milling	Dolphins exhibited nondirectional movement, with frequent changes in heading. Milling sometimes occurred as a transition behavior between other behavioral states. No net movement. Group spacing and dive interval varied.
Diving	Dolphins' direction of movement varies. Dolphins dived for long intervals often arching their backs at the surface to increase speed of descent. Group spacing varied. Note: This represents the "feeding/foraging" category in other studies.
Socializing	Dolphins observed chasing and/or engaged in any other physical contact with other individuals in the group. Aerial, sexual, and aggressive behaviors are frequently observed. A group was often split into small subgroups spread over a large area. Dive intervals varied. No obvious forward movement.
Resting	Dolphins engaged in slow movements (*i.e.*, <1.5 km/h) in a constant direction, with little evidence of forward propulsion. Dolphins were occasionally stationary. Dive intervals were short, relatively constant, and synchronous. Group spacing was tight (*i.e.*, less than one body length between individuals). Resting lacked the active components of the other behaviors described.

analytical purposes. Resting was not observed during the study and, therefore, not included in the analysis.

After the initial observations were recorded, continuous focal group follows (Altmann 1974) were subsequently used for the duration of each dolphin interaction (Table 3) with swimmers. Although focal individual follows offer clear advantages (Mann 1999, 2000), this sampling technique was neither feasible nor appropriate for this study, because Hector's dolphins have very few identifying scars (Slooten *et al*. 1992), needed to allow accurate individual follow protocols to be used successfully. Furthermore, focal groups were sampled to determine the effect of human-made noise on the behavior of dolphins at the group rather than individual level. For the purpose of this study, an interacting group was defined as any number of dolphins surrounding swimmers within two adult dolphin body lengths from the closest swimmer. This typically equated to a distance of 3 m.

The duration of each interaction was measured to determine the proportion of time dolphins were present in the proximity of swimmers during an encounter. The number of dolphin approaches was also recorded using an all-occurrences protocol (Martin and Bateson 1993), taking into account both the type of approach and the activity of a swimmer at the time of the approach (Table 1, Fig. 2). The different

Table 3. Definition of the different types of swimmer activity.

Term	Definition
Floating swimmer	A swimmer not engaged in any activity and simply floating at the surface (either in a horizontal or vertical position). Limited movement.
Singing swimmer	A swimmer engaged in making any underwater sound, except using stones, using the vocal area of their body. This includes singing, squealing, bubble blowing, *etc*.
Tapping swimmer	A swimmer engaged in making sound by tapping an object against another (*e.g.*, ring on mask) or winding underwater camera.
Swimmer with stones	A swimmer engaged in bringing stones together under the water to create sounds (clicks, bangs, and rhythms).
Active swimmer	A swimmer engaged in active swimming, including duck diving or swimming in circles.

types of swimmer activity were defined to be mutually exclusive and cumulatively inclusive (Table 3). If one dolphin approached and swam between two swimmers at a similar distance, that particular individual was recorded as approaching both swimmers. Stones were given by the skipper and/or guide to only one swimmer at any given time. Consequently, it was possible to keep track of the characteristics and behavior of that specific swimmer. The total time that stones were used by that same swimmer and the number of approaches dolphins made toward that swimmer were also recorded. In addition, dolphin approaches made toward the remaining swimmers, who did not have stones, were also noted. Given that the skipper and/or guide decided which of the swimmers should use the stones, the selection was considered random.

Swimmers have reported anecdotally that when they used the stones, dolphins had a tendency to approach more frequently and closely, circling around them. The validity of these claims was investigated by recording the number of close approaches,

