Notes

Successful suction-cup tagging of a small delphinid species, *Stenella attenuata*: Insights into whistle characteristics

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The Delphinidae is the most diverse family of cetaceans, with 38 species recognized. Small pelagic delphinids are also the most abundant cetaceans world-wide, yet their communication and behavior remain poorly understood. Many populations live in relatively remote habitats, which creates challenges in accessing study animals. Small odontocete species often face numerous anthropogenic stressors. For example, many pelagic delphinids incur significant interactions with fisheries (Gerrodette and Forcada 2005, Geijer and Read 2013). With a wide distribution, many delphinid populations utilize habitats that also are important for human seagoing activities that produce intense sound, such as seismic surveys or naval sonar exercises that may disturb or harm these odontocetes. Many U.S. naval sonar exercises take place on naval training ranges such as those in Hawai'i (Baird *et al.* 2013), California (Carretta *et al.* 1995, Henderson *et al.* 2014), and the Bahamas (DeRuiter *et al.* 2013). At least one delphinid stranding event involving melon-headed whales (*Peponocephala electra*) was correlated with military activities (Southall *et al.* 2006); a mass stranding of melon-headed whales has also been associated with multibeam echosounder operations as part of a seismic survey (Southall *et al.* 2013). Because many of these delphinid groups can number in the 100s to 1,000s, fisheries or sonar exposures can account for the highest estimates of marine mammal "takes" in related Environmental Impact Assessments (Department of the Navy 2013). Given the potential for anthropogenic interactions with large numbers of individual delphinids, improved methods of

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studying small delphinids are invaluable to understand, reduce, or mitigate potential human influences on these animals.

One important tool for studying the acoustic behavior of cetaceans is the digital acoustic recording tag (DTAG) (Johnson and Tyack 2003). Deployed using noninvasive suction cups, the DTAG is equipped with two hydrophones for recording environmental noise and sounds produced by the tagged animal, nearby conspecifics, as well as various sensors that capture diving behavior and 3-D orientation and movement of the tagged animal. Acoustic data from DTAGs have been used to gain insight into delphinid vocal behavior, such as the production of repeated call types in short-finned pilot whales (*Globicephala macrorhynchus*) and melon-headed whales (Sayigh *et al.* 2013, Kaplan *et al.* 2014).

Because they are attached directly to the animal, DTAGs can facilitate distinguishing focal (tagged animal) vocalizations from those of conspecifics (Johnson *et al.* 2009). Thus, these tools potentially offer a way for studying individual vocal behavior, an aspect of communication that was previously limited to studies involving captive animals, well-known resident populations, or sound localization methods using arrays (Caldwell and Caldwell 1965, Watkins and Schevill 1974, Sayigh *et al.* 1990).

Acoustic recording tags have been used to examine the ecology of various baleen whales, beaked whales, and larger odontocetes (Miller *et al.* 2004, Johnson *et al.* 2009, DeRuiter *et al.* 2013). Yet, acquiring focal tag data from small odontocetes has long remained a challenge. The size, speed, high activity, and social contact of many delphinids and some porpoises can limit tagging opportunities or dislodge tags, and attempts to tag wild, free-swimming small odontocetes have been relatively unsuccessful with a few exceptions. Hanson and Baird (1998) tagged free-swimming Dall's porpoise (*Phocoenoides dalli*) with suction cup time-depth recorders (TDRs), but for short periods of time (maximum 41 min). Six pantropical spotted dolphins (*Stenella attenuata*) were tagged with TDRs for periods ranging from five min to just over 12 h (Baird *et al.* 2001), although attempts to tag common bottlenose dolphins (*Tursiops truncatus*) with TDRs were unsuccessful (Schneider *et al.* 1998). Acoustic data loggers (A-tags) have been successfully deployed on harbor (*Phocoena phocoena*) and finless (*Neophocaena phocaenoides*) porpoises, but tagging was accomplished during capture-release events (Akamatsu *et al.* 2007). Similarly, the latest, smaller version of the DTAG, the DTAG3, has been deployed on harbor porpoise (DeRuiter *et al.* 2009) and common bottlenose dolphins (Wells *et al.* 2013), but tags were hand-placed on animals in captivity (DeRuiter *et al.* 2013) or during brief capture and release events (Wells *et al.* 2013). Kaplan *et al.* (2014) recently deployed DTAG3s on melon-headed whales, although maximum durations were limited to 57 min (largely due to the behaviors of the tagged animals). Thus, there has been a paucity of focal-individual bioacoustic data from noninvasively tagged animals, limiting analyses of individual call behaviors and descriptions of successful attachment.

