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REACTIONS OF BOTTLENOSE DOLPHINS TO TAGGING ATTEMPTS USING A REMOTELY-DEPLOYED SUCTION-CUP TAG

In recent years there has been an increase in the use of telemetry in the study of cetacean behavior (*e.g.*, Martin and Smith 1992, Goodyear 1993, Baird 1994, Martin *et al.* 1994, Baird and Hanson 1996). Despite convincing evidence that tagging sometimes produces substantial effects on behavior, energetics, and survival in other animal groups (*e.g.*, White and Garrot 1990, Culik *et al.* 1994, Walker and Boveng 1995), this problem has received little detailed attention in studies of cetaceans. In many studies the number of tagging attempts has been small, or on individuals which are not resighted, so that the potential effects of tagging or tagging attempts on individual behavior remain unclear (see Scott *et al.* 1990, for review of such studies on small cetaceans).

Research on bottlenose dolphins (*Tursiops truncatus*) in Doubtful Sound (45°30′S, 167°00′E), on the southwest coast of the south island of New Zealand, has been ongoing since 1990 (Williams *et al.* 1993). The population numbers about 70 individuals, most of which are identified photographically and seen on a daily basis year-round. Typically, these dolphins are seen in "groups" of 10–50 animals which travel cohesively for several hours and which are spread over less than 1 km^2 (Schneider, unpublished data). As part of an investigation of behavior and ecology of these dolphins (by KS) we wanted to study their diving behavior using time-depth recorders (TDRs). To reassure ourselves that the data from the tags represented "normal" behavior, we documented behavior before and after tagging attempts. The purpose of this note is to describe the reactions of bottlenose dolphins to tagging and tagging attempts. We observed and recorded the immediate responses of both the tagged individuals and other dolphins within the same group, as well as the behavior of these dolphins when they were encountered on subsequent days.

The tag used (designed by J. Goodyear) was a modified version of that used by Goodyear (1989) with several species of baleen whales and was the same tag as used by Baird (1994) with killer whales (*Orcinus orca*). The tag contained a VHF radio transmitter (Telonics, Mesa, AZ, USA Model Dart-4, 164.132

MHz, 70 pulses/min, 12 mW power output) attached to a 3-V lithium battery and a 44-cm custom-built wire antenna, and a time-depth recorder (Wildlife Computers, Redmond, WA, USA; Mk5, 250 m maximum depth, 1 m depth resolution), all encased in a housing made of syntactic foam (Billings Industries, Falmouth, MA). The housing and antennae were covered in a thin layer of plastic (Plasti Dip, PDI Inc, Circle Pines, MN, USA). The tag body (weighing 250 g and measuring 17.5 × 6 × 3.2 cm) was attached to a 7.5-cm diameter rubber suction cup (Canadian Tire Corp., used for automobile roof racks) using flexible plastic tubing. A magnesium release mechanism was incorporated into the suction cup to limit the maximum duration of attachment. The suction cup was lubricated with silicone grease (Dow Corning 111 valve lubricant and sealant) before deployment.

Tagging attempts (summarized in Table 1) were made 24–29 October 1995, using a crossbow or a 2.5-m pole. Tagging was attempted only when the dolphins were moving slowly and within 2 m of the bow of the tagging vessel. Two boats were used concurrently: a 4.3-m rigid-hull inflatable, powered by a 60-hp Yamaha outboard, carried a tagger and a driver, and a 4.5-m aluminum boat, with a 45-hp Honda outboard carried a driver/observer, recorder, and videographer. The observation boat was kept within 30–50 m of the tagging vessel during tagging attempts. The tagging vessel was operated in a manner similar to that of our routine photo-ID sessions. Note that these dolphins are acclimatized to having small boats amongst them for several hours at a time (before the first tagging attempt, KS had spent a total of 457 h over 16 mo photoidentifying and collecting behavioral data on these dolphins from the aluminum boat described above). Frequency of leaps within the group and the group's speed (noted as engine rpm to keep pace, later calibrated to knots), were recorded before and after tagging for 17 tagging attempts on six different days. We also attempted to record each tagging attempt on videotape to check and add detail to the behavior notes. We recorded only the immediate response of the tagged animal, because once the tag fell off we could not be sure which dolphin had been tagged, nor was it feasible to collect focal data on one individual and then attempt to tag that individual. Because our objective was to examine short-term response, we restricted comparisons to a maximum of 20 min immediately before and 20 min after tagging attempts. In seven cases, 20 min of data were not available. For these, comparisons were made instead between equal time periods before and after ($\bar{x}$ = 15.6 min; SD = 6.0; see Table 1).

