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 them. Many U.S. naval sonar exercises take place on naval training ranges such as those in 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 multi-beam 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 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 3D 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 (Kaplan *et al.* 2014, Sayigh *et al.* 2013).

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 (41 min maximum). 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 ten-second spectrograms (FFT size 1024 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-Duran 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 0-48 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, New York), 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 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 ten-minute bins and five meter 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 ten 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).

Whistle categorization suggests that pantropical spotted dolphins repeat stereotyped whistles. The recording of whistles in some categories on two days 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 (>10dB) 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 \( \mu \)Pa (IQR: 140 - 142.5). Other whistles (those not categorized as type B) had a median RL of 114 dB re 1 \( \mu \)Pa (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 degrees, whereas AOA for other whistles varied more substantially, from -43 to +41.9 degrees (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 (\textit{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 \textit{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.

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 inter-whistle interval for a signature whistle was 89.5 min (Janik et al. 2013).

Type B whistles 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 or not 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 – 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.

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 10-20 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 if tagging may induce stress.
Type B whistles were produced at depths ranging from 0-40 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 ($\chi^2$ 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 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 whale 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 one hour. 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 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 pre-existing 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 three of seven pantropical spotted dolphins and five of eleven 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 five out of eleven 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
(Aschettino et al. 2011, Brownell 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; nine of eleven melon-headed whales exhibited milling
behavior or slow travel prior to tagging, while five of seven 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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Institutional Animal Care and Use Committee approval (ID Number BI15245.00).


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.

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<td>Species</td>
<td>Date</td>
<td>Tag ID</td>
<td>Hit/miss</td>
<td>Behavior before</td>
<td>Reaction behavior</td>
<td>Behavior after</td>
<td>Deployment duration (hours:minutes:seconds)</td>
<td>Reason for tag release</td>
<td>Tag damage</td>
<td></td>
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</tr>
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<tr>
<td><strong>Pantropical spotted dolphin</strong></td>
<td>May 2013</td>
<td>sa146a</td>
<td>hit</td>
<td>milling</td>
<td>flinch/acceleration</td>
<td>milling</td>
<td>02:08:50</td>
<td>unknown</td>
<td>none</td>
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<td></td>
<td>May 2013</td>
<td>sa146b</td>
<td>hit</td>
<td>travel</td>
<td>acceleration</td>
<td>travel</td>
<td>01:38:47</td>
<td>unknown</td>
<td>none</td>
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<td></td>
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<tr>
<td></td>
<td>May 2013</td>
<td>sa147a</td>
<td>hit</td>
<td>bow ride</td>
<td>acceleration</td>
<td>unknown</td>
<td>00:00:29</td>
<td>breach</td>
<td>none</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>May 2013</td>
<td>sa147b</td>
<td>hit</td>
<td>bow ride</td>
<td>fast dive</td>
<td>unknown</td>
<td>00:25:50</td>
<td>unknown</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>May 2013</td>
<td>sa147c</td>
<td>hit</td>
<td>bow ride</td>
<td>acceleration</td>
<td>unknown</td>
<td>04:24:00</td>
<td>planned burn</td>
<td>none</td>
<td></td>
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<td></td>
<td>May 2013</td>
<td></td>
<td>hit, tag did not stick</td>
<td>travel</td>
<td>fast dive</td>
<td>unknown</td>
<td>n/a</td>
<td>n/a</td>
<td>none</td>
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</tr>
<tr>
<td></td>
<td>May 2013</td>
<td>sa147d</td>
<td>hit</td>
<td>slow travel</td>
<td>fast dive</td>
<td>slow travel</td>
<td>05:58:00 (audio 02:26:00)</td>
<td>planned burn</td>
<td>none</td>
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<td><strong>Melon-headed whale</strong></td>
<td>Oct 2011</td>
<td>pe292a</td>
<td>hit</td>
<td>slow travel</td>
<td>fast dive</td>
<td>slow travel</td>
<td>00:13:00</td>
<td>acceleration</td>
<td>none</td>
<td></td>
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<tr>
<td></td>
<td>Oct 2011</td>
<td>pe292b</td>
<td>hit</td>
<td>slow travel</td>
<td>tail flick/fast dive</td>
<td>slow travel</td>
<td>00:34:37</td>
<td>breach</td>
<td>suction cup moved, socket broke</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Oct 2011</td>
<td>pe297a</td>
<td>hit</td>
<td>bow ride</td>
<td>acceleration</td>
<td>unknown</td>
<td>00:00:02</td>
<td>tag damage</td>
<td>suction cup and socket broke</td>
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<tr>
<td></td>
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<td></td>
<td>miss</td>
<td>milling</td>
<td>acceleration</td>
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<td>n/a</td>
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<td>hit</td>
<td>milling</td>
<td>barrel roll</td>
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<td>animal rolled on tag</td>
<td>4 suction cups missing</td>
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<td>pe297c</td>
<td>hit</td>
<td>milling</td>
<td>acceleration</td>
<td>unknown</td>
<td>00:02:00</td>
<td>breach</td>
<td>1 suction cup missing</td>
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<tr>
<td></td>
<td>Oct 2011</td>
<td>pe297d</td>
<td>hit</td>
<td>milling</td>
<td>tail slap</td>
<td>acceleration</td>
<td>00:04:00</td>
<td>acceleration</td>
<td>2 suction cups missing</td>
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<td></td>
<td>May 2012</td>
<td>pe134a</td>
<td>hit</td>
<td>travel</td>
<td>barrel roll</td>
<td>travel</td>
<td>00:42:56</td>
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<td></td>
<td>Aug 2012</td>
<td>pe237a</td>
<td>hit</td>
<td>slow travel</td>
<td>fast dive</td>
<td>slow travel</td>
<td>00:57:39</td>
<td>unknown</td>
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<tr>
<td></td>
<td>Aug 2012</td>
<td></td>
<td>hit, tag did not stick</td>
<td>slow travel</td>
<td>fast dive</td>
<td>unknown</td>
<td>n/a</td>
<td>n/a</td>
<td>none</td>
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<td></td>
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<tr>
<td></td>
<td>Aug 2012</td>
<td>pe237b</td>
<td>hit</td>
<td>slow travel</td>
<td>fast dive</td>
<td>unknown</td>
<td>00:02:00</td>
<td>unknown</td>
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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. 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.
Figure 2. Received level vs. angle of arrival for type B whistles ($n = 74$) and other whistles ($n = 12$) recorded on sa147d.
Figure 3. A. Dive plot for sa147d with concurrent type B whistle production. Circles indicate depth and time of type B whistles recorded on sa147d. B. Number of type B whistles produced every 10 min over the tag duration.
Figure 4. Percent time spent in five meter depth bins for tagged animal sa147d and the number of type B whistles produced in the same five meter depth bins.
Figure 5. Reactions to tagging and reasons for tag release for pantropical spotted dolphins (*Stenella attenuata*) and melon-headed whales (*Peponocephala electra*).