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Identifying and Characterizing Signature Whistles Using Photo-Identification of Free-Ranging Bottlenose Dolphins (*Tursiops truncatus*) in Tampa Bay, Florida

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Abstract

The common bottlenose dolphin (*Tursiops truncatus*) uses vocal learning and acoustic signals within their highly social, fission-fusion lifestyle. When communicating with other individuals, they often use individually distinctive vocalizations called "signature whistles" that function in conspecific recognition. The objective of this study was to identify signature whistles in a population of bottlenose dolphins in Tampa Bay and use photographic identification to link potential individuals with specific signature whistles. Acoustic recordings from 2009 to 2023 were manually analyzed using the SIGnature IDentification (SIGID) method. Thirty-three unique signature whistles were identified. Whistles were categorized based on their frequency contour, duration, and maximum frequency ranges. A minimally invasive method was used to align dolphin identifications with signature whistles. Using concurrent acoustic and dorsal fin photo-identification data, we potentially attributed signature whistles to two resident dolphins. In addition, group size was tested as a predictor variable for total signature whistle and unique signature whistle presence, which were both found to decrease as group size increased. This study helps us to understand the acoustic communication of this highly resident population of bottlenose dolphins, and it further highlights the importance of acoustic communication for this population in an increasingly urbanized and noisy environment.

Key Words: acoustics, signature whistle, communication, Tampa Bay, bottlenose dolphin, *Tursiops truncatus*

Introduction

For many species, sound is the most effective method of underwater communication (Herman & Tavolga, 1980), and acoustic communication is used by all cetaceans. Dolphins use sounds to communicate with conspecifics, as well as to navigate and feed (Gordon & Tyack, 2002; Janik, 2009). The common bottlenose dolphin (*Tursiops truncatus*; henceforth referred to as bottlenose dolphin) produces a variety of acoustic signals to complement their social lifestyle (Sayigh et al., 1990; Janik, 2009; Janik & Sayigh, 2013). Bottlenose dolphins demonstrate fission-fusion grouping patterns where groups are fluid and frequently change in individual members and size (Connor et al., 2000; Wells, 2003), often depending on the benefits and costs of being within the group (Gowans, 2019). Vocal exchanges help to maintain contact and facilitate recognition among conspecifics at distances up to several kilometers (Caldwell et al., 1990; Janik & Sayigh, 2013). These exchanges play an important role in mother–calf reunions and maintaining social bonds (Smolker et al., 1993; Jensen et al., 2012; King et al., 2016; Chereskin et al., 2022).

Bottlenose dolphins produce narrowband, frequency-modulated whistles to communicate between conspecifics (Jones et al., 2019). In certain dolphin species and populations, a specific form of whistle known as "signature whistles" has been identified. Signature whistles were first defined by Caldwell & Caldwell (1965) as the most common whistle type produced when an animal is isolated. They are narrowband signals defined by a stereotyped pattern of frequency modulation (Caldwell & Caldwell, 1968), only lasting a few seconds within the mid-high frequency range (e.g., 4 to 25 kHz). The whistles vary in amplitude, duration, and production rate (Caldwell et al., 1990; Cook et al., 2004). Signature whistles are learned vocalizations (Fripp et al., 2004; Janik, 2014), developed within the first couple months of a calf's life (Caldwell & Caldwell, 1965) yet individually distinctive (Sayigh et al., 1999). Each signature whistle is unique, with identity information encoded within the frequency modulation pattern of the whistle (Janik et al., 2006), thereby acting like a fingerprint to identify the individual. Signature whistles have also been well-documented in Indo-Pacific bottlenose dolphins (*Tursiops aduncus*; Janik et al., 2006; Gridley et al., 2013), and have been reported in a number of other species (e.g., Pacific white-sided dolphins [*Lagenorhynchus obliquidens*]: Caldwell & Caldwell, 1971; Atlantic spotted dolphins [*Stenella frontalis*]: Caldwell et al., 1973; and possibly Atlantic white-sided dolphins [*Lagenorhynchus acutus*] and short-beaked common dolphins [*Delphinus delphis*]: Cones et al., 2022).

A variety of hypotheses address the function of signature whistles (Janik & Sayigh, 2013). Cook et al. (2004) found that roughly 50% of all whistles produced by free-ranging bottlenose dolphins were identified as signature whistles, supporting the hypothesis that signature whistles serve an important role in intraspecific communication. They also found that whistle rate increased significantly as group size increased, and signature whistles were most likely to occur when the group was socializing. Hill (1999) and Cook et al. (2004) found that signature whistles were most common when dolphins were milling, further supporting the idea that these whistles are used for socializing. Several studies have found that signature whistles are primarily used to keep cohesion in groups when individuals are separated. Janik & Slater (1998) found that signature whistles were primarily produced when an individual was separated from the group in a captive setting. When the group was together, vocalizations consisted primarily of non-signature whistles. Watwood et al. (2005) found that adult male alliance partners were more likely to produce signature whistles when separated than together, suggesting signature whistles function to facilitate reunions. Mother–calf pairs of wild Indo-Pacific bottlenose dolphins were found to use signature whistles when separated but rarely when together (Smolker et al., 1993). When a mother and calf were in proximity, signature whistles were not recorded; however, as the distance between the mother and calf increased, the probability of signature whistle production increased as well. This suggests that infants use their signature whistle immediately before reuniting with their mother (Smolker et al., 1993). In a similar anthropogenically active environment to Tampa Bay, Buckstaff (2004) found signature whistles increased within a group shortly before the passing of a boat, perhaps signaling for group cohesion or to communicate more effectively among acoustic masking. Another proposed use of signature whistles is to facilitate conspecific recognition when free-ranging groups of dolphins encounter one another. Quick & Janik (2012) found that whistle rates of free-ranging dolphins were nine times higher during initial joining between groups than any other time. Janik (2000) reported "learned whistle" (p. 1356) matching in groups of free-ranging dolphins, which was observed significantly more often when individuals were closer together, suggesting the use of signature whistles for addressing one another (King & Janik, 2013; King et al., 2014).