The tag contacted a dolphin in 10 cases and remained attached (for > 10 sec = "successful attachment") in five of these. Group speed increased in each of these five cases. The number of leaps increased in four cases, but declined in one. In five more cases the tag contacted but failed to attach, or detached within 10 sec (= "unsuccessful attachment"). Group speed also increased for four of the five unsuccessful attachments, while the number of leaps increased in three cases but declined in two. Responses to misses (n = 7), in which no contact was made, were more variable. We recorded elevated frequencies of

Table 1. Summary of tagging attempts and apparent reactions to them. Key: D = dolphin, TD = targeted dolphin, bow = bow of tagging boat, immed. = immediate, U/W = underwater.

Tag deploy-ment	Hit tar-get?	At-tached (for >10 sec)?	Obser-vation time (min: 50% before, 50% after)	Group size (app-rox)	# Leaps before	# Leaps after	Speed immed. before (kn)	Speed immed. after (kn)	Reaction level of targeted dolphin (reaction level of group)	Notes
pole	Y	Y	40	35	3	11	2.5	7.1	strong (strong)	TD moved away from bow at high speed and leapt vertically 3 times in quick succession before tag detached. Group dived immed., turned 180°, bunched, and increased speed to fast travel (high speed surfacing) for 8 min. They then slowed to 3 kn and reverted to original direction.
pole	Y	Y	40	35	8	>50	2.9	8.0	strong (strong)	Immed. high speed departure of all Ds from bow. TD leapt vertically 4 times before tag detached. Group increased speed to fast travel (high speed surfacing), covering 3.5 nmi in 17 min (avg. = 12.3 kn).
pole	Y	Y	40	15	0	1	2.0	5.0	moderate (moderate)	Vertical leap by TD, immed. dive of all Ds for 2 min, then high speed surfacing for another two min.
pole	Y	Y	34	38	3	9	4.6	7.1	moderate (moderate)	TD departed bow at high speed U/W. Group high-speed surfaced for 4 min, slowed, and bunched together (for 12 min).

Table 1. Continued.

Tag deployment	Hit target?	Attached (for >10 sec)?	Observation time (min: 50% before, 50% after)	Group size (approx)	# Leaps before	# Leaps after	Speed immed. before (kn)	Speed immed. after (kn)	Reaction level of targeted dolphin (reaction level of group)	Notes
Pole	Y	Y	10	30	7	0	3.1	3.4	moderate (low)	Sharp turn and high speed U/W departure from bow by TD. Immed. short dive of all Ds near bow.
Pole	Y	N	40	30	3	10	2.3	2.7	low (moderate)	Sharp turn with tail flick by TD, immed. dive of all 9 Ds near bow. Group bunched together for 15 min.
Pole	Y	N	16	17	0	8	2.6	7.1	moderate (moderate)	Tail flick by TD then high-speed surfaced away from boat with four companions. Group high-speed surfaced for 2 min.
Crossbow	Y	N	40	30	14	2	4.6	6.1	moderate (moderate)	Immed. dive by TD. Group increased speed to fast travel, covering 3 nmi in 20 min (avg. = 9 kn).
Pole	Y	N	30	25	10	13	3.9	4.0	low (low)	Immed. dive by all Ds around the boat for about 2 min. Surfaced 300 m away from boat, then started slow travel.
Pole	Y	N	30	22	13	10	5.7	6.1	low (low)	Immed. dive by all Ds for 1 min, then 90° change of direction with fast travel for 4 min.

Table 1. Continued.