Recently, Silva *et al.* (2016) presented whistle characteristics and daytime dive behavior recorded during the first successful deployment of DTAG3s on free-swimming pantropical spotted dolphins (*Stenella attenuata*). Here, we use these DTAG3 data to further explore the whistle repertoire of pantropical spotted dolphins, by presenting visual categorizations of whistle contours, addressing evidence of repeated whistle types, and providing new data on individual call behaviors. A second goal of this study is to evaluate attachments of DTAG3s to small delphinids. We compare the pantropical spotted dolphin data described here to that of Kaplan *et al.* (2014), who successfully deployed multiple DTAG3s on melon-headed whales off Hawai'i, providing a short description of the successful attachment methods. Thus, this work

provides insights into the acoustic behavior of small delphinids and a description and evaluation of successful tagging methodology and species-specific deployment details.

Tagging was conducted from an 8.2 m Boston Whaler off the west (leeward) side of the island of Hawai'i in May 2013. When groups were encountered we recorded location (with a GPS), predominant group behavior (*e.g.*, travel, feeding, milling), direction and speed (categorized as slow travel, travel, or fast travel) of travel, and estimated group size (see McSweeney *et al.* (2009) for details of behavioral categorization). In order to deploy a DTAG3, the boat gradually passed through the group, either allowing animals to approach the boat and bowride or approaching animals that were generally surfacing frequently and traveling in a predictable direction. When an animal surfaced near the bow, the DTAG3 was deployed with a carbon-fiber pole and attached with suction-cups. For each tagging attempt, we recorded: the age/sex class of the target animal (based on body size, spotting patterns, and the presence/absence of calves/juveniles in attendance; Perrin *et al.* 1976), its behavior immediately before tagging, the reaction to tagging (*e.g.*, fast dive, tail slap), behavior after tagging (if seen again), tag position on the animal's body, reason for tag release, and any tag damage. Location, predominant group behavior, and direction of travel were also recorded at the end of the encounter. When possible, photos of the tagged animal were obtained for individual identification. After tagging, the tag boat generally moved away from the tagged animal (*ca.* several hundred meters) to limit any potential influence on behavior and to reduce vessel noise on the acoustic tag record. Tag attachment was monitored by listening to the intermittent VHF pulse of surfacing tagged animals. During this time the research vessel moved with the group (which could be dispersed over several kilometers) at approximately the speed of the group. This slow moving through the traveling groups did not appear to influence the behavior of individuals or the group, as animals did not change observed behaviors (besides a few animals coming to bowride) or direction of travel. Individual animals that surfaced within 50 m of the tag vessel were photographed for future photo-identification and population studies. The research vessel stayed with the group until tag recovery except for DTAG sa147d. For this deployment, researchers left the group 4 h 41 min after tagging, and then returned to the area later that night to recover the detached tag.

The process of selecting whistles for analyses was described in detail in Silva *et al.* (2016). Briefly, acoustic data were initially analyzed in MATLAB (MathWorks, Natick, MA) using a toolbox designed for DTAG analysis (available at http://soundtags.st-andrews.ac.uk/dtags/dtag-3/). The acoustic recording for each tag was viewed as consecutive 10 s spectrograms (FFT size 1,024 samples, Hamming window, 50% overlap), and the entirety of acoustic files were audited. Times of all whistles with a clear start and end were marked within this program. For visual categorization, whistles were defined as tonal signals greater than 0.3 s in duration (Driscoll 1995), in an attempt to follow established criteria for whistles from *Stenella* spp. Using criteria defined by Bazua-Durán and Au (2002), 463 of these whistles were deemed "loud and clear" and thus selected for categorization.

A spectrogram of each whistle was printed using uniform settings: *y*-axis from 0 to 48 kHz and *x*-axis where 1.2 cm = 0.1 s. All spectrogram prints were randomly shuffled to remove any sequence information. Four judges participated in whistle classification by visual inspection of the spectrograms. They included one author (TLS) and three independent judges with some experience visualizing dolphin whistles, but no prior experience with pantropical spotted dolphin sounds. The three independent

judges were instructed to group the whistles into as many categories as they wanted based on similarities of the fundamental frequency contour, but were given no further instructions, following Sayigh *et al.* (2007).

When three out of four judges grouped two whistles together, a category was created. Whistle categories were assigned arbitrary letter designations. Whistles that were not grouped together by three judges were not considered further. Tag deployments on the same day often overlapped in time (Table 1) resulting in some whistles being recorded on multiple tags. If duplicate whistles were selected for analysis, only the whistle of highest amplitude (based on visual inspection of spectrograms) was included in the categorization. To evaluate potential differences in the fundamental frequency shape and characteristics of categorized whistles, ten whistles were randomly selected from each major (more than 10 whistles) whistle category and were used to create whistle contour plots. Using Raven Pro 1.5 beta version build 21 (Charif *et al.* 2010; Cornell Lab of Ornithology, Ithaca, NY), a frequency measurement was taken every 0.05 s along the fundamental frequency for the entire length of the whistle. These measurements were plotted using Microsoft Excel to produce contour traces.