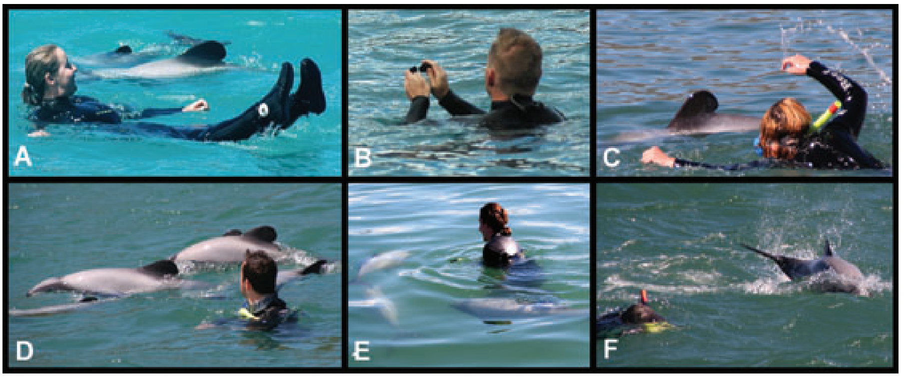

Figure 2. Photos showing (A) a swimmer floating; (B) a swimmer using stones; (C) an active swimmer; (D) a close approach; (E) a sustained approach, here circling; (F) a dolphin doing a tail slap near a swimmer. All photos courtesy A.R.E.V.A. Project.

defined as dolphin(s) swimming within an arm length of a swimmer (typically <1 m), taking into consideration swimmer activity. Finally, the occurrence of specific behavioral events (tail slaps and bubble blowing) was also recorded. As bubble blowing could not always be observed accurately (due to distance or water visibility), this behavioral event was excluded from subsequent analysis.

Data Analysis

Data recorded for each interaction within an encounter were potentially autocorrelated as they were collected sequentially from the same focal dolphin group and the same swimmers. To reduce the effect of dependence between interactions, the mean number of dolphin approaches was calculated for each encounter in order to examine if the use of stones had any effect on the dolphin behavioral responses. Each encounter or swim attempt was, therefore, considered as a single sampling unit (n = 62). Data were further standardized per minute, per dolphin, and per swimmer. This was deemed necessary to account for variations in (1) the duration of interactions, (2) the number of individual dolphins during each interaction, and (3) the number of swimmers in the water during a given interaction and engaged in a particular activity. The frequency of close approaches and occurrence of tail-slaps near swimmers were also calculated for each type of swimmer activity. Stones were given to only one swimmer at a time. Consequently, it was also possible to determine whether the use of stones had an effect on the number of approaches toward that particular swimmer. Subsequently, these data were also used to test whether swimmer gender affected dolphin approaches. No differences were detected between the genders (Welch's analysis of variance [ANOVA] tests: $P > 0.05$), so all swimmer data were pooled for analyses.

Given that data were heteroscedastic, Welch's ANOVA (Welch 1951) and Welch t-tests were used to test differences between group means (Zar 1996). Multiple comparison *post hoc* tests and 95% confidence intervals (CI) used Bonferroni correction to maintain a family-wise error rate of alpha = 5% (Miller 1981, Zar 1996).

Results

Field Effort

Fifty-four independent trips resulting in 62 observed swim attempts were recorded and analyzed during the present study. The number of swimmers participating in a swim-with-dolphin trip ranged between 4 and 10 (mean ± SE = 8.4 ± 0.233 swimmers, n = 54). Each swim attempt lasted between 5 and 48 min (mean ± SE = 33.1 ± 1.624 min, n = 62), with dolphins interacting 35.1 ± 2.27% (n = 62) of the duration of swim attempts.

Effect of Swimmer Activity on the Number of Dolphin Interactions and Approaches

The mean dolphin approach rate differed, depending on swimmer activity (Fig. 3; Welch's ANOVA: $F = 10.34$, df = 3, $P < 0.001$). The mean approach rate (minute/dolphin/swimmer) for swimmers using stones was higher at between 0.08 and 0.59 more approaches (95% CI) than when swimmers sang and between

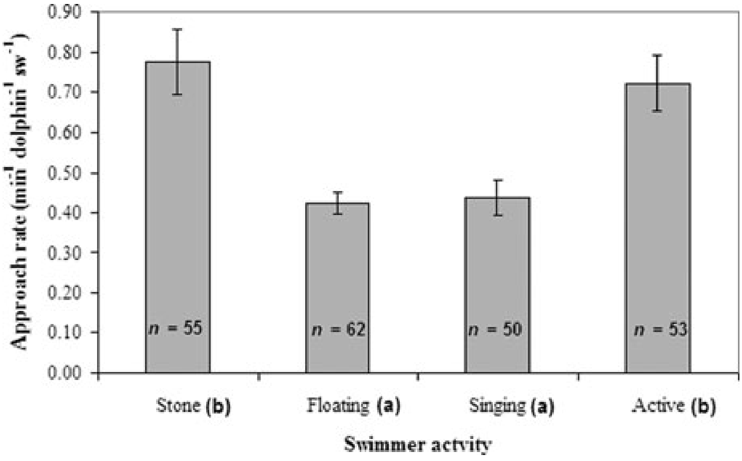

Figure 3. Mean approach rate (minute/dolphin/swimmer) according to swimmer activity. Swimmer activities that are significantly different have a different letter. Lines represent the standard error of the mean. Note: Not all swimmer activity categories were recorded for each of the 62 swim attempts. Sample sizes are therefore listed for each category as *n*.