While signature whistles have been identified in several other bottlenose dolphin populations (i.e., in Sarasota, Florida: Sayigh et al., 2022; in Namibia: Kriesell et al., 2014; in Mid-Atlantic Bight and Chesapeake Bay: Fandel et al., 2024; and in Scotland: Quick & Janik, 2012), they have not been investigated in lower Tampa Bay and Boca Ciega, despite close proximity (20 km) and ecological similarity to Sarasota Bay, home to the world's longest study of free-ranging bottlenose dolphins (Wells, 2003; Sayigh et al., 2022). Lower Tampa Bay and Boca Ciega are home to a highly resident population of bottlenose dolphins, with only limited mixing with adjacent communities (Urian et al., 2009; Michalec, 2019); therefore, this community represents a unique opportunity to explore comparisons of signature whistle form and function. Many of the previous studies on signature whistles have relied on captive dolphins or temporary capture-release events which facilitate the identification of which dolphin produces each signature whistle (e.g., Sayigh et al., 1999; Watwood et al., 2005). Linking a signature whistle to a specific free-ranging dolphin has been challenging, relying on hydrophone arrays and localization methods (Quick & Janik, 2008; King et al., 2018; Chereskin et al., 2022). While some studies have investigated signature whistles from free-ranging dolphins (Cook et al., 2004; Quick & Janik, 2012; Kriesell et al., 2014; Fandel et al., 2024), they have not been able to assign signature whistles to identified individuals without prior knowledge of the signature whistles of some group members. This study aims to provide a relatively non-invasive approach, combining passive acoustic recording and photographic identification of free-ranging groups to identify individuals and their potential corresponding signature whistles, especially those suitable for developing a signature whistle catalog using only low-cost methods. Additionally, this study aims to investigate if signature whistle production rate varies in relation to group size.

Methods

Data Collection

Acoustic recordings were collected during a long-term study (1993-present) conducted by the Eckerd College Dolphin Project. Sounds from free-ranging bottlenose dolphin groups in lower Tampa Bay and Boca Ciega Bay, Florida, were recorded during group follows with a calibrated digital acoustic recorder (M-Audio 24/96, M-Audio Micro-track II, or Sony PCM-M10) sampling at 96 kHz with 16-bit or 24-bit resolution with HTI-96-MIN hydrophones (-170 dB/V) (Figure 1). During follows, a single hydrophone was towed approximately 20 m behind a small vessel at approximately 2 m depth. Groups were defined as dolphins engaging in the same

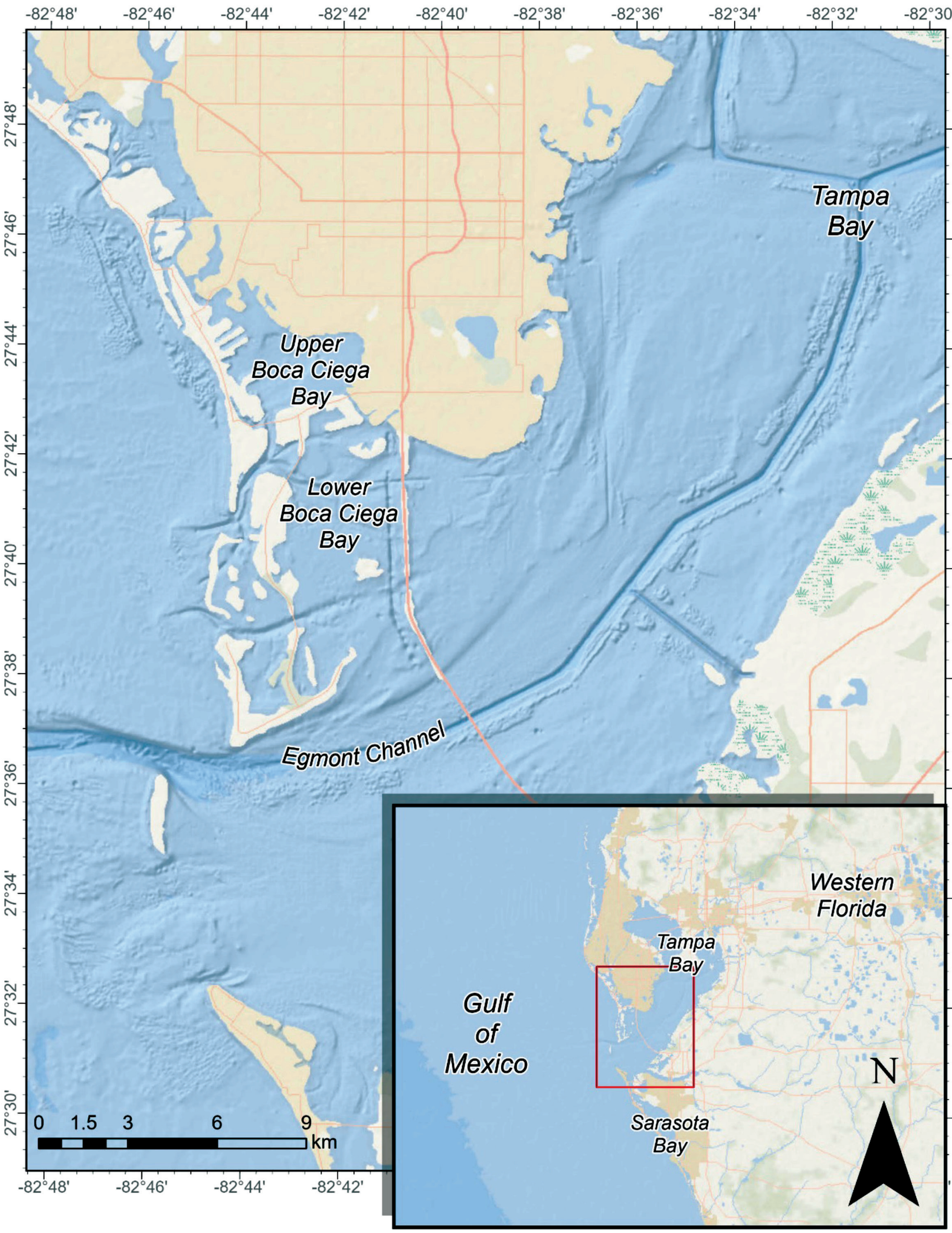

Figure 1. Map of study location. Note proximity to Sarasota Bay. (*Sources:* Esri [2024], GEBCO, National Oceanic and Atmospheric Administration, National Geographic, DeLorme, HERE, Geonames.org, and other contributors)

behavior within a 100-m radius (e.g., Wells et al., 1987). Acoustic recordings typically covered the majority of a group focal follow. Group size, number of calves and juveniles, location, and recording start and end times were recorded for each group follow. The boat generally stayed with the closest group of dolphins; however, a new group encounter began if the boat moved away from the original group. Individuals were identified via dorsal fin photo-ID data collected throughout follows using Canon EOS-60D and EOS-20D digital cameras with 100-400 mm ultrasonic autofocus lenses. All identifications were made using photographic identification; no individuals were identified based on visual identification in the field. Group sizes and compositions were estimated in the field and were confirmed using photo-ID records in the lab. Suitable recordings, paired with photo-ID data, were obtained in 2009, 2013, 2017, 2018, 2019, 2021, 2022, and 2023.