Tag deployment	Hit target?	Attached (for >10 sec)?	Observation time (min: 50% before, 50% after)	Group size (approx)	# Leaps before	# Leaps after	Speed immed. before (kn)	Speed immed. after (kn)	Reaction level of targeted dolphin (reaction level of group)	Notes
Crossbow	N	N	10	30	1	0	4.8	4.8	low (no reaction observed)	Immed. dive by TD and a companion close by. No visible group reaction except for three lobtails 1 min after tagging event.
Crossbow	N	N	40	35	10	0	2.3	2.5	low (low)	Immed. short dive by all dolphins (<1 min), then slightly faster travel.
Crossbow	N	N	32	22	2	21	3.5	3.8	low (no reaction observed)	Immed. dive by TD.
Crossbow	N	N	40	28	11	33	5.9	6.7	low (low)	Immed. dive by TD. No immed. group reaction, but 35 sec after tagging group changed direction by 180°.
Pole	N	N	10	30	1	2	2.3	2.3	no reaction observed (no reaction observed)	All Ds continued slow travel as before tagging attempt.
Pole	N	N	40	35	2	1	4.3	4.3	low (low)	TD left bow at high speed, group dived immed. for 1.15 min.
Pole	N	N	40	35	5	0	6.1	6.1	no reaction observed (no reaction observed)	Group dived 15 sec after attempt.

leaps in two cases, a much lower frequency in one case, and relatively little change in the other four (Table 1). Group speed also changed little for misses.

In 16 out of 17 tagging attempts the immediate reaction of the targeted dolphin was rapid departure from the bow of the tagging vessel or an immediate dive. In the remaining case (a miss) no reaction was visible. In each of the five cases in which the tag contacted and stuck, the tagged animal immediately began a bout of high-energy behaviors, apparently attempting to dislodge the tag. In three of these the dolphin leapt vertically 1, 3, or 4 times and in the other two cases the dolphin moved underwater at very high speed away from the tagging vessel. Tags remained attached on these dolphins for periods of about 10 sec to about three minutes. TDR data were collected from two tag deployments (depth sampled once per second). In one case the dolphin sped away from the bow and leapt vertically four times, with dives between each leap to 11, 14, and 21 m before the tag detached. Maximum short-term rate of descent (calculated using the program Dive Analysis, Wildlife Computers) was 8.0 m/sec (15.5 kn). In the other case the tagged dolphin leapt vertically three times and in between dived to 29 m, 9 m, and 6 m before the tag detached.

For the purpose of comparison with other studies, we also classified immediate reactions of the targeted individual using the criteria of Weinrich *et al.* (1991) and Baird (1994), taking into account both the intensity of the reaction and its duration. Reaction intensity was classified as either: (1) low (fast dive, tail flick, change in direction); or (2) high (vertical leap, horizontal leap, high-speed surfacing). Reaction duration was categorized as either: (1) short (< 5 min); or (2) long (≥ 5 min). Low-level reactions were of low intensity and short duration. Moderate-level reactions were either low-intensity, long-duration reactions, or high-intensity, short-duration reactions. Strong-level reactions were those which were both high intensity and of long duration. We note that two problems exist with this classification system, however: (1) the behaviors which make up the high- and low-intensity categories may not accurately reflect the reaction of the animals (for example, does a horizontal leap always indicate a higher level response than a direction change?) and (2) maintaining prolonged (> 5 min) observation of the targeted dolphin was not possible due to the large group sizes involved. Group reactions were categorized using the same method, with the additional criterion of bunching together (decreasing interindividual spacing) being classified as a moderate-level reaction. In one event the targeted dolphin's reaction was classified as low level, whereas the group reaction was classified as moderate level, because the targeted dolphin was lost from sight. Classifications of individual and group reactions are given in Table 1.

In general, reaction intensity decreased in the following order: successful attachments > unsuccessful attachments > misses (Table 1). No obvious differences in reactions to attempts using the crossbow *vs.* the pole deployment were apparent.

Throughout our previous work with this population, and for the first three days of tagging attempts, dolphins regularly bowrode at both slow (< 3 kn) and higher speeds. After the first three days of tagging attempts, dolphins bowrode rarely and only for short periods (on both the tagger and the observer vessels). Surfacing within two meters of the boat (which regularly occurred before and during the first three days of tagging) decreased to the point that it became much more difficult to deploy the tag successfully. Dolphins that did bowride typically moved three or more meters away from the boat to surface and then would return to the boat. This behavior remained consistent throughout 10 more days of field work immediately following our last tagging attempt and changed only slowly back to "normal" over the next two months (KS, unpublished observations).