The majority of whistles grouped by judges into one category (termed "type B") were recorded from a single tag (sa147d) deployed on an animal classed as an adult male. Particularly high amplitudes of these whistles (based on visual inspection) suggested that this whistle category was potentially produced by the tagged animal. Based on these observations, we chose to focus on this tag for a more in-depth look at an individual's whistle repertoire.

To explore the possibility that type B whistles were produced only by the tagged animal, the received level (RL) and angle of arrival (AOA) were calculated for whistles recorded on sa147d. The AOA is calculated from the time delay between the two hydrophones, and indicates the angle from which the sound is arriving. Whistles produced by the tagged animal should have a relatively high received level and a

Table 1. Number of whistles in each whistle category that were grouped by three judges. The top three rows represent day 1 of tagging. The bottom five rows represent day 2 of tagging. The number of whistles from a tag that were grouped by three judges into a given whistle category is listed. The number of whistles in each category that were recorded on multiple tags is also listed. Tag IDs correspond to the following information: sa = species, *Stenella attenuata*; 146, 147 = day of tagging (Julian day), a–d = the order animals were tagged.

	Whistle category									
Tag	A	B	D	E2	H	D3	G	Q	C	BB
sa146a	11	1	4	13	4	0	6	0	8	2
sa146b	8	0	1	23	32	0	2	1	1	1
sa146a and sa146b	5	1	2	31	29	0	1	1	2	1
sa147b	47	0	0	0	0	0	0	0	0	0
sa147c	6	0	28	0	3	8	6	9	0	0
sa147d	8	74	23	0	0	10	3	1	0	1
sa147b and sa147c	10	0	0	0	0	0	0	0	0	0
sa147c and sa147d	5	45	32	0	0	13	8	3	0	1
Total	80	75	56	36	39	18	17	11	9	4

consistent AOA, while whistles produced by nearby animals will have varying angles of arrival as these animals move in relation to the tag (Johnson *et al.* 2009).

From the 463 whistles analyzed, 136 were recorded on sa147d and were used to address individual sound production. Whistles from sa147d were extracted using a custom MATLAB script and saved as individual sound files with an additional 0.1 s added onto the beginning and end of each whistle. All selected whistles were individually imported into MATLAB and amplitude corrected for nominal tag hydrophone sensitivity (–175 dB re 1 V/μPa). Low frequency flow and boat noise were reduced by applying a user-selectable 6-pole variable bandpass Butterworth filter (3,000–40,000 Hz) (Jensen *et al.* 2011). The root mean square (rms) intensity of the last 0.1 s of each clip was calculated and used as a noise measure. For signal to noise ratio (SNR) calculation, signal duration was defined as the length of the window containing 95% of the total energy after subtracting the noise energy (Madsen and Wahlberg 2007) and excluding the additional 0.1 s at the beginning and end of the clip. SNR was calculated as the difference between rms signal amplitude and rms noise amplitude on a decibel scale and only calls with SNR greater than 10 dB were analyzed further (Jensen *et al.* 2011).

Received sound pressure level (rms) was calculated for each remaining whistle. DTAG toolbox scripts were used to estimate the AOA of each whistle by cross-correlating time differences of arrival between the two tag hydrophones (Johnson *et al.* 2009; 45 mm separation). Received level was plotted with AOA for all whistles analyzed from sa147d.

We further examined where type B whistles were recorded in time and depth. For this analysis, all type B whistles recorded on sa147d were included, even if they were not initially selected for analysis. A dive profile for sa147d was created using DTAG toolbox MATLAB scripts. The time and depth where each type B whistle was recorded was annotated within the dive profile. Time intervals between each type B whistle as well as the number of type B whistles recorded in 10 min bins and 5 m depth bins were quantified. The percent time spent in five meter depth bins for sa147d was also quantified. A chi-square test was used to determine if type B whistles were recorded more often than expected in any particular depth bin based on the amount of time spent in each depth bin. Counts for the deepest five depth bins were pooled to meet the sample size requirements of chi-square.

Whistle categorization resulted in judges grouping 345 of the 463 whistles (75%) into 10 categories. Whistles that were not grouped together by three judges (118/463) were not considered further. Five categories had more than 25 whistles each, accounting for 83% (286 out of 345) of categorized whistles (Table 1). Eight categories had 10 or more whistles (Table 1). The remaining two categories contained four and nine whistles each. Overlapping deployments of tags on the same days resulted in many cases where the same whistle was recorded on multiple tags. For each whistle category, the number of whistles that were recorded on a simultaneously deployed tag was also reported (Table 1).

