PAPER

Reducing By-Catch: Can Acoustic Pingers Keep Hector's Dolphins Out of Fishing Nets?

Gregory Stone
New England Aquarium
Central Wharf, Boston, MA

Scott Kraus
New England Aquarium
Central Wharf, Boston, MA

Alistair Hutt
New Zealand Department of Conservation
Akaroa, New Zealand

Stephanie Martin
New England Aquarium
Central Wharf, Boston, MA

Austen Yoshinaga
New England Aquarium
Central Wharf, Boston, MA

Lauren Joy
New England Aquarium
Central Wharf, Boston, MA

ABSTRACT

Underwater acoustic pingers, emitting a 10 kHz sound (with harmonics up to 110 kHz), were tested in New Zealand to evaluate their potential effectiveness in preventing entanglement and death of Hector's dolphins (Cephalorhynchus hectori) in gillnets. A 1996 study site was established in Akaroa Harbour, an area known for high concentrations of Hector's dolphins. A remote controlled device was installed which would raise and lower either active or passive acoustic pingers via a radio link from shore. Observations of dolphin movement and distribution were made from a land-based station using a theodolite and logged directly into a computer. Observers did not know if the pinger in the water was active or passive. This "blind" experiment was designed to measure the spatial difference in dolphin distributions between active or passive pinger use. Two data subsets were used in the analysis, representing the distance between sighted dolphins and an active pinger and the distance between sighted dolphins and a passive pinger. The distribution of the distance data was significantly non-normal ($p < 0.001$), so the non-parametric Mann-Whitney rank sum test was used to compare dolphin distributions from the two subsets. In this analysis, all sightings data were included; the median distance value for the passive pinger trials was 299m ($n = 492$) and the median distance value for the active or ensonified trials was 372m ($n = 552$). Results indicate that Hector's dolphin distributions were affected by the 10 kHz pingers and that dolphins avoided the immediate area where the pingers were active, but did not avoid the larger area of Akaroa Harbour. All dolphin sightings made during active pinger trials were distributed significantly farther from the sound source ($p < 0.001$) than were sightings during passive trials.

INTRODUCTION

Tens of thousands of cetaceans are killed annually by commercial fishing gear worldwide (Perrin, ed. 1994). In an effort to address part of this problem, the New England Aquarium (Boston, MA) has been studying Hector's dolphins in a cooperative research and conservation program with the New Zealand Department of Conservation (DOC) since 1989, and the Whale and Dolphin Conservation Society in England since 1996 (Stone, Brown, and Yoshinaga, 1995; Stone *et al.*, 1994; Stone *et al.*, 1992).

Hector's dolphin is one of the rarest marine dolphins in the world with the most recent population estimate between 3,000 and 4,000. The current population is unknown since the last population survey was conducted in 1984/85 (Dawson and Slooten, 1988). Urgency to continue work on this species is accentuated by its low reproductive rate (females' first calving is thought to be at around eight years of age, with calvings only at three year intervals) and by its near-shore distribution and potential vulnerability to human activity in the region.

This endemic New Zealand species is at risk because it suffers from entanglement in coastal recreational and commercial gillnets. In 1988, the New Zealand Department of Conservation established the Banks Peninsula Marine Mammal Sanctuary, which resulted in a seasonal ban of gillnets within its approximately 1140 square kilometers. However, recreational and commercial gillnetting still occur in other areas of New Zealand, including the areas immediately adjacent to this sanctuary. The sanctuary covers a relatively important area which contains high concentrations of Hector's dolphins, but when compared to the known range of the animals and other areas of unrestricted gillnet fishing, the sanctuary is quite small. It is difficult to assess the mortality rate in these other areas because an observer program on the commercial fishing boats began in 1997 and only on the east coast of the South Island of New Zealand.

It is likely that entanglement and death of Hector's dolphins occurs in these other areas based on a) the occurrence of beachcast animals during the fishing season, and b) the fact that in other regions, most notably the U.S. northeast region, the true extent of entanglements was vastly under reported until observers were placed on the fishing vessels.

In a paper submitted to the New Zealand Minister of Conservation, the DOC proposed that the acoustic pinger technology, successfully used to reduce entanglement of the New England harbor porpoise (*Phocoena phocoena*) in gillnets (Kraus *et al.*, 1995; Kraus *et al.* In Press), should be tested for application in New Zealand's gillnet fishery to reduce the entanglement and death of Hector's dolphins.