Acoustic Data Analysis

Signature whistles were manually detected on spectrograms in *Raven Pro*, Version 1.6 (Cornell University, Ithaca, NY, USA; spectrogram 1,024-point resolution, 512-point Hann window) using standard protocols (e.g., Cook et al., 2004; Janik et al., 2013). The spectrogram duration window was set to 10 s with a maximum frequency of 25 kHz. Default contrast/brightness settings were used unless features such as whistles were too faint. They were then adjusted until the entire contour could be identified. If the entire whistle contour could not be seen, they were not included in the analysis. The duration, maximum and minimum frequency, delta frequency, and start and end times were recorded for each whistle using selection functions in *Raven Pro* (Figure 2). An additional new whistle parameter, maximum frequency, was used in an attempt to better separate whistle classification categories (L. S. Sayigh, pers. comm., 4 March 2022). If

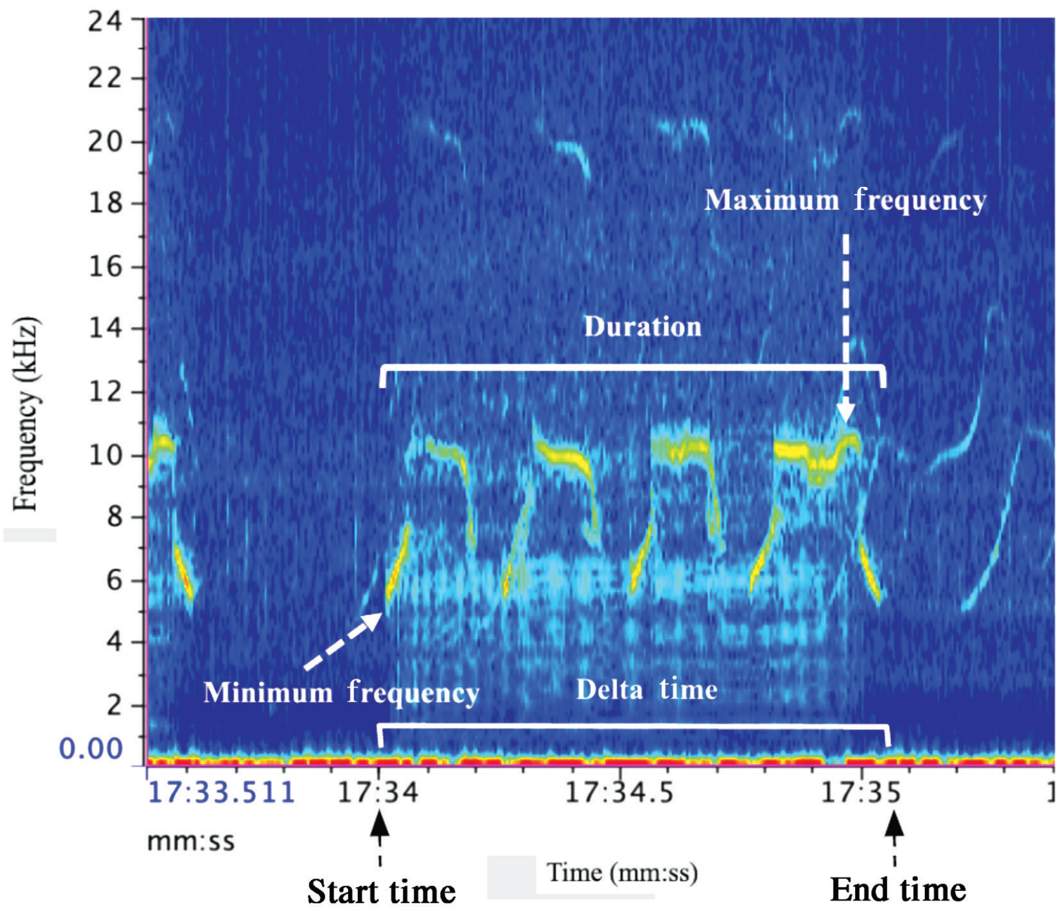

Figure 2. Spectrogram of a signature whistle with whistle parameters highlighted

whistles differed in maximum frequency by more than 4 kHz, the whistles were further classified into different types.

The SIGnature IDentification (SIGID) method was used for separating signature whistles from non-signature whistles (Janik et al., 2013). This method identifies temporal patterns indicating signature whistles when studying free-ranging dolphins. Signature whistles are often produced in bouts; thus, whistles with identical frequency modulation had to be present at least four times within the audio file with at least three of the four whistles or at least 75% of the total number of signature whistles occurring within 1 to 10 s of each other (Janik et al., 2013). Other whistles occurring in between bouts of signature whistles were ignored. Signature whistle sequences frequently have an inter-whistle interval of approximately 1 s or longer. A whistle with a duration less than or equal to 0.2 s was classified as a chirp and thus not classified as a signature whistle (L. S. Sayigh, pers. comm., 4 March 2022). A repeating whistle in a bout with an inter-whistle interval less than 0.5 s was not identified as a signature whistle as it also fit the criteria of chirp whistles (Caldwell et al., 1990; Figure 3). Whistles were identified as separate whistles if there were more than 0.5 s of silence between them. For multi-looped whistles, any separation in the loops of more than 0.2 s signified the end of the individual whistle (Esch et al., 2009a). The inter-whistle interval was measured as the time between the end of the first whistle and the start of the second. Each whistle was then categorized using an alphabetical label.