Certain whistle categories dominated several tag records. Over half of type A whistles were recorded on tag sa147b. Of type B whistles, 74/75 were recorded on sa147d; one was recorded on sa146a. Although the type C category only contained nine whistles, all were recorded on the first day of tagging; eight were recorded on tag sa146a and one on sa146b. For type H whistles, 32/39 were recorded on sa146b. Whistles within the same category exhibited similar contour shapes (Fig. 1), with whistle E2 contours being the most similar in shape and duration (Fig. 1B) and whistle Q showing the most variation in contour shape (Fig. 1H).
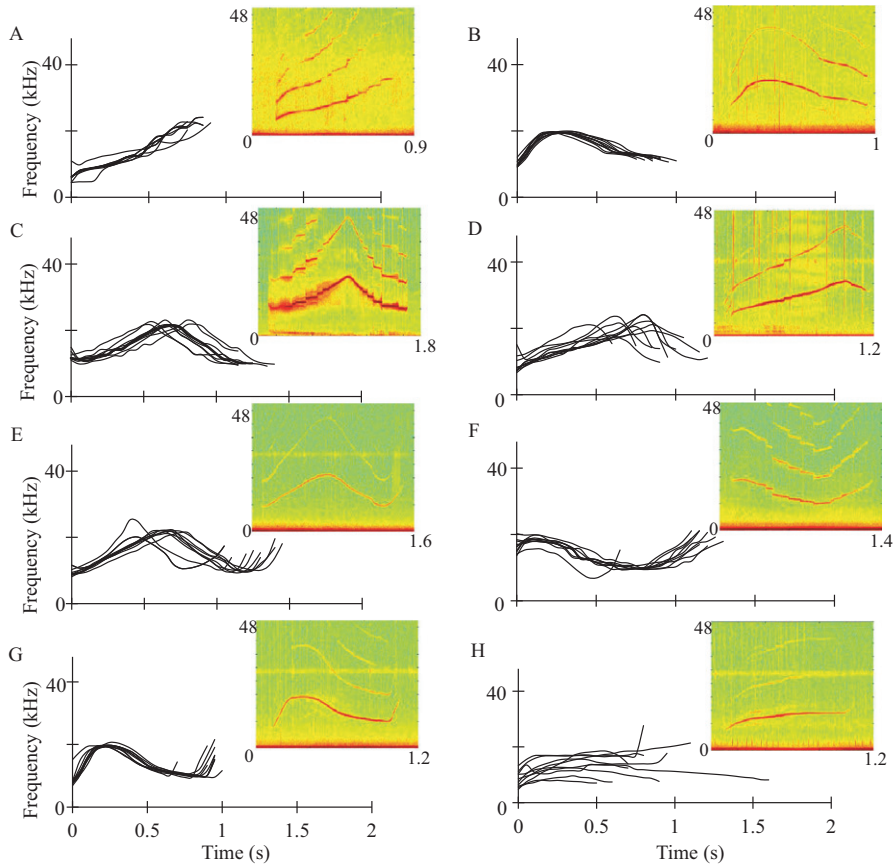
Figure 1. Contour traces for 10 randomly selected whistles from eight whistle categories. A representative whistle from each category is also shown as a spectrogram (insets). All whistles are from pantropical spotted dolphins. Letters assigned to whistle categories are arbitrary designations. A. type A, B. type E2, C. type B, D. type G, E. type D, F. type H, G. type D3, H. type Q.

Whistle categorization suggests that pantropical spotted dolphins repeat stereotyped whistles. The recording of whistles in some categories on 2 d of tagging (Table 1) may be suggestive of shared whistles across groups or subgroups as found in short-finned pilot whales (Sayigh *et al.* 2013) and killer whales, *Orcinus orca* (Ford 1989). However, pantropical spotted dolphin group membership is likely fluid, making stable group repertoires unlikely. Given large group sizes (400 and 140, respectively) and the relative proximity of tagging locations (36 km), it is possible that some animals were common to both groups and therefore could have produced the same whistles recorded on different days. Alternatively, whistles could be shared across larger sets of groups within an area. Future photo-identification analysis could confirm the presence of animals common to both groups, although this has yet to be determined.