0.13 and 0.59 more approaches than when swimmers floated. Likewise, the mean approach rate for active swimmers was from 0.06 to 0.51 and between 0.10 and 0.51 approaches higher (95% CI) than when singing and floating, respectively (Fig. 3).

The mean sustained approach rate (minute/dolphin/swimmer) was also strongly dependent on swimmer activity (Fig. 4; Welch's ANOVA: $F = 20.3$, df = 3, $P < 0.001$). For active swimmers, the mean sustained approach rate was 0.09–0.31 approaches higher (95% CI) than for swimmers singing and 0.10–0.30 approaches higher than floating swimmers. Similarly, swimmers using stones averaged between 0.05 and 0.15 more sustained approaches (minute/dolphin/swimmer) (95% CI) than swimmers singing and from 0.06 to 0.16 more sustained approaches than floating swimmers.

There was also strong evidence that the mean frequency of close approaches (per total approaches) varied significantly with the types of activities swimmers engaged in when dolphins were around (Welch's ANOVA: $F = 19.4$, df = 3, $P < 0.001$). The mean frequency of close approaches for active swimmers was from 0.17 to 0.43, 0.15 to 0.40, and up to 0.28 higher (95% CI) than for swimmers singing, floating, and using stones, respectively. The mean frequency of close approaches for swimmers using stones was between 0.04 and 0.15 higher (95% CI) than swimmer singing and from 0.06 to 0.16 higher than floating swimmers (Fig. 5).

Comparison of Number of Approaches toward an Individual Swimmer while Using Stones and after Transferring Them to Another Swimmer

There was strong evidence that individual swimmer activity affected both the approach rate (minute/dolphin) (Welch's ANOVA: $F = 24.4$, df = 3, $P < 0.001$) and the sustained approach rate ($F = 19.7$, df = 3, $P < 0.001$). When an individual

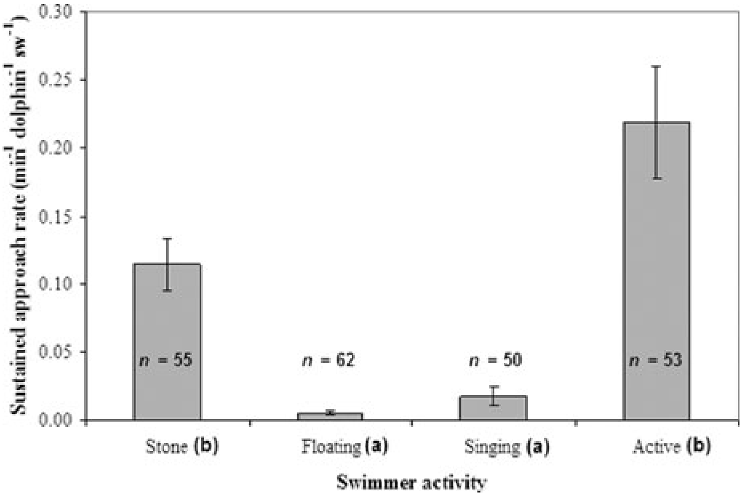

Figure 4. Mean sustained approach rate (minute/dolphin/swimmer) according to swimmer activity. Swimmer activities that are significantly different have a different letter. Lines represent the standard error of the mean. Note: Not all swimmer activity categories were recorded for each of the 62 swim attempts. Sample sizes are therefore listed for each category as *n*.

swimmer used stones during a swim encounter, that individual averaged 0.78–1.72, 0.8–1.77, and 0.57–1.60 more approaches (95% CI) than the same swimmer when being active, singing or floating, respectively (Fig. 6). The use of stones also increased the frequency of sustained approaches (per total approaches) toward an individual by