Repetitions and deletions of a signature whistle's contours were noted with a number subset within the category letter. For example, a multiloop whistle can vary from two repeating loops to five or six loops. This was important to keep a record of as a dolphin's signature whistle features, such as the loop number, can change from one whistle to another (Sayigh et al., 2022). If a previously identified signature whistle was present in a new audio file, the SIGID method was not applied, and the whistle was categorized as the previously identified whistle type.

Vocal exchanges and vocal matching were also noted during analysis. If, at minimum, two different signature whistles occurred within 1 s of each other and repeated more than once to resemble a call and response, it was noted as a vocal exchange (Chereskin et al., 2022). Vocal matching was noted if a signature whistle of the same type was emitted by two dolphins, overlapping in time (Janik, 2000).

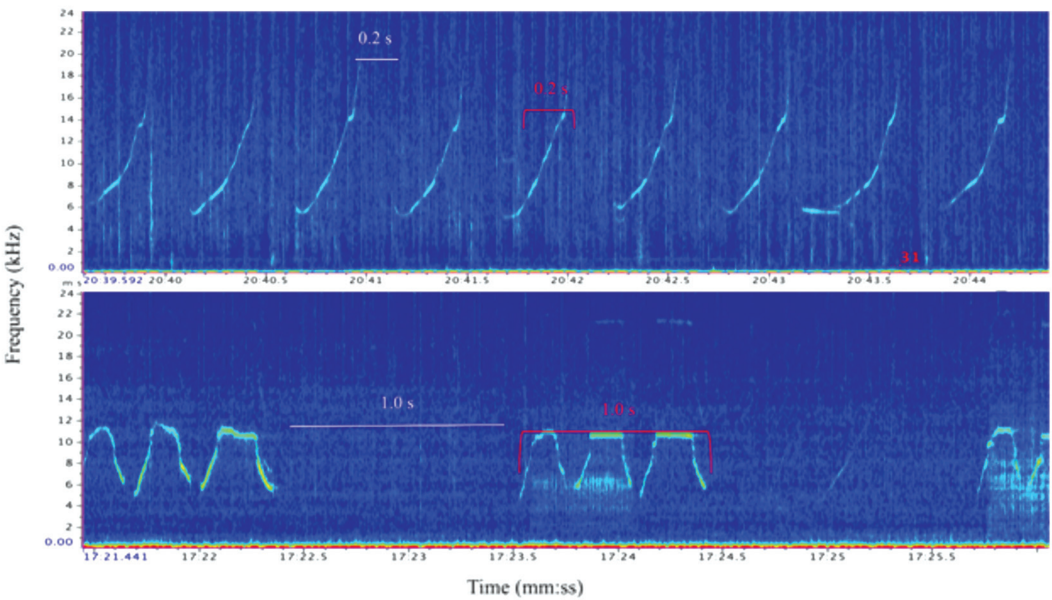

Figure 3. Spectrogram comparison of non-signature whistles (top) and signature whistles (bottom) of bottlenose dolphins (*Tursiops truncatus*) in Tampa Bay. The duration measures the start and end time of the whistle (shown in red). The minimum frequency measures the lowest pitch of the whistle, and the maximum frequency measures the highest pitch. Also shown in yellow are the inter-whistle intervals.

Photographic-Identification Analysis

Dorsal fin photo-ID data concurrent with the audio files were used to identify which bottlenose dolphins were present during each audio recording with signature whistles. Photos of all dolphins in the group were taken throughout the follow, and each fin photographed was assigned an identification (assuming sufficient photo quality and unique markings). To link a signature whistle to an individual dolphin, a process of elimination was used. All dolphins present within a group follow were grouped with each signature whistle type present within the audio file. When the same signature whistle was recorded in a different follow, the photo-ID record was compared, and any dolphin not present in both follows was eliminated. Potential signature whistles were only linked to a dolphin identification if the individual was photographed and the potential whistle was recorded in a minimum of three follows together. No other individual could be present during all concurrent follows. Photo records were examined to ensure identified dolphins were present in the group during the time when signature whistles were recorded.

Group Size Analysis

A linear regression model (*SPSS*, Version 26) was used to compare the number of signature whistle types and total signature whistle presence with group size. As it is likely that the number of whistles increased with recording length and group size, signature whistle presence and unique signature whistle types were normalized per minute per individual. The response variables were different signature whistle types and total signature whistle presence in a group follow. The explanatory variable was group size. The assumptions of normality, linearity, homoscedasticity, and absence of multicollinearity were tested using a P-P plot, residual scatterplot, and the variance inflation factor (VIF) values within *SPSS*.

Results

Acoustic Data

For this study, 117 audio files (approximately totaling 32 h of recording), recorded over 8 y between 2009 and 2023, were analyzed for signature whistles. Recording durations ranged from 33 s to 45 min. Twenty-nine of the 117 audio files contained signature whistles. Thirty-three different signature whistle types were identified, totaling 471 signature whistles detected (Figure 4). Four of these whistle types (A, G, P, and T) were classified as possible signature whistles as they only occurred three times within an audio file but met the other requirements for a signature whistle. Over half of the whistles (19/33; 57.6%) varied in the number of loops or upsweeps. Whistle type M was the most common ($n = 64$), occurring across three audio files from 2009, 2018, and 2019. Whistle type W was the least common ($n = 4$) and was observed in only a single recording.

Linking Signature Whistles to Individual Bottlenose Dolphins

There were 20 groups with photo-ID data available. Of the 20 groups, 119 bottlenose dolphins were photographically identified, 34 of which were repeat individuals. The individual dolphin "HNGR" was present in 3/3 groups when signature whistle type S occurred (Figure 5). HNGR was photographed during one encounter when whistle type S was not recorded; however, this recording also contained boat noises which masked the frequency range of the whistle throughout the duration of the audio file. Whistle type S was never present in other analyzed recordings. Sightings of HNGR and whistle type S occurred over a span of 10 y—first in 2009 and again on two separate recordings in 2019. Individual "DMBK" was also matched with whistle type Y, present in 3/3 groups—first in 2013 and twice again in 2019 (Figure 5). DMBK was not present during any other recordings with signature whistles, nor was whistle type Y present in other recordings without DMBK. No other signature whistles could be uniquely linked to an identifiable individual.