Of 136 whistles initially selected from sa147d, 86 had suitable SNR (>10 dB) for computing received level. Of these 86 whistles, 74 were type B whistles, three were

type D whistles, five were type D3 whistles, one was a type A whistle, and three were not grouped by three judges. Type B whistles exhibited significantly higher received levels than other whistles (Mann-Whitney-Wilcoxon test, $W = 0$, $P < 0.0001$). The median RL of type B whistles was 141 dB re 1 μPa (IQR: 140–142.5). Other whistles (those not categorized as type B) had a median RL of 114 dB re 1 μPa (IQR: 112.7–115.1) (Fig. 2). Angles of arrival also differed significantly between type B and other whistles (Mann-Whitney-Wilcoxon test, $W = 754$, $P = 0.0001$). For type B whistles, AOA ranged from –44.7° to –27.1°, whereas AOA for other whistles varied more substantially, from –43° to +41.9° (Fig. 2). Based on these data, we conclude that type B whistles were likely produced by the tagged individual, and that examining individual whistle production using DTAGs can be done in some cases.

Caldwell *et al.* (1970) report individually distinctive signature whistles recorded from five captive Atlantic spotted dolphins (*Stenella frontalis*) captured in Florida waters and Herzing (1996) reports stable signature whistles produced by individuals of this species in the wild for over 10 yr. The recording of a repeated whistle type from a single animal suggests it may be producing signature whistles, a novel observation for *S. attenuata*. The identification of type B whistles as a potential signature whistle was only possible after judges classified them as the same whistle type, demonstrating the utility of whistle categorization in exploring both group and individual whistle repertoires. While the repeated nature and stereotyped contours of the remaining whistle categories also suggests signature whistle production by this species, we chose not to conduct a detailed analysis of these categories, as they exhibited high variability in amplitude and AOA and were likely not produced by tagged animals, but by other animals nearby. Some slight variation in AOA was also noted for type B whistles and was to be expected as the tagged animal moves its head with respect to the tag location. In addition, tag placement on the flank as opposed to more anterior, dorsal locations may cause slight variations in AOA as the dolphin undulates while swimming.
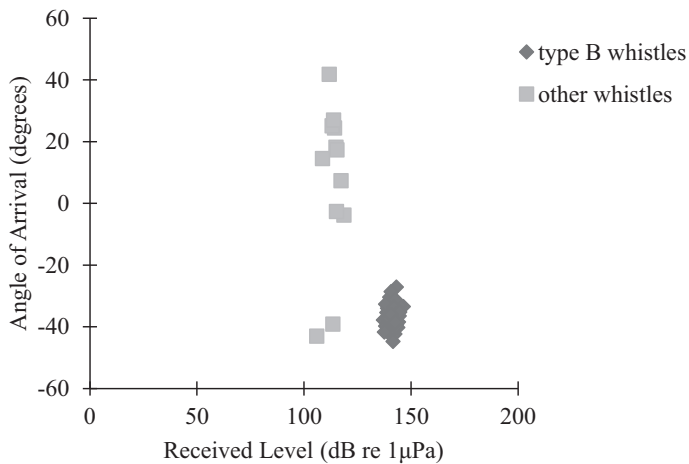

Figure 2. Received level *vs.* angle of arrival for type B whistles ($n = 74$) and other whistles ($n = 12$) recorded on sa147d.

Janik *et al.* (2013) found that signature whistles in free-swimming common bottlenose dolphins could be identified based on a temporal production pattern. Using recordings of animals whose signature whistles are known, Janik *et al.* (2013) reported that signature whistles were characterized by a bout structure in which at least 75% of whistles were produced within 1–10 s of another whistle of the same type. However, this was a conservative criterion created to avoid identifying false positives; out of seven potential signature whistles that could have been identified from recordings of wild animals, only four were identified as such. Thus, not all bottlenose dolphins in the aforementioned study used the 1–10 s bout production pattern; the longest interwhistle interval for a signature whistle was 89.5 min (Janik *et al.* 2013).

Type B whistles analyzed here did not follow the 1–10 s bout production pattern (Fig. 3). Intervals between type B whistles were between 1–10 s only 4.1% of the time, and between 10–20 s 42% of the time. Given the variability shown by bottlenose dolphins and the fact that we present data for only one animal from a different species, it is impossible to use bout structure to determine whether the type B whistle is a signature whistle. Additional acoustic recordings and tagging of multiple associated animals may provide insights into potential pantropical spotted dolphin signature whistle production.