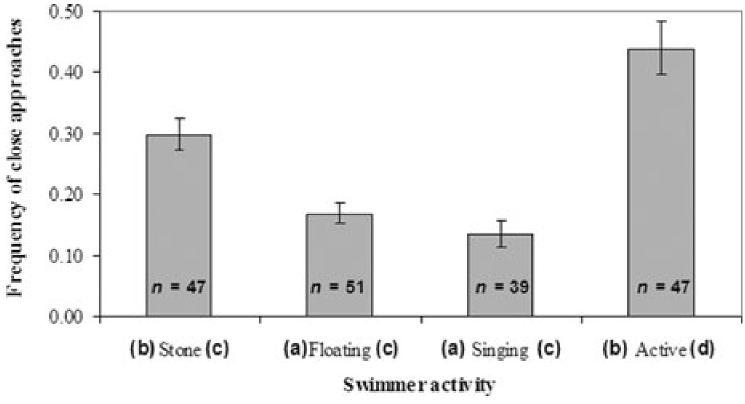

Figure 5. Mean frequency of close approaches (per total approaches) according to swimmer activity. Swimmer activities that are significantly different have a different letter (a/b, c/d). Lines represent the standard error of the mean. Note: Not all swimmer activity categories were recorded for each of the 62 swim attempts. Sample sizes are therefore listed for each category as *n*.

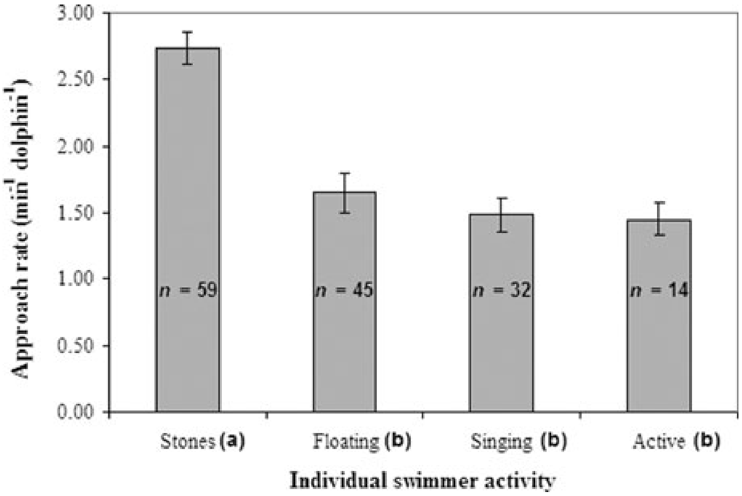

Figure 6. Mean approach rate (minute/dolphin) while an individual swimmer had stone and after having given them to another swimmer. Swimmer activities that are significantly different have a different letter. Lines represent the standard error of the mean. Note: Not all swimmer activity categories were recorded for each of the 62 swim attempts. Sample sizes are therefore listed for each category as *n*.

between 8.6% and 23.3% more (95% CI) than when singing and between 11% and 24.3% more than when floating (Fig. 7).

Influence of the Initial Predominant Dolphin Behavior on Their Interactions with Swimmers during a Whole Encounter

The initial predominant dolphin behavior did not affect the mean time to first interaction (Fig. 8A; Welch's ANOVA: $F = 1.9$, df $= 4$, $P = 0.152$) or mean interaction time (Fig. 8C; $F = 2.53$, df $= 4$, $P = 0.07$). However, interaction rate (minute/dolphin/swimmer) during an encounter depended upon initial predominant dolphin behavior (Fig. 8B, $F = 5.26$, df $= 4$, $P = 0.004$). The interaction rate for milling and traveling dolphins was higher than socializing dolphins by up to 0.22 and 0.10 interactions, respectively. There was also evidence that the percentage of time dolphins were present in the proximity of swimmers was influenced by the initial predominant dolphin behavior (Fig. 8D; $F = 3.59$, df $= 4$, $P = 0.02$). When socializing, dolphins were observed between 2.9% and 52.3% more (95% CI) in the presence of swimmers than when dolphins were diving.

Occurrence of Tail-Slaps

Although tail-slaps did not occur during all swim attempts, there was strong evidence that the mean frequency of tail-slaps (per total approaches) near swimmers differed according to swimmer activity (Fig. 9; Welch's ANOVA: $F = 7.31$, df $= 3$, $P < 0.001$). The occurrence of tail-slaps near swimmers (*i.e.*, within 3 m) using stones was up to 0.04 slaps higher than those singing or floating.