Whistle Rates as a Function of Group Size

A total of 179 bottlenose dolphins were included in the group size analysis. The total number of signature whistles present per dolphin per minute of recording significantly decreased with group size (Figure 6; Table 1). The average number of signature whistles per minute per individual was 0.04 ± 0.04. In addition, the number of unique signature whistles present per dolphin per minute of recording significantly decreased with group size (Figure 7; Table 1). The average number of unique signature whistle types per minute per individual was 0.05 ± 0.04. All assumptions were met for both regressions except homoscedasticity; this was likely due to sample size. The dataset contains an outlier (Figures 6 & 7) showing very high whistle rates in a small group size. This recording occurred over a 9 min 38 s period with two photographically identifiable dolphins.

Other Observations

We observed what appears to be a biphonic whistle (also known as a two-voiced whistle) where a whistle is simultaneously produced by both sound production organs of a dolphin (Madsen et al., 2013). Signature whistle type W was observed four times across one event. All four times, this whistle was

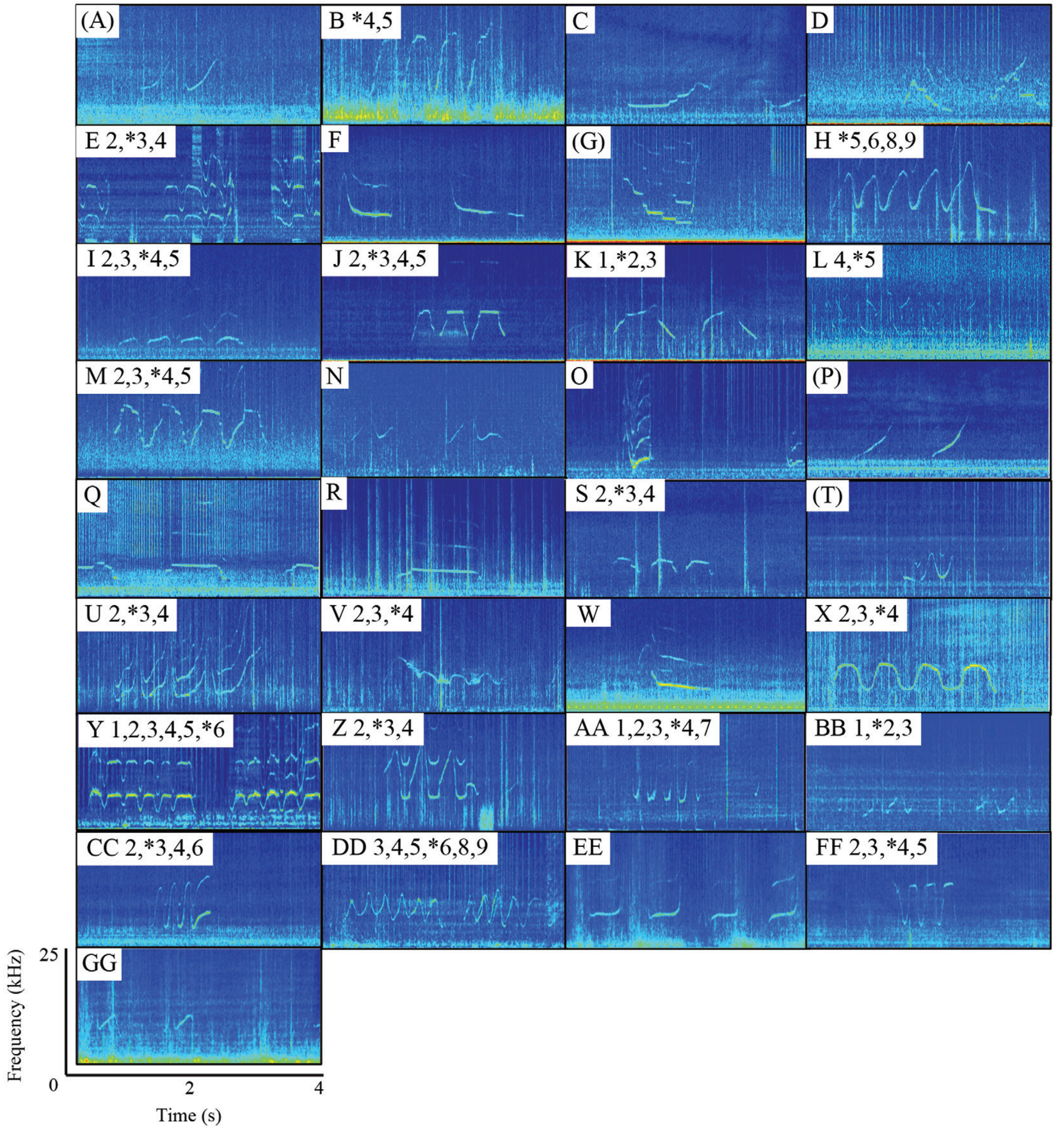

Figure 4. Spectrograms of all signature whistle types (n = 33; each whistle identified by a unique letter code) identified in free-ranging bottlenose dolphins in Tampa Bay. Number of loops observed for each whistle type follows the lettered whistle types; * = the number of loops shown in the figure. Whistle types in parentheses were only observed three times in the study. Frequency (kHz) is on the y-axis from 1 to 25 kHz; and time (s) is on the x-axis, scaled to 4 s duration.

defined by a higher-frequency loop accompanying a lower-frequency narrowband contour, overlapping by 0.3 s (Figure 8).

Vocal exchanges were recorded in six different events with multi-looped signature whistles present at a high amplitude while lower amplitude whistles occurred at the same time, likely multiple dolphins vocalizing at once. The number of loops would change in each vocal exchange. During all six events, signature whistles were exchanged simultaneously, as well as in exchanged intervals (Figure 9).

Evidence of vocal matching was observed across three of the six vocal exchanges. Only looped whistles were confidently observed being copied. In all three events, a looped signature whistle was copied simultaneously by a different dolphin, each varying in amplitude and maximum frequency (Figure 9).

