A complex baleen whale call recorded in the Mariana Trench Marine National Monument

Sharon L. Nieukirk, Selene Fregosi, David K. Mellinger, and Holger Klinck

Citation: The Journal of the Acoustical Society of America 140, EL274 (2016); doi: 10.1121/1.4962377
View online: http://dx.doi.org/10.1121/1.4962377
View Table of Contents: http://asa.scitation.org/toc/jas/140/3
Published by the Acoustical Society of America

Articles you may be interested in

Evaluation of smartphone sound measurement applications
The Journal of the Acoustical Society of America 135, EL186 (2014); 10.1121/1.4865269

Evaluation of smartphone sound measurement applications (apps) using external microphones—A follow-up study
The Journal of the Acoustical Society of America 140, EL327 (2016); 10.1121/1.4964639

Localization and visual verification of a complex minke whale vocalization
The Journal of the Acoustical Society of America 109, 3038 (2001); 10.1121/1.1371763

The role of periodicity in perceiving speech in quiet and in background noise

The image of scientists in The Big Bang Theory
Physics Today 70, 40 (2017); 10.1063/PT.3.3427

The Journal of the Acoustical Society of America 138, 1702 (2015); 10.1121/1.4927418
A complex baleen whale call recorded in the Mariana Trench Marine National Monument

Sharon L. Nieukirk, a) Selene Fregosi, David K. Mellinger, and Holger Klinck b)

Cooperative Institute for Marine Resources Studies, Oregon State University and NOAA Pacific Marine Environmental Laboratory, Hatfield Marine Science Center, 2030 SE Marine Science Drive, Newport, Oregon 97365, USA
sharon.nieukirk@oregonstate.edu, selene.fregosi@oregonstate.edu, david.mellinger@oregonstate.edu, holger.klinck@cornell.edu

Abstract: In fall 2014 and spring 2015, passive acoustic data were collected via autonomous gliders east of Guam in an area that included the Mariana Trench Marine National Monument. A short (2–4 s), complex sound was recorded that features a \(\sim\)38 Hz moan with both harmonics and amplitude modulation, followed by broad-frequency metallic-sounding sweeps up to 7.5 kHz. This sound was recorded regularly during both fall and spring surveys. Aurally, the sound is quite unusual and most resembles the minke whale “Star Wars” call. It is likely this sound is biological and produced by a baleen whale.

© 2016 Acoustical Society of America

Date Received: April 19, 2016 Date Accepted: August 23, 2016

1. Introduction
Passive acoustic monitoring (PAM) has become a common means of investigating vocal species in a variety of habitats. This is especially true in cetacean research, where acoustic surveys have become commonplace in most of the world’s oceans. PAM’s effectiveness depends upon a comprehensive understanding of the vocal repertoire of the species being studied. Cetaceans make a wide variety of sounds; animal-mounted recorders and localization via a towed hydrophone or sonobuoy array, coupled with visual survey data, have confirmed the source of many biological signals (e.g., minke whale bio-duck sounds—Risch et al., 2014). Despite these advances, many “unknown” biological sounds are still recorded, especially in areas that are remote and have not been extensively monitored. Here we report a new, complex call likely produced by a baleen whale, which was recorded via passive acoustic ocean gliders in an area east of Guam that includes the Mariana Trench Marine National Monument (MTMNM).

2. Methods
2.1 Study area
In 2009, a 246 000 km\(^2\) area east of the Mariana Archipelago (Fig. 1) was designated as the Mariana Trench Marine National Monument (U.S. Fish and Wildlife Service, 2016). This area also includes the Mariana Islands Range Complex (MIRC), which is the primary Western Pacific range for U.S. military training activities. Glider surveys were conducted east of the islands in support of the U.S. Navy monitoring program for cetacean species occurrence within the MIRC.

2.2 Glider specifications and survey design
Three passive-acoustic surveys in offshore waters east of Guam and Saipan were conducted using a Seaglider™ (Kongsberg Inc., Lynwood, WA). The glider was equipped with a custom-designed and -built passive acoustic recording system (Applied Physics Laboratory, University of Washington, Seattle, WA). Acoustic signals were received by a single omnidirectional hydrophone (type: HT1-99-HF, High Tech Inc., Gulfport, MS; sensitivity: \(-164\) dB re 1 V/\(\mu\)Pa), amplified by 36 dB, and recorded at 194 kHz sample rate and 16-bit resolution. The acoustic system was optimized for continuously collecting data in the frequency range 15 Hz to 97 kHz, and thus was well suited for the recording of both baleen and toothed whales. The glider repeatedly dove in a saw

---

a)Author to whom correspondence should be addressed.
b)Also at: Bioacoustics Research Program, Cornell Lab of Ornithology, Cornell University, 159 Sapsucker Woods Road, Ithaca, New York 14850, USA.

© 2016 Acoustical Society of America
tooth pattern to 1000 m depth and back to the surface at a typical horizontal speed of 25 cm/s. Dive durations were usually on the order of 4–6 h.

In 2014, a glider was deployed on 29 September 2014 off the west coast of Guam (13°30.79'N, 144°35.04'E). The glider was recovered about 24 nautical miles southwest of the deployment location (13°10.81'N, 144°31.22'E) on 14 November 2014. In March 2015, two gliders successfully surveyed this area again. Both gliders were recovered on 27 April 2015 (Fig. 1).