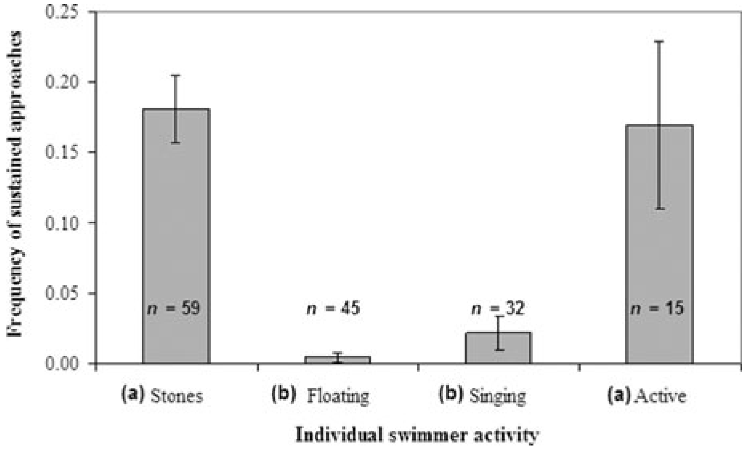

Figure 7. Mean frequency of sustained approaches (per total approaches) while an individual swimmer had stone and after having given them to another swimmer. Swimmer activities that are significantly different have a different letter (a/b, c/d). Lines represent the standard error of the mean. Note: Not all swimmer activity categories were recorded for each of the 62 swim attempts. Sample sizes are therefore listed for each category as *n*.

Discussion

The Use of Stones as Auditory Stimulants

The use of sound to facilitate interactions between tourists and Hector's dolphins in Akaroa Harbour occurs within a wider context of marine mammal tourism. Findings presented here support anecdotal reports that the use of stones can sustain and result in closer interactions between Hector's dolphins and swimmers in that particular location. Overall, the use of stones as an auditory stimulant had a significant effect on the movement and proximity of dolphins to swimmers. More specifically, swimmers with stones had a greater probability of close approaches by dolphins than those singing or simply floating on the surface of the water. The number of close and sustained approaches was also significantly higher for swimmers banging stones underwater. The same observations were made for active swimmers. In addition, dolphins were found to significantly focus more on the stone bearer, when focusing on an individual level. As such, a swimmer was significantly more likely to be approached, experience longer interaction times and have dolphins in closer proximity when they used stones than when they did not. Furthermore, the number of approaches from dolphins to a specific person decreased once the stones were passed on to another swimmer. Therefore, it was the use of stones and not the individual swimmer that was the influential variable.

There was no overall evidence to suggest that a singing swimmer had greater probability of interaction with dolphins than a swimmer simply floating at the surface. However, being active (*e.g.*, duck diving and spinning around) did significantly increase the number of dolphin approaches, including close and sustained approaches, toward swimmers. Both noise and movement (also likely to produce sound underwater) appear to entice dolphins to approach and interact with swimmers, supporting earlier anecdotal reports from commercial tour operators,

