Title	Propagation Characteristics of High-Frequency Sounds Emitted During High-Resolution Geophysical (HRG) Surveys: Acoustic Modeling Effort
Administered by	Headquarters
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Procurement Type(s)	Contract
Performance Period	FY 2019–2020
Date Revised	May 2, 2019
PICOC Summary	Write one or two sentences for each of the following elements, as appropriate.
Problem	Sound Source Verification is needed for multiple shallow water locations and bottom types, yet current data are only for a few specifically measured situations. Modeling will allow the existing data to be extrapolated to nearly any shallow water situation.
Intervention	Predictive modeling will allow the difficult propagation environment of shallow water to be addressed for HRG sonars in nearly any situation.
Comparison	This study is to define the optimal acoustic models and techniques for predicting the HRG sonar sound field in shallow water. It will finish the calibration of the data, and identify which models to use and how to operate them.
Outcome	This project ultimately will answer the question of what is the predicted sound field from these HRG sources and if it can be used to directly identify potential acoustic impacts to marine animals in the shallow water areas.
Context	This is applicable in all shallow water locations.

BOEM Information Need(s): Improved understanding of the operational and propagation characteristics of high-frequency sound sources is crucial to predict or assess the potential behavioral response of marine species to such sounds and determine appropriate mitigation, as required under the National Environmental Policy Act, the Marine Mammal Protection Act, and the Endangered Species Act. Currently, limited observations are available on the underwater propagation of the high frequency sound generated from sources other than air guns (e.g., boomers, sparkers, chirpers, side-scan sonar, and single, swath, and multi-beam bathymetry).

Background: Marine geophysical data is critical for industry and BOEM to make informed leasing decisions. High frequency marine acoustic sources are commonly used and required during infrastructure siting, geological or environmental characterization, and shallow hazard or archaeological cultural surveys. The acoustic sources currently in use include boomers; sparkers; sub-bottom (chirp or other) profilers; side-scan sonar; and single, swath, and multi-beam bathymetric fathometers. The marine source acoustic source levels generally range from 170 to 240 dB re 1 µPa @1 m (peak-to-peak), and operate in the < 300 Hz to several hundred KHz range.

Many of these HRG systems' characteristics may affect marine life (e.g., marine mammals, sea turtles, and fish). The potential for impacts range from physical injury to behavior, and are highly dependent on the species' hearing bandwidth and integration time along with the source characteristics and the local acoustic propagation effects.

Currently, limited calibrated or in-field source characterization data exist for these sources, other than that provided by the manufacturer. Additionally, there is a dearth of *in situ* measurements of these systems. Specifically, the sound fields produced by the interaction of these sources with the local propagation characteristics are poorly understood, and shallow to intermediate water depths (e.g., 10 to approximately 100 m) further exacerbate the issue. In the shallow water areas where these system frequently operate, the propagation may be severely complicated by bathymetric interaction, variable sediment composition, shallow water processes (i.e., breaking waves), and mesoscale oceanographic properties. Numerical models currently used to predict propagation and transmission loss also need to be validated to not only more accurately represent these important physical processes, but also to provide a referable document that can be used to assure BOEM, the National Marine Fisheries Service, and the public, of the efficacy of impact modeling of these types of sources in shallow water for the environmental compliance processes.

Objectives: The specific objectives of this study are to:

(1) Complete the calibration of the acoustic data collected in Halvorsen and Heaney (2018);

(2) incorporate the acoustic and support data from the two previous projects in this series (i.e., the tank testing and open water testing of these high frequency sources) into the best or most appropriate acoustic models currently available to the community and produce model results that predict the situation present during those tests;

(3) analyze and compare the measured and modeled data produced to determine the accuracy and utility of the standard modeling;

(4) examine methods that may improve the accuracy of these modeled predictions so that they better approximate the measured data;

(5) investigate if additional models and/or techniques improve the accuracy of the modeled results; and

(6) identify and recommend any changes to models or techniques that would improve the robustness of future shallow water modeling efforts for these identified, or similar, sonar systems.

This investigation should provide insight into the full list of the sources/systems examined in the first two studies, and include examination all critical parameters (frequency content, source levels, variations in sediment type and depth, variations in water depth for the range of depths measured previously, multipath, etc.) or any other parameters identified during this study that are deemed important.

Methods: This study relies upon the ability of the performer to:

- Produce predictive acoustic propagation modeling results using standard models and databases of environmental parameters;
- Improve or upgrade those environmental parameters with *in situ* measured data;
- Incorporate the source parameters identified in previous studies; and
- Understand the underlying physics of the models in order to adjust or correct parameters to better match measured propagation or received level data.

It is expected that the performer would start by investigating how the standard databases for the measured locations perform, since these would need to be relied upon by modelers in the future for different locations, conditions, and sources. Next, the investigation would examine how refinements to those databases by measured data improve or degrade the results. Finally, the analyst would investigate other changes to the models or source or environmental parameters that could improve the fidelity of the results.

Specific Research Question(s): How ought BOEM model and predict the sound field for HRG sources in shallow water?

References:

Crocker SE. Fratantonio FF. 2016. Characteristics of sounds emitted during high-resolution marine geophysical surveys. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management and United States Geological Survey. Naval Undersea Warfare Center Division New Port (NUWC-NPT) Technical Report 12,203 and OCS Study BOEM 2016-044. https://espis.boem.gov/final%20reports/5551.pdf. 259 p.

Halvorsen, MB, Heaney KD. (**2018**). Propagation characteristics of high-resolution geophysical surveys: open water testing. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2018-052. https://espis.boem.gov/final%20reports/BOEM_2018-052.pdf. 806 p.