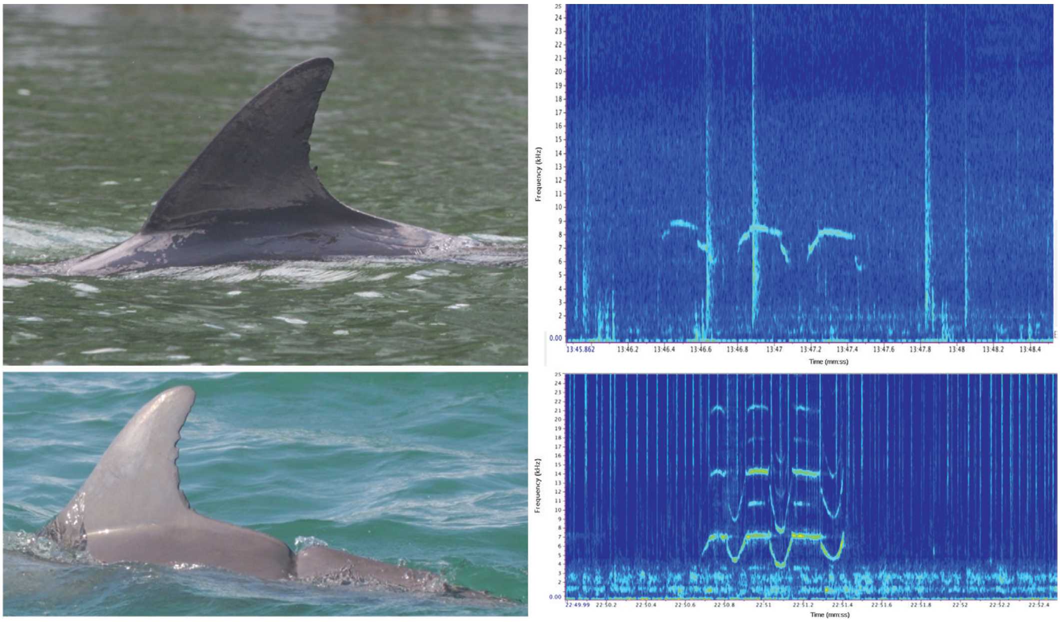

Figure 5. *Top:* Photo-ID of HNGR from 2018 with spectrogram of potential signature whistle type S. *Bottom:* Photo-ID of DMBK from 2012 with spectrogram of potential signature whistle type Y. (*Photo credit:* ECDP)

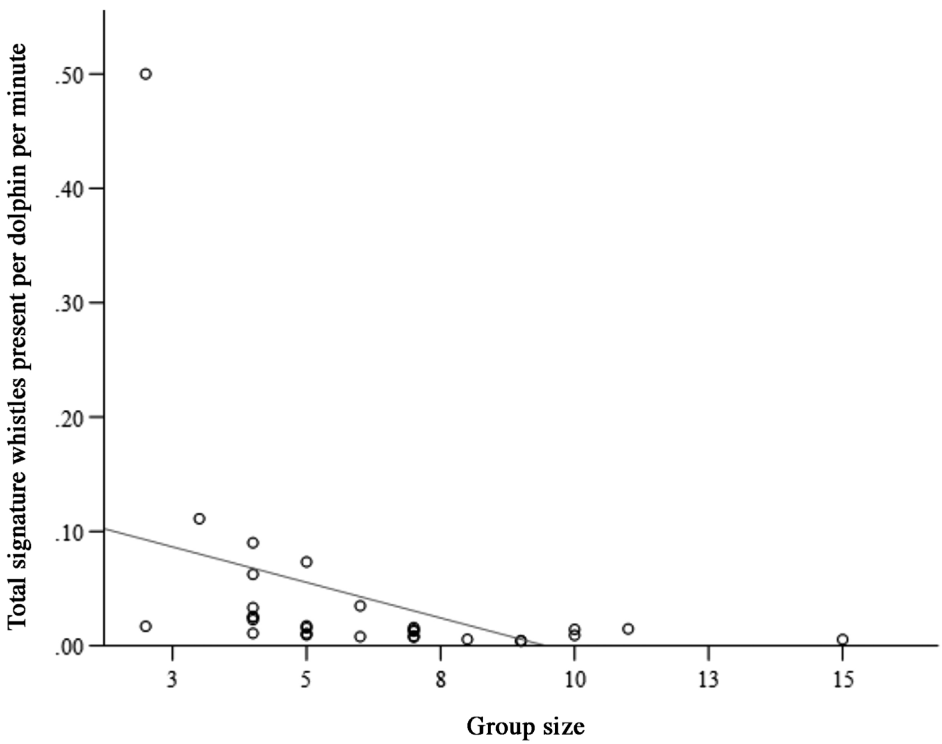

Figure 6. Signature whistle presence (per minute per dolphin) of bottlenose dolphins at varying group sizes (n = 29, p = 0.035, R^2 = 0.155). The best-fit line of the linear regression is represented by the following equation: total signature whistle present = 0.117 to 0.012 * group size.

Table 1. Results of linear regressions between group size and dependent variables. * = statistically significant; alpha = 0.05.

Variable	Coefficient	Std error	t-statistic	R^2	F-statistic	*p* value
Total signature whistle presence	0.118	0.038	3.086	0.155	4.936	0.035*
Signature whistle type	0.124	0.038	3.298	0.160	5.132	0.032*
Group size	-0.013	0.006				