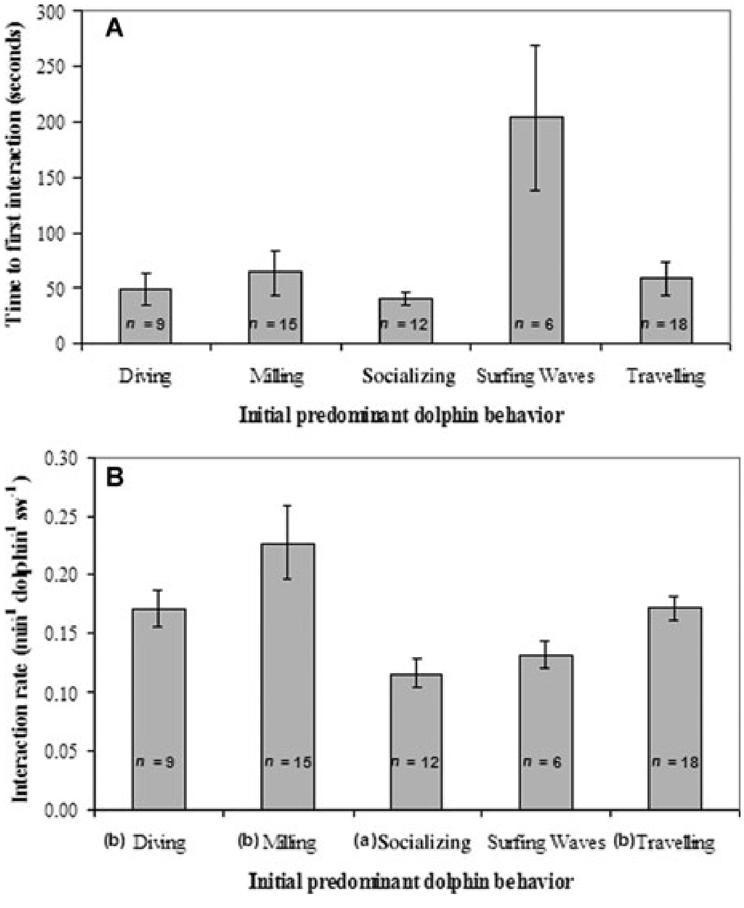

Figure 8. Mean (A) time to first interaction; (B) interaction rate (minute/dolphin/swimmer); (C) interaction time (min); (D) percentage of time dolphins present; according to the initial predominant dolphin behavior. Swimmer activities that are significantly different have a different letter (a/b, c/d). Lines represent the standard error of the mean. Sample sizes are listed on each column as *n*. Note: The behavior of the focal dolphin group at the start of an encounter was unknown on two occasions.

guides, and swimmers.[1] Neumann and Orams (2006) also noted that swimmers had more successful encounters with common dolphins (*Delphinus delphis*) when duck diving.

When socializing, Hector's dolphin groups had a tendency to have longer interactions and overall encounters. Approaches were standardized by dolphin group size as preliminary analyses found larger dolphin groups (five individuals or more) interacted longer with swimmers. Based on these results, commercial operators were more likely to have prolonged encounters with Hector's dolphins if they interacted

[1] Personal communication from C. Edwards, School of Medicine, University of Otago, Dunedin, New Zealand, 16 March 2010.

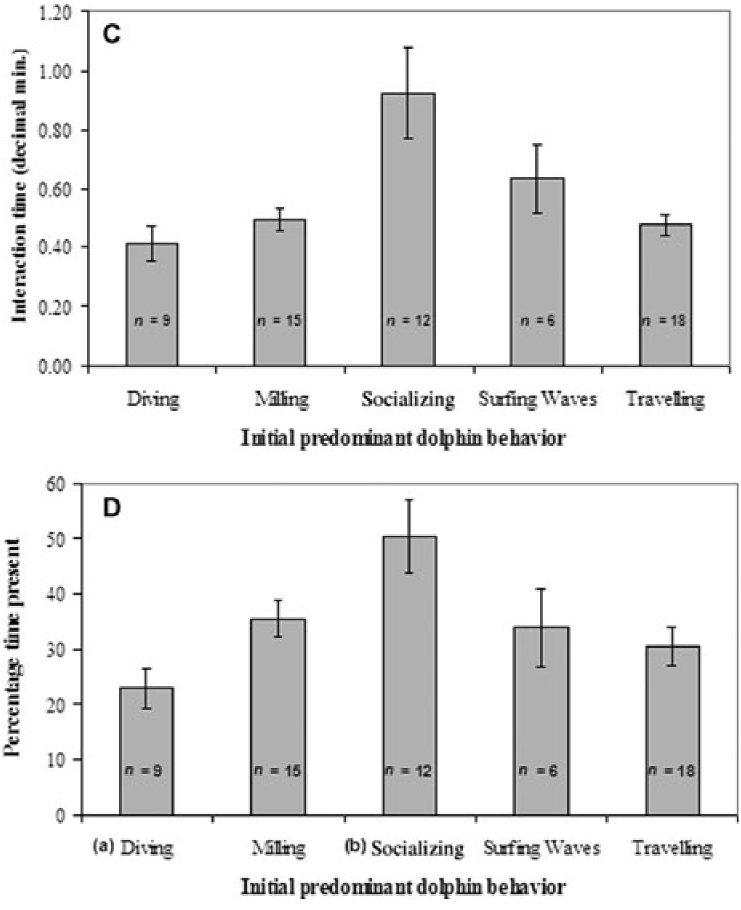

Figure 8. Continued

with a group engaged in socializing activities, had a swimmer banging stones, and encouraged other swimmers to be active when dolphins were present.