This project enabled the first necessary step in developing a comprehensive mitigation program for entanglement of Hector's dolphins in New Zealand waters by testing the sensitivity of the species to an acoustic deterrent. Acoustic deterrents were successfully used with harbor porpoise in 1994 and there is now reason to believe that Hector's dolphins may also benefit from this technology.

METHODS

The research team used two methods to test the reaction of Hector's dolphins to acoustic pingers: clifftop observations and boat trials.

Clifftop Observation

The clifftop observations used a theodolite to track dolphin movements in the study area around the sound source. The theodolite was located at 43° 50′ 22.0 S by 172° 56′ 31.6 E and the study area was defined by the waters at a 45° angle out from the observation site to 1 km beyond the pinger buoy. Vertical and horizontal angles from the theodolite were calculated to measure the height of the theodolite above sea level, which was 14.7m, and the distance from observation site to sound source, which was 181 m.

Two pingers were attached with nylon line to a small motor in a waterproof case mounted on a float. The float was attached to a buoy and anchored at 43° 50′ 22.0 S by 172° 56′ 01.6 E. The pingers were raised and lowered using a remote controlled device. The mechanism was custom built from components used in remote controlled airplanes. Attached to the device were one active pinger with fresh batteries installed and one passive pinger without batteries. Active pingers emitted a 10 kHz (with harmonics over 100 kHz) sound for 300 ms every four seconds. The pingers were identified with the color codes red or white. Observers looked through the theodolite or binoculars to determine which color pinger was in the water. However, the observers never knew whether the active pinger for the day was white or red. The color of the active pinger was randomly determined each day by the project director, who did not make observations, thus creating blind experimental conditions. At the beginning of each observational hour, a coin was tossed to determine whether the red or white pinger would be lowered into the water. Using the remote controls, observers could lower and raise the pingers on command. Each night the mechanism was brought ashore for maintenance and battery charging.

A team of three or four observers worked on the cliff site. One observer would record and track dolphins' positions with the theodolite while another entered a group number and behavioral data into a laptop computer. There was a direct and automatic link between the theodolite and the computer, and data were entered using a program called THEO (copyright 1991, Bill Muench). Dolphins were tracked as long as possible while they were within the study area. Behavioral data included surfacing, porpoising, breaching, and logging. In addition, observers would record group size and other data not entered into the computer, besides monitoring dolphin movements in and out of the study area.

Boats moving through the study area also were tracked with the theodolite and recorded by boat type. Dolphins were not tracked when approached by boats. Observations ceased when the sea state became Beaufort sea state three or higher due to adverse sighting conditions.

Boat Trials

Boat trials were conducted eight times using a three-meter inflatable boat. Upon sighting a group of dolphins, the boat would slow down and wait to see if the dolphins would approach it and bow ride. All but one of the trials occurred with the boat engine running. If the dolphins stayed near the boat, a passive pinger was placed in the water for two minutes followed by an active pinger for another two minute trial. Trials were videotaped and any behavioral changes or reactions were recorded.

Analysis

Positions were calculated for all dolphin sightings from the theodolite data. Trigonometric functions were used to obtain distances from the observed dolphin groups to the pingers in the water. The data were divided into two subsets, one representing all dolphins sighted when an active pinger was in the water, and the second included all dolphins sighted when the passive pinger was in the water. These data were analyzed using the computer programs T-Track (copyright 1991, Frank Cipriano), SigmaPlot and SigmaStat.

RESULTS AND DISCUSSION

Clifftop Observation

A research team worked in Akaroa Harbour, New Zealand from January 18 to February 17, 1996. During that time, twelve days had weather conditions favorable for making observations for the above experiment. Of these twelve days, there were ten days when dolphins were present in the study area and the weather remained good for at least two hours. The table below summarizes the results from these ten days. The two columns under "ACTIVE" indicate "Trials" (number of one-hour observation periods) and "Groups" (number of dolphin groups observed) recorded when an active pinger emitting a 10 kHz sound was in the water.

Table 1. Data summary by day for Akaroa Harbour, New Zealand, 1996 pinger trials.