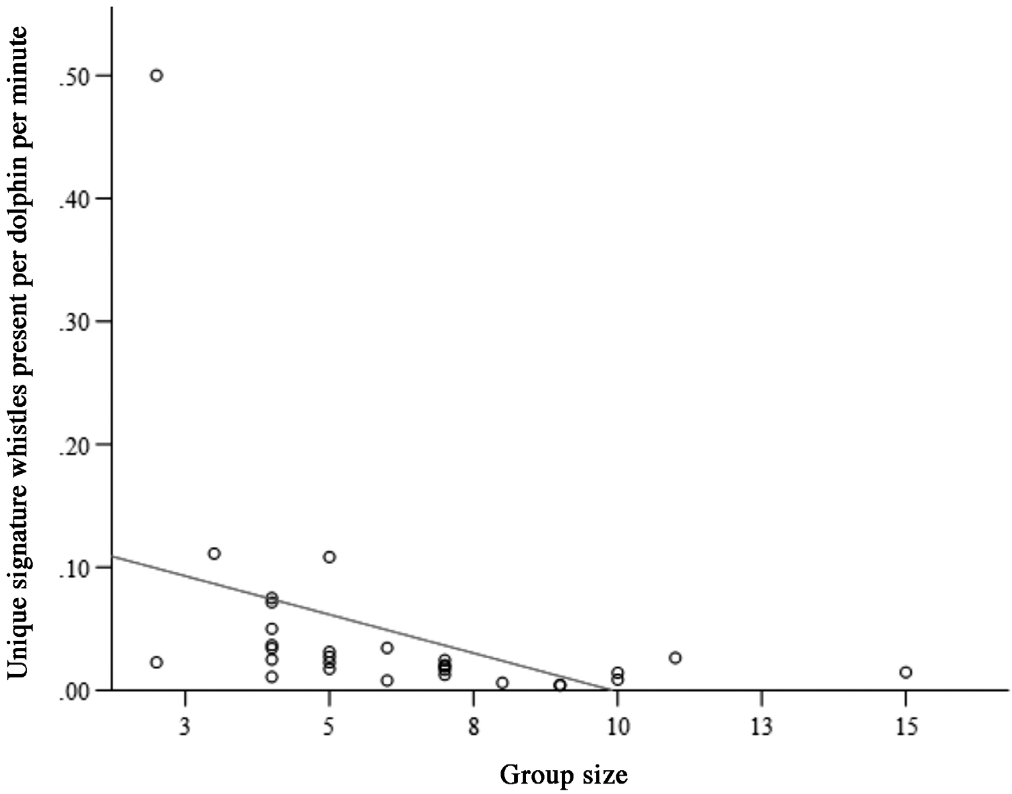

Figure 7. Signature whistle type presence (per minute per dolphin) of bottlenose dolphins at varying group sizes ($n = 29$, $p = 0.032$, $R^2 = 0.160$). The best-fit line of the linear regression is represented by the following equation: unique signature whistle present = 0.124 to 0.013 * group size.

Discussion

We identified 33 signature whistles using the SIGID method from approximately 32 h of acoustic recordings of free-ranging bottlenose dolphins in lower Tampa Bay and Boca Ciega Bay. The total number of signature whistles was similar to other studies of free-ranging dolphins (Janik et al., 2013; Kriesell et al., 2014). We were able to assign unique signature whistles to two dolphins from our existing photo-ID catalog. This method is feasible with large datasets and, in the future, could be a cost-effective and minimally invasive way to assign signature whistles to individual dolphins. This approach will be valuable for locations where temporary captures and acoustic localization are not feasible; and it may expand our ability to monitor dolphin populations using passive acoustics.

We observed similar low mean signature whistle rates as was found in other free-ranging dolphin studies (Buckstaff, 2004; Watwood et al., 2005; Esch et al., 2009b; Janik & Sayigh, 2013). There was a significant negative relationship

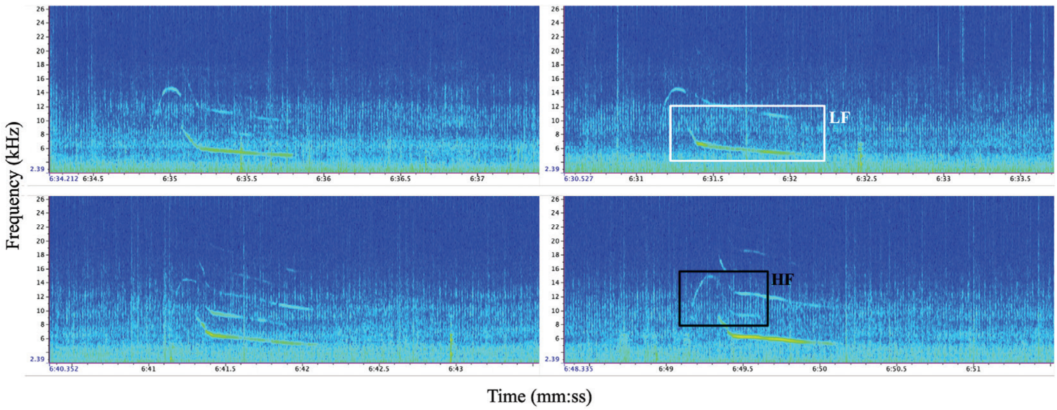

Figure 8. Spectrograms of signature whistle type W with the possibility of a biphonic whistle produced by a bottlenose dolphin, recorded during a group follow. LF = low frequency; HF = high frequency. Note harmonics of the low-frequency and high-frequency whistles.

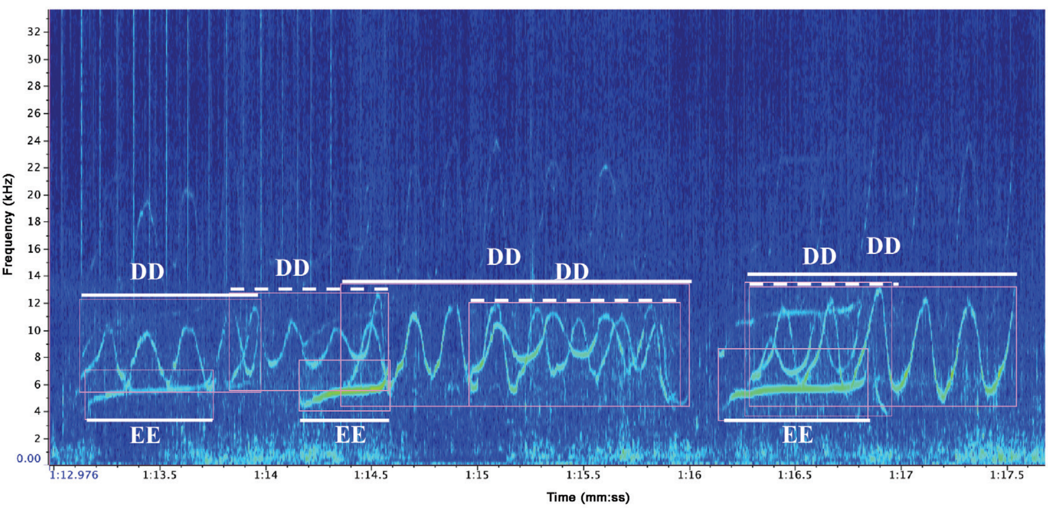

Figure 9. Spectrogram of signature whistle vocal exchange between signature whistle type DD and EE. Boxes outline the duration of a single whistle. Dashed lines indicate a copied whistle of DD—evidence of simultaneous vocal matching.