Understanding why the use of stones had an effect on interactions between Hector's dolphins and swimmers, as well as the proximity of dolphins to swimmers was beyond the scope of this study. Future research on acoustic and individual dolphin monitoring would help determine how similar the sound created by stones is to echolocation and communication clicks and whether it is the same individuals that consistently approach swimmers with stones.

Implications for the Use of Stones during Swim-with-Dolphin Trips

Until now, the use of auditory stimulants (particularly stones) has not, to our knowledge, been empirically investigated. Their effect on the targeted animal behavior, biology, and physiology is, therefore, unknown. This is surprising given the (1) routine practice of tour operators encouraging tourists to participate in such

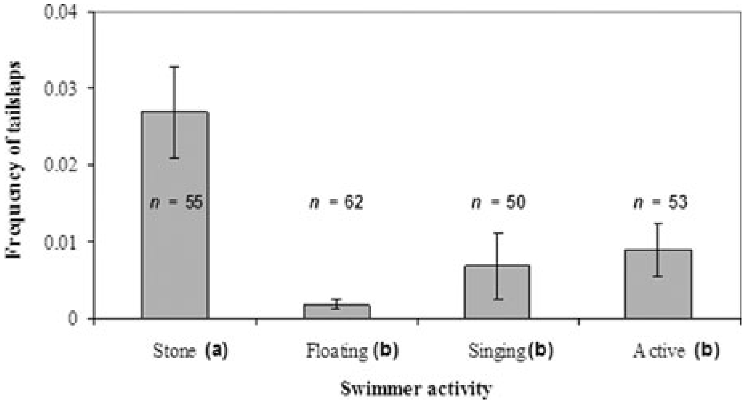

Figure 9. Mean frequency of tail-slaps (per total approaches) according to swimmer activity. Swimmer activities that are significantly different have a different letter. Lines represent the standard error of the mean. Note: Not all swimmer activity categories were recorded for each of the 62 swim attempts. Sample sizes are therefore listed for each category as *n*.

activities; (2) increasing concerns reported in the literature regarding noise pollution on cetaceans, including from tour vessels (*e.g.,* Richardson *et al*. 1995, Nowacek *et al*. 2007, Martinez and Orams, in press); and (3) increasing evidence demonstrating that swim-with-dolphin activities also disturb the targeted animals in the short term (*e.g.,* Bejder *et al*. 1999, Constantine 2001, Samuels *et al*. 2003). Research focusing specifically on quantifying sound produced by tour vessels and their effects on targeted species is, at this time, still limited (*e.g*., Erbe 2002, Williams *et al*. 2002, Buckstaff 2004). Furthermore, the New Zealand MMPA and MMPR clearly prohibit actions that attract, disturb, or alter natural behavioral patterns of marine mammals.

In most studies, it remains difficult to differentiate between the effects of dolphin swimming *vs*. the effects of dolphin viewing, especially when swimmers in the water are accompanied by a vessel, as is the case in Akaroa Harbour. Previous studies measuring the effects of swimmer presence on Hector's dolphin behavior in the absence of vessels showed that the majority of swim-with-dolphin attempts caused only weak, nonsignificant effects compared to their reactions toward vessels (Bejder *et al*. 1999, Green 2003). However, these studies assessed the effects of a small number of swimmers who entered the water from shore, not from a vessel. In Akaroa Harbour, given that the swim-with-dolphin encounters only occur from vessels, the impact of swimming cannot be disassociated from the potential reaction of the dolphins toward the vessel. Similarly, the use of auditory stimulants cannot be totally separated from the potential behavioral responses of dolphins to the presence of both the tour vessel and other vessel traffic in the harbor.

In comparison to most other marine mammal tourism locations around New Zealand, Akaroa Harbour has the highest level of permitted commercial tourism operations. Land-based research has reported that vessels/swimmers were absent over the austral summer months (November to March) less than 15.0% of daylight hours Hector's dolphins were found inside the harbor (Martinez 2010). In Porpoise Bay (46.65°S, 169.1°E), Southland, 440 km southwest of Akaroa, vessels/swimmers were present 23% of the time Hector's dolphins were found in the bay over the same time period (Green 2003). However, even relatively low-level tourism such as this has been shown to have short-term effects on group dispersion, length of encounters with vessels, and behavioral budget of targeted species (*e.g.,* Bejder *et al*. 1999, 2006*b*; Stockin *et al*. 2008), negating the presumption that any cetacean-based tourism is benign.