DATE	ACTIVE Trials	ACTIVE Groups	PASSIVE Trials	PASSIVE Groups	# Marks
Jan. 27,1996	3	7	4	24	160
Jan. 28, 1996	0	0	1	1	17
Jan. 30, 1996	4	15	2	32	337
Jan. 31, 1996	2	14	3	36	340
Feb. 1, 1996	1	12	2	14	197
Feb. 2, 1996	1	2	1	3	134
Feb. 5, 1996	3	21	2	20	291
Feb. 6, 1996	3	17	2	27	328
Feb. 7, 1996	2	0	1	7	96
Feb. 10, 1996	0	0	0	0	24
TOTAL	19	88	18	164	1924

The two columns under "PASSIVE" indicate the same data for instances when a silent pinger without batteries was in the water. The column under "Marks" indicates how many dolphin position data points were recorded for that day. A total of 1,924 marks were collected representing observed dolphin locations relative to the buoy containing the sound source.

To determine whether the observed Hector's dolphins responded to the sounds, we pooled the data and examined the positions of all dolphins relative to the pingers, excluding the positions of all dolphins beyond 500m from the sound source. These two data sets of sighted dolphin distances are shown in Figures 1 and 2 as histograms. Scatter plots showing dolphin positions relative to active and passive pingers are shown in Figures 3 and 4. The distribution of the distance data was significantly non-normal ($p < 0.001$), so the non-parametric Mann-Whitney rank sum test was used to compare dolphin distributions from the two subsets. In this analysis, all sightings data were included; the median distance value for the passive pinger trials was 299m ($n = 492$) and the median distance value for the ensonified active trials was 372m ($n = 552$). This difference is significant ($p < 0.001$).

These results indicate that wild, free-swimming Hector's dolphins did, on average, respond to active pingers in the study area by staying farther away from the sound source. This effect appeared to be localized and did not inhibit dolphin movement in and out of the Harbour or exclude the animals from this habitat.

Boat Trials

In addition, eight trials were conducted from a boat when dolphin reactions and behavior were recorded using videotape. These data

Figure 1. Observed dolphin distances from active pinger. Akaroa Harbour, New Zealand.

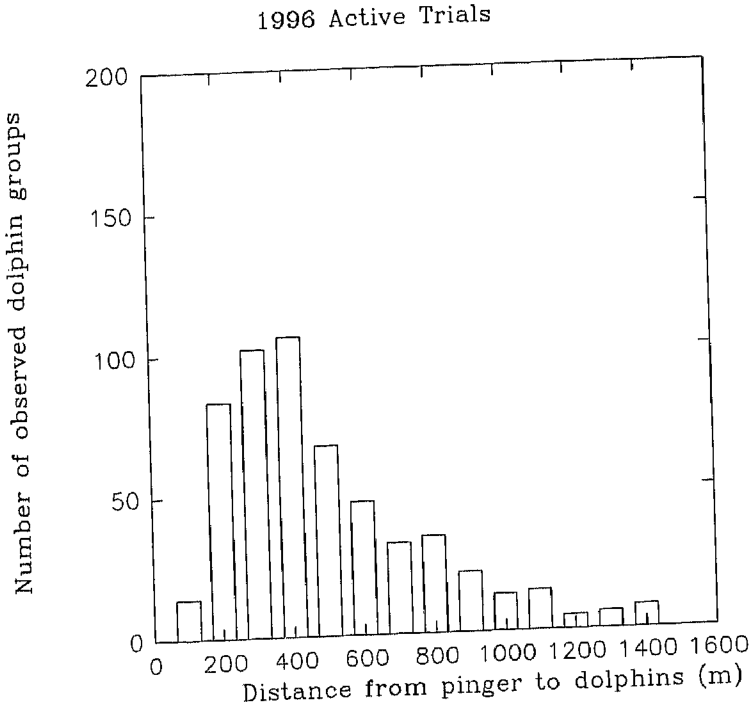


Figure 2. Observed dolphin distances from passive pinger. Akaroa Harbour, New Zealand.