Two other whistles recorded on tag sa147d had similar angles of arrival to type B whistles, but had RLs approximately 30 dB lower (Fig 2). Documented source levels for Atlantic spotted dolphin whistles range from 115 to 163 dB re 1 μPa (Frankel *et al.* 2014). Based on the dynamic range of Atlantic spotted dolphin whistles and the attachment of the tag directly to the animal, it is possible that the tagged animal (sa147d) produced these lower amplitude whistles, suggesting that pantropical spotted dolphins may produce different whistle types at different amplitudes. Additional tag recordings may help identify instances of production of multiple whistle types by the tagged animal.
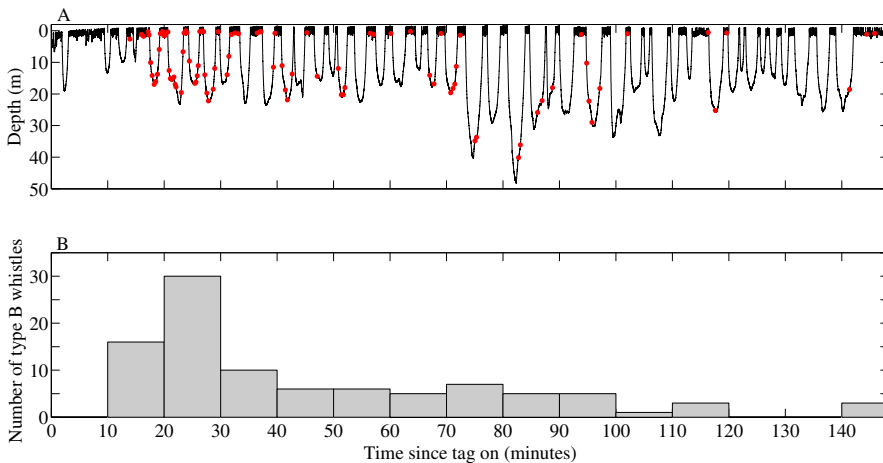

Figure 3. A. Dive plot for sa147d with concurrent type B whistle production. Circles indicate depth and time type B whistles were recorded on sa147d. B. Number of type B whistles produced every 10 min over the tag duration.

All occurrences of type B whistles on tag sa147d, regardless of whistle quality ($n = 97$), were overlaid on a dive plot for this animal to investigate timing and depth information for type B whistle production. No type B whistles were recorded in the first 10 min of tag deployment (Fig. 3) although they were generally noted throughout the rest of the tag record. Production of type B whistles peaked between 10 and 20 min after tag deployment. Increased whistle rate has been shown to indicate stress in common bottlenose dolphins (Esch *et al.* 2009). It is unclear if the observed pattern indicates a possible response to the tagging, as dolphins also increase whistle rate during feeding, socializing, and in the presence of vessels (Acevedo-Gutiérrez and Stienessen 2004, Buckstaff 2004, Quick and Janik 2008). Given that no other whistle types were attributed to specific tagged animals, we were unable to quantify individual-specific whistle rates on the other tags. Quantification of whistle production and behavior before, during, and after tagging, as well as a larger sample size could provide insights into whether whistle rates may be influenced by tagging and whether tagging may induce stress.

Type B whistles were produced at depths ranging from 0 to 40 m (Fig. 3, Fig. 4). Based on the time spent in each depth bin, the number of type B whistles produced in each bin did not differ significantly (χ^2 test, $P = 0.226$), suggesting that type B whistles were produced independent of depth.

Pantropical spotted dolphin reactions to tagging appeared relatively minor and attachments were of generally longer duration compared to other small odontocete bioacoustic tag data. To place these data in a better context, DTAG attachment performance for pantropical spotted dolphins was compared with that of melon-headed
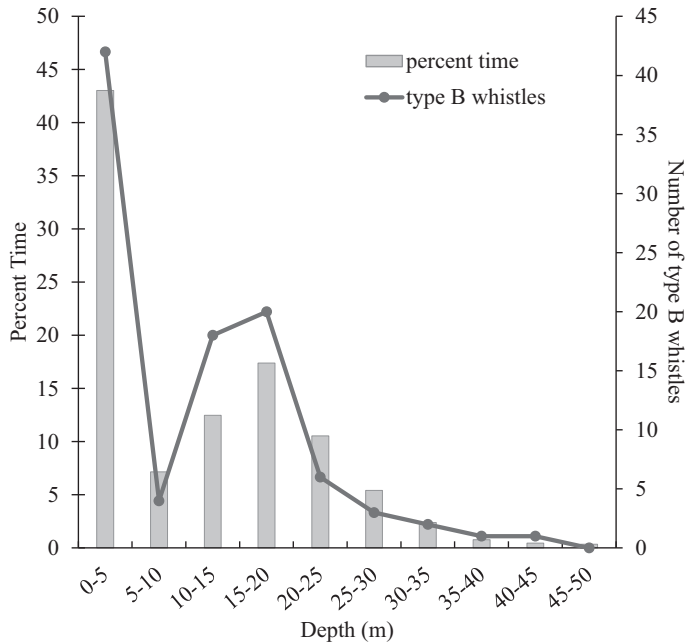

Figure 4. Percent time spent in 5 m depth bins for tagged animal sa147d and the number of type B whistles produced in the same 5 m depth bins.