between group size and both the total rate of signature whistle production and the rate of signature whistle type production. These results could be correlated to Quick & Janik (2008) who found individual whistle rates decreased as group size increased as a result of potential acoustic masking occurring within larger groups of dolphins. However, it is important to note that our study includes smaller group sizes (maximum group size being 15 dolphins) while their study involved group sizes of 40+. They saw a notable decline in whistle production of 20+ individuals, a threshold our study never reached. Our results contradict previous studies that found a positive correlation with group size (Cook et al., 2004; Kriesell et al., 2014). However, Cook et al. (2004) normalized their signature whistles into 5-min intervals and separated group size into either pairs, three to five dolphins, or more than five dolphins. In addition, Cook et al. defined group size as individuals within a 50-m radius from the focal animals. Kriesell et al. (2014) normalized signature whistles per minute of encounter but did not normalize per individual, nor did they define their parameters for a group. If signature whistles are more commonly produced during the initial join of an individual or group (as found in Quick & Janik, 2012), and if individuals tend to produce more non-signature whistles when the group is together (as found in Janik & Slater, 1998), one would expect a decrease in signature whistle production when individuals are clustered together and have already surpassed the initial joining phase. This suggests the purpose of a signature whistle is to maintain cohesion with other bottlenose dolphins (Janik & Slater, 1998), which is in line with results from previous studies (Janik & Sayigh, 2013). An additional analysis of non-signature whistle rate to group size would be beneficial in solidifying the cohesion hypothesis. In addition, our definition of a group is based on spatial and temporal proximity that makes sense to human observers at the surface but may not adequately reflect what constitutes a dolphin group from a dolphin's perspective. Although groups defined by proximity can be biologically meaningful, definitions of groups also based on acoustics can better identify the full communication range and association between individuals. If acoustic communication is key to group membership, then a group might be better defined by the range in which dolphins produce and receive vocalizations between individuals effectively. In the future, what defines a dolphin group should include acoustic communication as a component of the definition when possible.

One observation contained a very high rate of whistle production (mean = 0.5 whistles per minute per dolphin; Figures 6 & 7) from a group of two photographically identifiable individuals that deviated from the standard low rates. This observation represented a short bout of intense signature whistle production of whistle type W. Additionally, this observation included the two-voiced whistles where lower-frequency contour was higher in amplitude for all recorded instances of whistle type W. The harmonic of overlapping contours occurred at twice the original frequencies, thus making it unlikely that the higher-frequency loop is a harmonic of a nonvisible lower-frequency whistle. It is possible that two dolphins were overlapping their signature whistles in a call and response event; however, each component of the whistle was never seen by itself throughout the audio file. Bottlenose dolphins can click and emit tonal frequencies at the same time (Powell, 1966). Kriesell et al. (2014), Papale et al. (2015), and Sayigh et al. (2022) have also documented potential two-voiced signature whistles by wild bottlenose dolphins. Creating a biphonic whistle could be advantageous to the individual in high population density areas where the chance of their whistle being lost in vocal exchanges can be minimized as it adds to the identification value being unique to certain dolphins. This is especially true in environments with high levels of anthropogenic noise, such as Tampa Bay, with high boating activity contributing to increased ambient noise (van Ginkel et al., 2017). Ambient noise levels have been found to influence the characteristics of a signature whistle, leading to shorter whistles in noisy environments (Fandel et al., 2024). In the future, it would be valuable to explore if varying levels of ambient noise cause an individual to alter its signature whistle or if they lead to the production of biphonic whistles. In addition, future comparisons with the Sarasota signature whistle catalog (Sayigh et al., 2022) can compare whistle features and confirm cross-residence of individuals between adjacent communities, thus broadening the geographical range of population monitoring.

The variation in the number of loops and upsweeps in a signature whistle vocal exchange may be due to age as whistles produced by mature dolphins have been found to be longer (Caldwell et al., 1990; Esch et al., 2009b), or they may be due to behavioral context. Esch et al. (2009b) determined that whistle rate and number of loops increased during capture-release events, indicating these parameters could communicate stress levels. In this study, multi-looped whistles changed loop number very frequently in bouts when other individuals were vocalizing simultaneously. These multi-looped whistles would rarely change in structure when vocalized alone. It is possible that the individual changes the number of loops vocalized while other dolphins are vocalizing to better communicate their own message between conspecifics.

The whistle matching that was observed in the vocal exchanges of this study occurred with signature whistles half of the time. Signature whistles are often repeated and mimicked by other members of the group (Janik, 2000; Quick & Janik, 2012; Janik & Sayigh, 2013). This has been seen most often between males in non-aggressive contexts as well as in mother–calf pairs (King et al., 2013). Signature whistle matching has been hypothesized as a form of greeting and acknowledgment among individuals (Janik, 2000). Janik (2000) reported the distance between conspecifics in whistle matching events was significantly smaller than in the groups who did not exhibit vocal matching. In future studies, a hydrophone array would be valuable for localizing individuals and for measuring the distance between two vocalizing individuals. Further analysis of group composition of these vocal exchanges is needed to investigate the vocal matching behavior and to understand why signature whistles are being mimicked by other dolphins within the group.

This study presents an inexpensive and relatively non-invasive method to develop a signature whistle catalog tied to photographically identified individuals in small populations in the absence of acoustic localization or capture methods. It is also the first investigation of signature whistles with the resident bottlenose dolphins of lower Tampa Bay and Boca Ciega Bay. This signature whistle catalog will aid in monitoring bottlenose dolphins in the lower Tampa Bay region. It is particularly important to compare these signature whistles to adjacent communities for better identification of individuals via PAM listening stations (e.g., the Sarasota Bay Listening Network; Sarasota Dolphin Research Program [SDRP], 2024). In addition, this study found a relationship between group size and signature whistle presence and identified two likely matches between an individual bottlenose dolphin and a signature whistle. These results suggest that a larger sample size would be beneficial in successfully assigning all 33 signature whistle types to identified dolphins in future studies. In addition, collecting group behavior in the field samples would allow for context of when these free-ranging dolphins are more likely to produce signature whistles to expand on the use of these whistles. Lastly, half of the whistles cataloged contained a varying number of loops or upsweeps. A future study should look at the behavioral context behind these variations to decode the information that this characteristic of the whistle conveys.

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