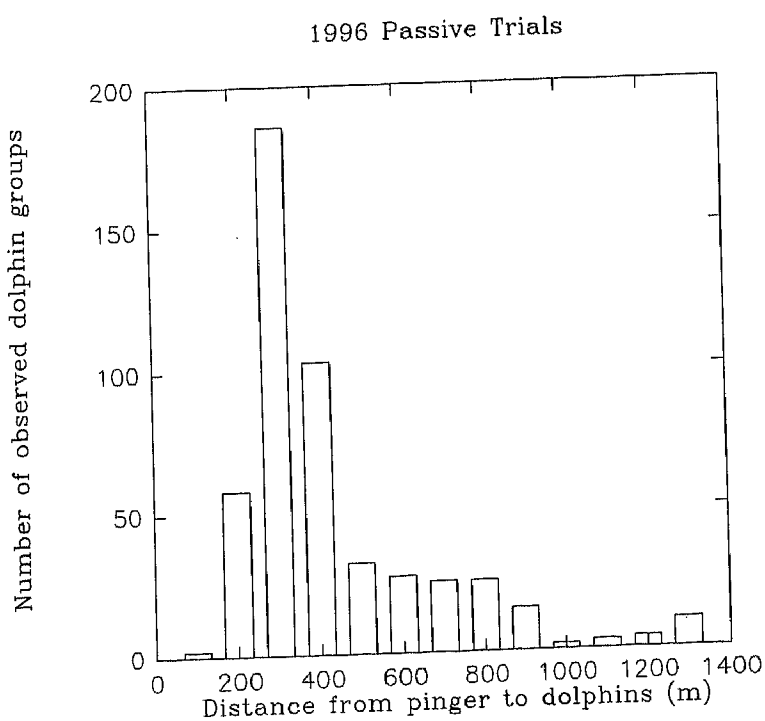


Figure 3. Observed dolphin groups relative to active pinger. Distances on X and Y axes in meters. Pingers located at (0,0).

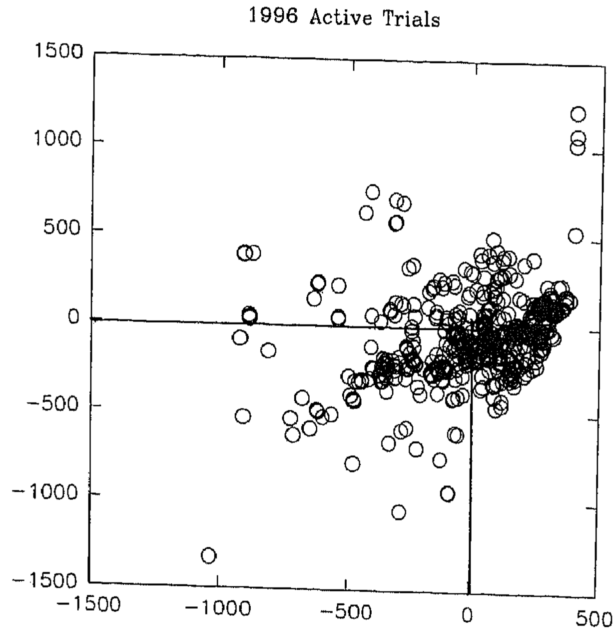
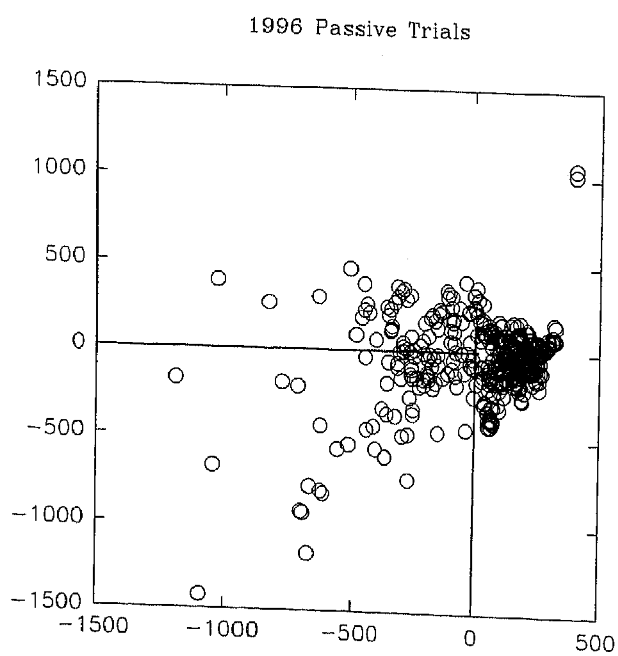


Figure 4. Observed dolphin groups relative to passive pinger. Distances on X and Y axes in meters. Pinger located at (0,0).



are more qualitative in nature, but in conjunction with the above experiment, they are further justification that these dolphins respond to the sounds produced by the pingers. During all eight boat trials, both active and passive pingers were placed in the water for a period of ten minutes each while dolphins swam next to the boat.