whales (Table 2). For this evaluation, attachment of the tag to the animal was considered a successful deployment. Seven attempts were made (Table 2) to tag pantropical spotted dolphins, resulting in six successful deployments. While the tag made contact with the focal animal in all seven attempts, one deployment only lasted 29 s and was not analyzed, and in one attempt, the tag did not stick. Spotted dolphin reactions to tagging ranged from a flinch to fast dives and accelerated swimming speeds. Eleven deployment attempts on melon-headed whales resulted in nine successful deployments, one missed attempt, and one tag that did not stick. Melon-headed whales exhibited slightly stronger reactions to tagging including barrel rolls, tail flicks, and tail slaps (Fig. 5, Table 2). Additionally, tag deployment durations for the two species differed substantially. Spotted dolphin tag deployments averaged ~2.9 h and ranged from ~29 s to ~6 h. All but one of the spotted dolphin tags stayed on for more than 1 h. For three of six pantropical spotted dolphin deployments, the reason for tag release is unknown. Of the other three tags, one was dislodged following a breach, and two ended at the programmed time for tag release (Fig. 5, Table 2).

For melon-headed whales, tag attachment durations averaged ~0.25 h and ranged from ~2 s to ~58 min (Table 2). Five out of nine deployments lasted 2 min or less. Less adverse reactions to tagging in spotted dolphins likely resulted in longer tag durations compared with melon-headed whales. Melon-headed whales seemed to engage in active behaviors to intentionally dislodge the tag. No melon-headed whale tag deployment resulted in a tag releasing at the programmed time. Reasons for tag
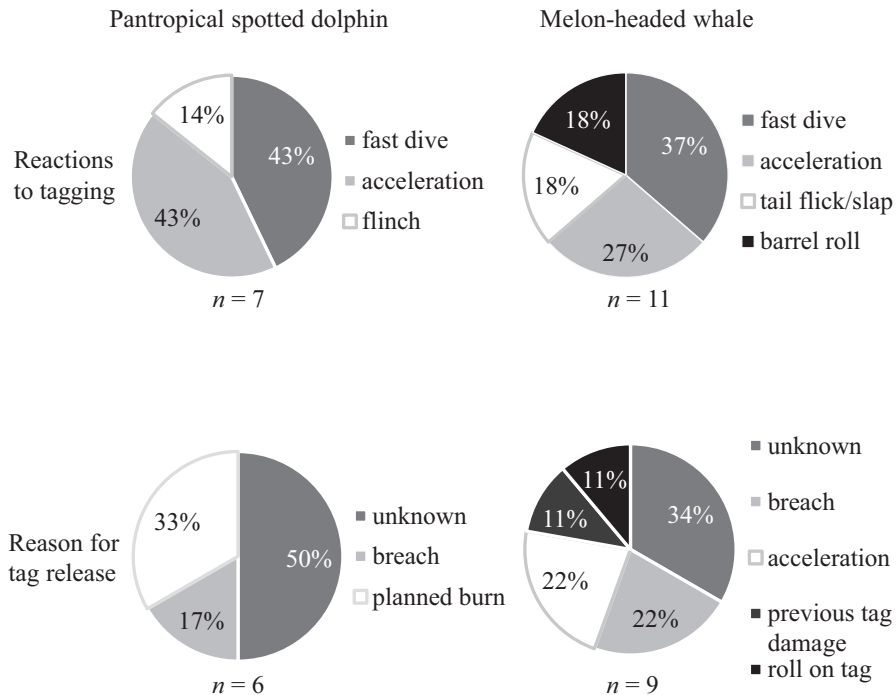

Figure 5. Reactions to tagging and reasons for tag release for pantropical spotted dolphins (*Stenella attenuata*) and melon-headed whales (*Peponocephala electra*).

Table 2. DTAG3 deployment summary for pantropical spotted dolphins and melon-headed whales.

Species	Date	Tag ID	Hit/miss	Behavior before	Reaction behavior	Behavior after	Deployment duration (hours:minutes: seconds)	Reason for tag release	Tag damage
Pantropical spotted dolphin	May 2013	sa146a	hit	milling	flinch/ acceler-ation	milling	2:08:50	unknown	none
	May 2013	sa146b	hit	travel	acceleration	travel	1:38:47	unknown	none
	May 2013	sa147a	hit	bow ride	acceleration	unknown	0:00:29	breach	none
	May 2013	sa147b	hit	bow ride	fast dive	unknown	0:25:50	unknown	none
	May 2013	sa147c	hit	bow ride	acceleration	unknown	4:24:00	planned burn	none
	May 2013		hit, tag did not stick	travel	fast dive	unknown	—	—	none
	May 2013	sa147d	hit	slow travel	fast dive	slow travel	5:58:00 (audio 2:26:00)	planned burn	none

(Continued)

Table 2. (Continued)

