STUDY TITLE: Pressure Wave and Acoustic Properties Generated by the Explosive Removal of Offshore Structures in the Gulf of Mexico

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CONTRACT NUMBER(S): M13PX00068

SPONSORING OCS REGION: GOMR

APPLICABLE PLANNING AREA(S): East; Central; West

FISCAL YEAR(S) OF PROJECT FUNDING: 20132016

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COST(S): (BY FISCAL YEAR); CUMULATIVE PROJECT COST: FY 2014: $22,495.53; FY 2015 $59,988.09; FY 2016 $67,486.60; Cumulative project cost: $149,970.22

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KEY WORDS:

BACKGROUND: Under the OCS Lands Act (OCSLA), the Bureau of Ocean Energy Management (BOEM) establishes decommissioning obligations to which an operator must commit when they sign an offshore lease, which includes the requirement to apply for and obtain a permit for subsequent removal of wells and facilities. The Bureau of Safety and Environmental Enforcement (BSEE) is responsible for regulating the decommissioning of OCS facilities in accordance with 30 CFR 250 Subpart Q. Decommissioning of these structures may be accomplished using mechanical or explosive severance techniques. Explosive severance relies on the use of specially designed charges to produce enough energy to completely sever the structure's bottom-founded components.

In the past, National Marine Fisheries Service (NMFS) typically applied take-threshold criteria for explosives from models that were developed for the incidental-take authorization of U.S. Navy's "shock trials"; wherein, large, open-water charges of 5,000 to 10,000 lbs are detonated within close proximity of new classes of warships to assess how well the ship can withstand damage and how well the crew can respond to mass system casualties (Department of the Navy, 1998, 2001). Conventionally, these conservative predictions of the impact zone have been used to satisfy Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) requirements. However, explosive severance and, particularly, below-mud-line (BML) detonations are likely to produce lower pressure levels at the same propagation distances than open-water shock trial configurations due to absorption, attenuation of energy by sediments, and the confinement of the explosion within well casings and platform piles. Conservative take estimates and large exclusion zones have been used for explosive severance due to a wide range of probabilistic error associated with insufficient in situ measurements from which to calculate the most plausible impact zone. By collecting acoustic data under various settings (e.g., varying cut depth, charge size), more accurate estimates of Pressure Wave and Acoustic Propagation (PWAP) can be calculated to apply appropriate mitigations to protect marine mammals and sea turtles, while also optimizing operations (safety and efficiency) during detonations.

Before this study, Minerals Management Service's Technology Assessment and Research (TAR) Project funded three similar, in situ PWAP projects. The first, TAR Project No. 118, conducted measurements of 27 separate severance detonations for West Delta (WD) Block 30 structures during the winter of 1988 (Connor, 1990). The second, TAR Project No. 429, centered on development of improved, linear shaped charge cutters; however, the project was modified during field testing to allow for deployment of an acoustic array to measure pressure wave characteristics (Saint-Arnaud et al., 2004). The third, TAR Project No. 570, collected data to determine the effect of placement depth of the severance charges (15, 20, 25, and 30 ft BML) on the recorded PWAP (Poe et al., 2009).

Data collected from the studies resulted in a model developed by ARA (2002) referred to as the Underwater Calculator (UWC). The UWC is a spreadsheet-based tool that calculates the underwater shock wave, specifically the peak pressure, impulse, and energy flux density expected to result from the explosive detonation charges during explosive severance work. The tool is used to calculate the range from the explosive to a specified peak shock pressure and energy level that may result in impacts to marine life. Version 1 of the calculator (UWCv1) is based on physics models, whereas version 2 (UWCv2) employs curves fit data from the in situ sampling at two specific locations

OBJECTIVES: This study was developed to be a successive project and so applied a comparable methodology and equipment used in previous explosive severance studies to collect measurement data. The primary objective of this study, where possible, was to obtain additional in situ data points and charge parameters necessary to fill in information gaps from the previous projects. A secondary objective of this project was to provide supplemental data for the validation and fine tuning of previously developed modeling used to establish impact zones for mitigative monitoring needed during decommissioning projects using explosives.

DESCRIPTION: Platform targets were selected based on consultation with BSEE and platform owner/operators to identify platforms that would be the best to use for model verification while still conforming to their decommissioning schedule. The goal was to choose targets that would allow numerous detonations and charge configurations such that the data collected would maximize charge types and BML configurations identified as high priority data gaps for refining the UWCv2. Targets were prioritized to increase the number and type of detonation (shot) measurements as inputs to the UWCv2, thus strengthening the UWC's value for potential use in estimating peak pressure and protected species safety zones during decommissioning activities that use explosive severance.

SIGNIFICANT CONCLUSIONS: UWCv1 returned accurate predictions of the results from this study but overestimated the measurements from Connor and TAR 570 projects. UWCv2 predicted a faster decay rate than was shown in the in-situ measurements. However, both the UWCv1 and UWCv2 predictions will produce safety ranges that are smaller than those for an open-water explosion. The observed data from the current experiment were accurately predicted by UWCv1. As with the Connor and TAR 570 data, the UWCv1 generally over-predicted the actual measured PWAP levels.

STUDY RESULTS: The predictions of UWCv2 had a quicker decay rate with range than both the UWCv1 predictions and the measured data from the current study. These results suggest that the effects of the differing structural and environmental combinations are not fully incorporated into the UWCv2. The implications for applying either UWC for determining exclusion zones and impact assessment from decommissioning events lie in the utility of these calculators in predicting the impulse, EFD, and peak pressure at given distances from the platform. For impulse, EFD, and peak pressure, the measured attenuation was consistently better fit to the predicted values produced by the UWCv1 rather than the UWCv2. Measured peak pressures were consistently lower than those predicted by UWCv1, but were variable in comparison to UWCv2, with closer distances being over predicted and farther distances being under predicted. UWCv1 provides a consistently more conservative and accurate prediction of measured values important in impact evaluation.

All predicted and measured pressure level data for the BML detonations were lower than the predicted amplitudes of an open-water charge for all charge weights, indicating that using an open-water model calculation to establish take or safety zones would consistently overestimate the size of the impact area for detonations at any charge weight or depth BML. The conservative estimates from both UWCv1 and UWCv2 provide impact zone predictions that remain far below calculations for an open-water blast.

Peak pressure (psi) and EFD are the dual criteria typically used by NMFS in determining impact zones and take estimates for marine mammals and sea turtles from explosive sources. Measured psi values during this study were always lower than unconfined, open-water predictions for either UWCv1 or UWCv2. The data collected during this study can be applied for updating the UWCv2 model.

STUDY PRODUCT(S): Barkaszi, M.J., A. Frankle, J. Martin, and W Poe. 2016. Pressure wave and acoustic properties generated by explosive removal of offshore structures in the Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2016-019. 62 pp.

Map showing area of study (PWAP WD40)