Due to the paucity of reports and differences in methods, it is difficult to compare reactions of Doubtful Sound bottlenose dolphins to those of other cetaceans. Many studies utilizing radio telemetry have involved capturing individuals or using individuals incidentally caught in fishing gear, and others have used tags which penetrate the skin (see Scott *et al.* 1990). In most published studies, reactions to tagging are not discussed in sufficient detail to facilitate comparisons. Baird (1994) discussed reactions of killer whales to tagging attempts using the same tag, and a crossbow deployment method. These reacted less strongly than did Doubtful Sound bottlenose dolphins, showing no moderate or high-level reactions (defined as above), and no reaction by other group members (Baird 1994). Baird and Hanson (1996) used a very similar tag and the same pole-deployment method with Dall's porpoise in Washington state and British Columbia. Reactions by Dall's porpoise appeared to be less intense than did those of bottlenose dolphins in Doubtful Sound. No reaction was observed for misses, and individuals regularly returned to bowride after unsuccessful tagging attempts. As with bottlenose dolphins, reactions to successful attempts were stronger and of longer duration than unsuccessful ones; evidence collected from a TDR on one individual suggested the reaction was sustained for about eight minutes (Baird and Hanson 1996)

Though our sample size is small, the reactions exhibited both by individual dolphins and those in the surrounding group, and the inability of the suction-cup tag to remain attached during leaps and high-speed swimming, suggest that suction-cup tagging of this population of bottlenose dolphins is not feasible. Even if modifications to the tag allowed longer-term retention, reactions exhibited by tagged individuals imply that data from the tag are unlikely to be representative of the natural behavior of these animals. It seems to us that unless tagging studies incorporate investigations of potential tagging effects, the validity of the data from the tag is open to question (see also White and Garrot 1990 for a similar view). This could be argued to be less of a problem with invasively attached tags which stay in place for several weeks, as presumably the animals habituate to the tag. Suction-cup tags may stay attached on small cetaceans for several hours (Baird 1994, Stone *et al.* 1994). While being attractive because they cause no injury, they may not stay attached long enough for the animal to habituate to them.

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KILLER WHALE (*ORCINUS ORCA*) PREDATION ON DUSKY DOLPHINS (*LAGENORHYNCHUS OBSCURUS*) IN KAIKOURA, NEW ZEALAND

Killer whales (*Orcinus orca*) are known to prey on a wide variety of marine mammal species, including large and small cetaceans, as well as pinnipeds (Jefferson *et al.* 1991). No well-documented records of killer whales feeding on dusky dolphins (*Lagenorhynchus obscurus*) have been reported in the literature. Würsig and Würsig (1980) reported one second-hand account of predation on dusky dolphins off Peninsula Valdés, Argentina. Accounts of killer whales preying on other species in the genus *Lagenorhynchus* are also infrequent (Dahlheim and Towell 1994), especially given that these animals are both regularly observed in similar habitats. We present accounts of four killer whales preying on dusky dolphins over a period of 11 d off Kaikoura, New Zealand (42°25′S, 173°42′E) (Fig. 1).

Killer whales have frequently been seen associating with marine mammals with no apparent aggressive actions (Jefferson *et al.* 1991). Such non-predatory associations between killer whales and other cetaceans have been recorded for 26 species including four species of *Lagenorhynchus* (Jefferson *et al.* 1991). Dusky dolphins have been observed in non-predatory associations with killer whales off the Otago Peninsula, New Zealand (Hawke 1989). There are also anecdotal reports of dusky dolphins and killer whales interacting in an apparently non-predatory way in the waters off Kaikoura (S. Dawson and B. Todd, personal communication). In January 1995 near Kaikoura, a juvenile killer whale was filmed while riding the bow pressure wave of a sperm whale (*Physeter macrocephalus*) in close proximity to at least five dusky dolphins, also at the head of the sperm whale (B. Würsig, personal communication).

Avoidance responses by dusky dolphins to the presence of killer whales also are frequently observed. Cipriano (1992) observed nearshore movements by dusky dolphins off Kaikoura when killer whales were present. Dusky dolphins in Golfo San José, Argentina, moved close to shore in waters less than one meter deep when killer whales were present and traveled rapidly away from the whales