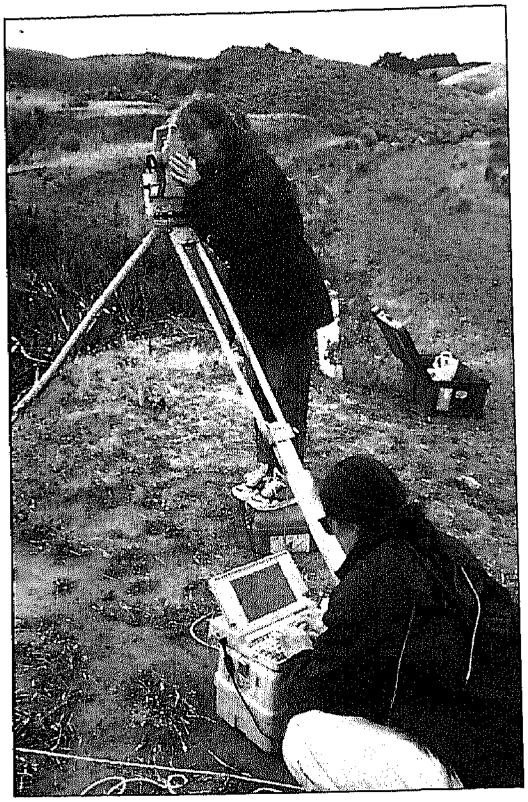
During the passive trials, dolphins seemed unaffected by the pingers, showing no change in behavior. When the active pingers went into the water, dolphins at the surface would submerge instantly, turn away from the boat and swim rapidly away. Dolphins that were submerged would also turn away from the boat and rapidly swim off.

It is difficult to determine effects on larger spatial scales from these boat trials because the boat stayed in the area for a limited time and the visibility was limited to fairly close range. The clifftop observations were a better method for determining larger scale effects.

CONCLUSION

The important question is, "How do the results of this experiment pertain to excluding Hector's dolphins from entanglement in gillnets?" Small cetaceans might become entangled in fishing nets because these animals travel without continually echolocating (Kraus *et al.*, 1995; Goodson *et al.*, 1994). Other experiments concerning incidental catch of Dall's porpoise (*Phocoenoides dalli*) suggest that entanglement may often occur due to an animal's temporary lapse of echolocation (Hatakeyama *et al.*, 1994). This experiment was modeled after Baldwin and Kraus (1995) who conducted a sound-source experiment off the northeast United States coast and found that harbor porpoise responded to a variety of sound-sources in a similar way to Hector's dolphin. Their harbor porpoise experiment was then followed by the first successful test in an active fishery (Kraus *et al.*, 1995; and Kraus *et al.*, In Press). That work provided the first statistical measure that pingers are effective for reducing harbor porpoise entanglement in a commercial gillnet fishery setting. The New Zealand Hector's dolphin experiment used the same pingers as those used in Baldwin and Kraus' harbor porpoise commercial fishing trial.

These studies suggest that the ability of a small cetacean to detect a fishing net without echolocation may be critical in avoiding collisions since dolphins do not always have their echo-location "on." One explanation for why acoustic pingers were successful in the harbor porpoise experiment is that the ensonified net caused the animals to use echolocation to explore what was making the sound and thus to detect the net and avoid it. This possible phe-



New England Aquarium researcher, Austen Yoshinaga (foreground), and Dr. Jenny Brown of Canterbury University, Christchurch, New Zealand, use a theodolite to track Hector's dolphin's reactions and movements relative to a 10 kHz acoustic pinger. A portable computer is used to download data from theodolite while working from the cliffs surrounding Akaroa Harbor, New Zealand.

nomenon is what Baldwin and Kraus (1995) call the "alerting" hypothesis. Alternatively, the animals may have simply avoided the area of the sound in what Baldwin and Kraus call the "aversion" hypothesis. In either case, it appears that Hector's dolphins in New Zealand responded similarly to the pinger sounds as did harbor porpoise in North America. Future work is warranted to explore this phenomenon further in its application to mitigating cetacean entanglement in fishing nets.

ACKNOWLEDGMENTS

The authors would like to thank the New Zealand DOC and the Whale and Dolphin Conservation Society for their support of this study. We would also like to thank Robin Burleigh and John Watson of DOC for field support, and Dr. Jenny Brown of Canterbury University, Christchurch, New Zealand, for help with the analysis. We also thank Ellie Linen, Kylie Hellier, Marjorie Mooney-Seus, Sarah Cuddihy and Elizabeth Lines for observational help. Finally, we wish to thank Michael Cuddihy, Michael Donoghue, and Alison Smith for their continued interest and support of this work.

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