Species	Date	Tag ID	Hit/miss	Behavior before	Reaction behavior	Behavior after	Deployment duration (hours:minutes: seconds)	Reason for tag release	Tag damage
Melon-headed whale	Oct 2011	pe292a	hit	slow travel	fast dive	slow travel	0:13:00	acceleration	none
	Oct 2011	pe292b	hit	slow travel	tail flick/ fast dive	slow travel	0:34:37	breach	suction cup moved, socket broke
	Oct 2011	pe297a	hit	bow ride	acceleration	unknown	0:00:02	tag damage	suction cup and socket broke
	Oct 2011	pe297b	miss	milling	acceleration	unknown	—	—	none
	Oct 2011	pe297b	hit	milling	barrel roll	unknown	0:02:00	animal rolled on tag	4 suction cups missing
	Oct 2011	pe297c	hit	milling	acceleration	unknown	0:02:00	breach	1 suction cup missing
	Oct 2011	pe297d	hit	milling	tail slap	acceleration	0:04:00	acceleration	2 suction cups missing
	May 2012	pe134a	hit	travel	barrel roll	travel	0:42:56	unknown	none
	Aug 2012	pe237a	hit	slow travel	fast dive	slow travel	0:57:39	unknown	none
	Aug 2012		hit, tag did not stick	slow travel	fast dive	unknown	—	—	none
	Aug 2012	pe237b	hit	slow travel	fast dive	unknown	0:02:00	unknown	none

release included animals breaching (two deployments), barrel-rolling away from the tag pole during the deployment (potentially impacting attachment; one deployment), accelerating and burst swimming (two deployments), and preexisting tag damage (one deployment) (Fig. 5, Table 2); the reason for release was unknown for three deployments.

Observations after the initial tagging event occurred for 3 of 7 pantropical spotted dolphins and 5 of 11 melon-headed whales. The remaining animals were not seen after tagging and no behavioral observations could be recorded. While initial reactions to tagging were variable and generally indicative of some response, most animals of both species resumed pretagging behavior within *ca*. 5 s after a tagging attempt was made, regardless of whether the attempt was successful or not.

Deployments on melon-headed whales resulted in damage (loss of suction cups and broken brackets) to the tag in 5 out of 11 tagging attempts. No tag damage was noted after any attempts or deployments with pantropical spotted dolphins. While these differences in tag damage may be a result of variations in species behavior this notion is confounded by improvements to the tag (as a result of these experiences with melon-headed whales). The structure of the DTAG3 and the suction-cup mechanism were updated between the studies of these two species. Improvements included a thicker and more robust bracket that held the suction cups (to reduce bracket tearing) and a denser suction cup stem, to prevent it from slipping out of the bracket under high speeds. While the stronger reactions of melon-headed whales may have been more likely to cause tag damage and early release, it is possible that the longer deployment times and lack of tag damage seen with pantropical spotted dolphins was due at least in part to improvements in the tag. Thus, future deployments on melon-headed whales may benefit from these tag improvements, suggesting the need for follow-up studies.

While reactions to tagging and the resulting deployment durations may be species-dependent, the behavior of animals prior to tagging could play a role in successful deployments. Melon-headed whales typically engage in resting and slow travel during daytime hours (Brownell *et al*. 2009, Aschettino *et al*. 2009), while pantropical spotted dolphins tend to exhibit more steady movement during the day (Baird *et al*. 2001). This typical daytime behavior of each species was observed in these data sets; 9 of 11 melon-headed whales exhibited milling behavior or slow travel prior to tagging, while 5 of 7 pantropical spotted dolphins exhibited bow-riding or travel. It is possible that differences in behavior states between the two species influenced tagging reactions and resulting deployment durations. Animals in a more active behavior mode, regardless of species, may be more receptive to tagging than animals in a resting mode. Future tagging studies of small delphinids may consider daily activity patterns of a particular species when planning deployments.

This work represents one of the first successful tagging studies of a small delphinid species. Here, we highlight the benefits of DTAGs in studying delphinid vocal behavior by documenting repeated, stereotyped whistles and providing preliminary support for signature whistle production in pantropical spotted dolphins. Until the development of the DTAG3, data collection opportunities on small delphinids were limited by their active behavior and the comparatively large size of acoustic logging tags. We consider spotted dolphin deployment durations of multiple hours and 33% success in tags remaining attached for planned lengths of time to be important achievements and advancements in tagging of small pelagic delphinids. Tag data are extremely useful for establishing natural acoustic and behavioral patterns as well as for evaluating impacts of noise or other anthropogenic activities on delphinids. This

study demonstrates success in using tags to evaluate communication and behavior of these small, abundant animals and shows promise for future studies focusing on small cetaceans.

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