2.3 Data analysis

The FLAC files were decoded to standard WAV audio file format at 194 kHz sampling rate. Two datasets with reduced sampling rates of 10 kHz and 1 kHz were generated for baleen whale call occurrence analyses. Long-term spectral average (LTSA) plots were calculated using the Triton Software Package (version 1.81, Scripps Whale Acoustic Lab, Scripps Institution of Oceanography, La Jolla, CA). LTSA parameters were Δt of 2 s and Δf of 10 Hz (for 10 kHz data) and Δt of 1 s and Δf of 1 Hz (for 1 kHz data). The 10 and 1 kHz data were then time-aligned in the software package Raven Pro (version 1.5 beta, Bioacoustics Research Program, Cornell University, Ithaca, NY), and calls were logged for both datasets simultaneously. Analysts used the MATLAB based software Osprey (Mellinger, 2014) to measure calls. Calls selected for measurements (n = 20 calls) had a high (>20 dB) signal-to-noise ratio (SNR), did not overlap other calls, and were at least a few hours apart to maximize the chance that measured calls represented more than one animal.

3. Results

3.1 Call description

On numerous occasions, analysts observed a multi-part Western Pacific “Biotwang” (WPB) call, so named because of its unusual synthetic sound. WPB calls were complex and difficult to measure, lasting 2.5–3.5 s overall (Fig. 2). The call began with a brief 0.4 ± 0.3 s long tone (Part A) centered at 60.1 ± 6.0 Hz, followed by a 1.6 ± 0.1 s low-frequency moan (Part B) that swept from 44.5 ± 3.5 Hz down to 30.8 ± 2.7 Hz. The moan appeared to have both amplitude modulation and strong harmonics; the harmonic at ~410 Hz was typically one of the stronger components of the call, often
appearing above the background noise level in the LTSA, making it useful for finding WPB calls in long recordings. The moan was followed by two \( \sim 60-150 \) Hz upsweeps lasting \( 0.5 \pm 0.1 \) s (Part C) that often had diffuse energy up to 1000 Hz; a \( \sim 0.2 \) s long noisy burst of sound with energy up to 7.5 kHz (Part D); and finally, metallic-sounding upsweeps (Part E) lasting \( 0.66 \pm 0.03 \) s with most energy between 700 and 800 Hz, but up to 7.5 kHz. In calls with low SNR, Parts A, C, D and E were often not visible or audible.

### 3.2 Call occurrence

Between 14 October and 6 November 2014, 326 of these WPB calls were recorded during 38 glider dives (Fig. 1). Calls were typically 5–6 min apart and often occurred in long sequences. In data from March–April 2015, analysts identified 29 WPB calls during seven glider dives in the northern survey and 81 calls during nine dives in the southern survey (Fig. 1). Calls were recorded during both nearshore and offshore portions of the survey, in shallow and deep water and during all portions of a dive.

### 4. Discussion

In an ocean soundscape, sounds originate from anthropogenic, geophysical, and biological sources (Pijanowski et al., 2011). The sounds reported here are not similar to known anthropogenic sources such as noise produced by ships or seismic airguns. They also do not resemble geophysical sources such as the very low-frequency sounds produced by earthquakes and ice, nor the sounds produced by wind or rain (Hildebrand, 2009). Using the spectral and temporal criteria long established in the bioacoustics community (Stafford et al., 1999), the authors hypothesize that these complex sounds were produced by a biological source.

Given the call characteristics and low-frequency components of this sound, it is likely produced by a baleen whale. The MTMNM study area may be inhabited, at least seasonally, by numerous species of baleen whales that produce low-frequency vocalizations, including blue (Balaenoptera musculus musculus and B. m. brevicauda), fin (B. physalus), sei (B. borealis), Bryde’s (B. edeni), minke (B. acutorostrata), and
Nieukirk et al.: JASA Express Letters [http://dx.doi.org/10.1121/1.4962377] Published Online 13 September 2016

sequences (Payne and McVay, 1971) and does not match the stereotypy we observed. Humpback song consists of many complex and diverse sounds repeated in predictable patterns. Hill and March–April 2015, indicating the presence of this species during fall, winter, and early spring. This is similar to the pattern reported by Hill and March–April 2015, indicative of the presence of this species during fall, winter, and early spring. This is similar to the pattern reported by Hill et al. (2015), in which their “unidentified whale - tonal calls” were recorded off Tinian in most months of the year. Thus, the species making the WPB call is vocalizing and in the area during both the breeding and feeding season for most baleen whales, indicating that this call may have a complex function similar to blue whale vocal behavior in the Eastern Tropical Pacific (reviewed in Stafford, 2016) or the bio-duck calls recorded in Antarctica (Risch et al., 2014). Interestingly, the J stock of minke whale breeds in fall, which is different from other North Pacific minkes and most other baleen whales that breed in the winter (Reilly et al., 2008). The year-round presence of this call in MTMNM and surrounding waters may facilitate the identification of the species making this sound.

Here we have presented a first report of recordings of a novel call we believe to be from a baleen whale, most likely a minke whale. We have provided a quantitative and qualitative description of the acoustic features and location and timing of detections. In publishing these data, we hope others will be able to identify this call in...
past and future data, and in time identify the source of this sound. More data are needed, including genetic, acoustic, and visual identification of the source to confirm the species and gain insight into how this sound is being used.

Acknowledgments
The authors thank Julie Rivers and Chip Johnson (Commander of the U.S. Pacific Fleet), Robert Uyeyama (Naval Facilities Engineering Command), Michael Richlen and Mark Deakos (HDR Inc) for funding the MIRC glider surveys (HDR Contract No. N62470-10-D-3011; Task Orders KB23 and KB25). Thanks also to Jim Luby, Sean Lastuka, Geoff Shilling, and Myles Lemaistre for their assistance with the data collection and glider operation, and Jay Barlow for interesting discussions of J stock minke whales. This is PMEL Contribution No. 4478.

References and links