Data presented here suggest there is a trend for dolphin groups to be present longer during swim attempts when stones were used as auditory stimulants and, in some cases, when swimmers were active. They also indicated that when in the presence of a group of dolphins engaged in diving, total encounter lengths were shorter compared to socializing groups. In other species in New Zealand waters, dolphin behavioral activity also influences swim encounter duration or the success of swim attempts. In Mercury Bay, Bay of Plenty, common dolphins were more interactive when the predominant group behavior was socializing (Neumann and Orams 2006). Similar observations were made with dusky dolphins in Kaikoura, Canterbury (Markowitz *et al*. 2009).

Studies examining behavioral changes in relation to the presence of vessels report a decrease in the amount of time dolphins forage (*e.g.,* Allen and Read 2000, Lusseau 2003, Williams *et al*. 2006, Carrera *et al*. 2008, Dans *et al*. 2008, Stockin *et al*. 2008, Lusseau *et al*. 2009). Disturbance or disruption of foraging and subsequent feeding can have major biological consequences for dolphins (Williams *et al*. 2006). Changes in the duration of diving and other critical aspects of behavioral budgets, as a consequence of interactions with vessels, have been shown to have long-term biological consequences at both individual and population levels (*e.g.,* Bejder *et al*. 2006*b*, Lusseau *et al*. 2006, Williams *et al*. 2006, Higham *et al*. 2009). In Akaroa Harbour, the current level of tourism activities is significantly altering the behavior budget of Hector's dolphins (Martinez 2010). The additional use of auditory stimulants that increase interaction time between dolphins and swimmers could potentially contribute to and exacerbate behavioral changes caused by the presence of vessels.

Finally, the significantly higher occurrence of tail-slaps, near swimmers using stones, is also worthy of consideration. Within the literature, mouthing, chasing, and tail-slaps are generally considered to be indicators of aggression in at least some cetacean species, although they can also be classified as play aggression (Shane 1990, Slooten 1994, Mann and Smuts 1999, Ritter and Brederlau 1999). Slooten (1994) suggested that tail-slaps were not only associated with aggressive and sexual behaviors but also with aerial behaviors (leaps) and bubble blowing. For Hector's dolphins, tail-slapping appears to indicate a high level of motivation and sometimes, but not always, aggression (Slooten 1994). It is possible, therefore, that sustained approaches with swimmers act as stimuli to which dolphins respond with a higher frequency of tail-slaps in the proximity of active swimmers and those using stones. Aggravation of this motivational state could be a cause of concern for both animals and swimmers, an opinion also expressed by Nichols *et al*. (2001).

Management Recommendations

The wording contained within section 4 of the New Zealand MMPA (1978) appears to make the use of auditory stimulants, including stones, unlawful if the intent is to "attract" the dolphins. Tour operators at Akaroa are aware of this stipulation and, possibly as a consequence, argue that stones are used only to "sustain" the attention of the dolphins. Observations made from swim-with-dolphin vessel platforms during the course of this study, however, indicate that operators do encourage swimmers to use the stones (and other techniques) prior to the first interaction between dolphins and swimmers or when dolphins left their vicinity. In this case, stones are clearly being used with the intent of "attracting" the dolphins. Furthermore, this study indicates such actions are successful in doing so.

In Akaroa Harbour, the current level of tourism activities is significantly altering the normal daily behavioral patterns of the dolphins (Martinez 2010). By using stones underwater to create sounds to either entice dolphins or sustain their interaction with swimmers, the amount of time dolphins interact with humans is increased and could, therefore, potentially contribute to the breach of the New Zealand MMPA, in particular section 18(i), by exacerbating this situation.

Any additional impact to Akaroa Hector's dolphins is of particular concern given this endemic and endangered species already faces significant anthropogenic pressures, especially from fisheries bycatch. This, in conjunction with a low migration rate (Bräger *et al*. 2002, Rayment *et al*. 2009) and high site fidelity (Bräger *et al*. 2002, Stone *et al*. 2005, Rayment *et al*. 2009), further add to their vulnerability. Currently, it is difficult to determine whether the use of stones as auditory stimulants has quantifiable long-term detrimental impacts on Hector's dolphins in Akaroa Harbour. However, this study demonstrates there are short-term behavioral responses that warrant concern.

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