Quarterly Progress Report

Technical and Financial

Deep Water Ocean Acoustics
Award No.: N00014-14-C-0172

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Submitted by:
Principal Investigator/Author: Kevin Heaney
Ocean Acoustical Services and Instrumentation Systems, Inc.
5 Militia Drive
Lexington, MA 02421

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Table of Contents

Technical Progress Report

1. Introduction

The goal of this research is to increase our understanding of the impact of the ocean and seafloor environmental variability on deep-water (long-range) ocean acoustic propagation and to develop methodologies for including this in acoustic models. Experimental analysis is combined with model development to isolate specific physics and improve our understanding. During the past few years, the physics effects studied have been three-dimensional propagation on global scales, deep water ambient noise, under-ice scattering, bathymetric diffraction and the application of the ocean acoustic Parabolic Equation to infrasound.

2. Tasks

a. Task 1: Basin Scale Acoustic Propagation and CTBTO Data Analysis

The paper "*Three-dimensional parabolic equation modeling of mesoscale eddy deflection*", by Heaney and Campbell, was published in JASA in February of 2016. This paper introduces the Peregrine model to the community and establishes its capability for performing global scale 3D propagation experiments. Dr. Heaney also completed and submitted the paper "*Bathymetric diffraction of basin-scale hydroacoustic signals*" , by Heaney, Campbell and Mark Prior (TNO/CTBTO) describing observations and modeling of seismic events in the acoustic shadow of large land masses (South Georgia Island and South America).

Work was conducted evaluating the arrivals of a series of explosive shots dropped by Japanese Seismologists off the coast of Japan. Explosions from these two tests, (Normal Mantle – NOMAN) and JT (Japanese Trough) were both detected 19000 km away at the Juan Fernandez (HA03) station of the International Monitoring System of the Comprehensive Test Ban Treaty Organization.

The first set of runs was from HA03 over the entire globe, at a frequency of 4Hz, for both 2-dimensional and 3-dimensional propagation. The 3D propagation result is shown in Figure 1.

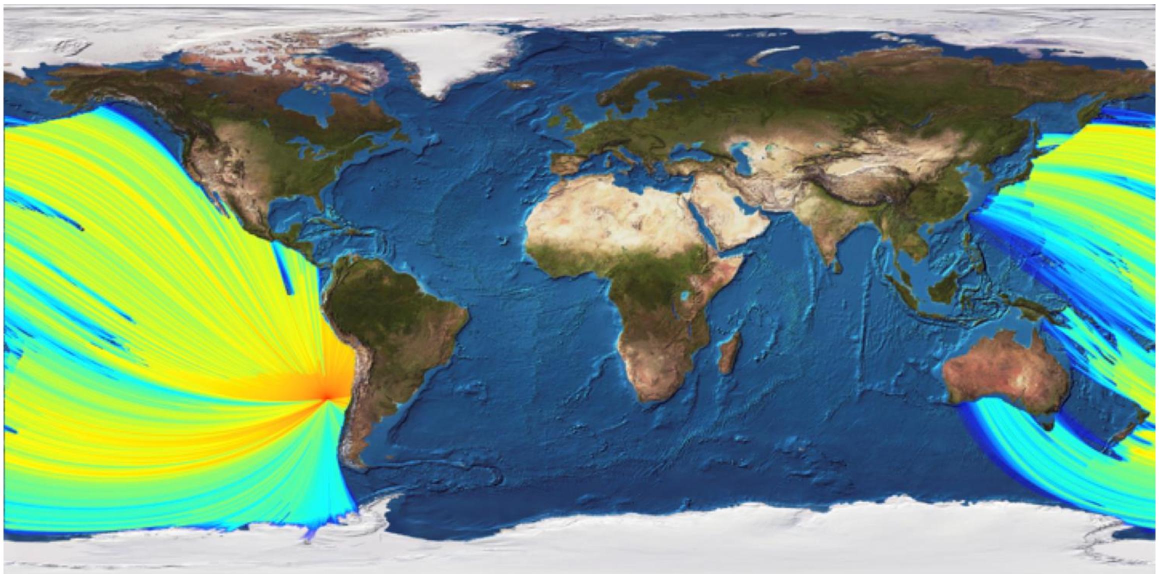

Figure 1. 4Hz Transmission Loss using 3D Peregrine Model for HA03N (Juan Fernandez) CTBTO Receiver

Of interest to these measurements from sources off Japan is the blockage of the Hawaiian Archipelago. There is also a row of seamounts off the coast of northern Chile, which scatter and diffract sound. Dr. Tomoaki Yamada, of the University of Tokyo, has spent the past year at CTBTO in Vienna processing the data from both tests. Of interest to us it the levels of arrivals from the Japan Trough site, which should be in the shadow of the Hawaiian Islands. Work is also being done to calibrate the source spectra, which for a large explosion is much more complicated than the impulse response typically modeled using the PE. Bubble pulse effects will significantly increase the pulse duration even without propagation effects. The final research topic is the multiple arrivals at HA11 (Wake Island). These will be explored in future work.

Comparing the receiver power from each pulse (in a band-passed 4-20Hz window over 20s) with the 2D incoherent (4-20Hz) shows significant discrepancies (Figure 2). In particular, for the Northern portion where the two legs intersect, there is substantial energy. For the 2D computation, there is no received energy as this point is in the shadow behind the big Island of Hawaii. Note that care has not been applied to calibrate the two figures.

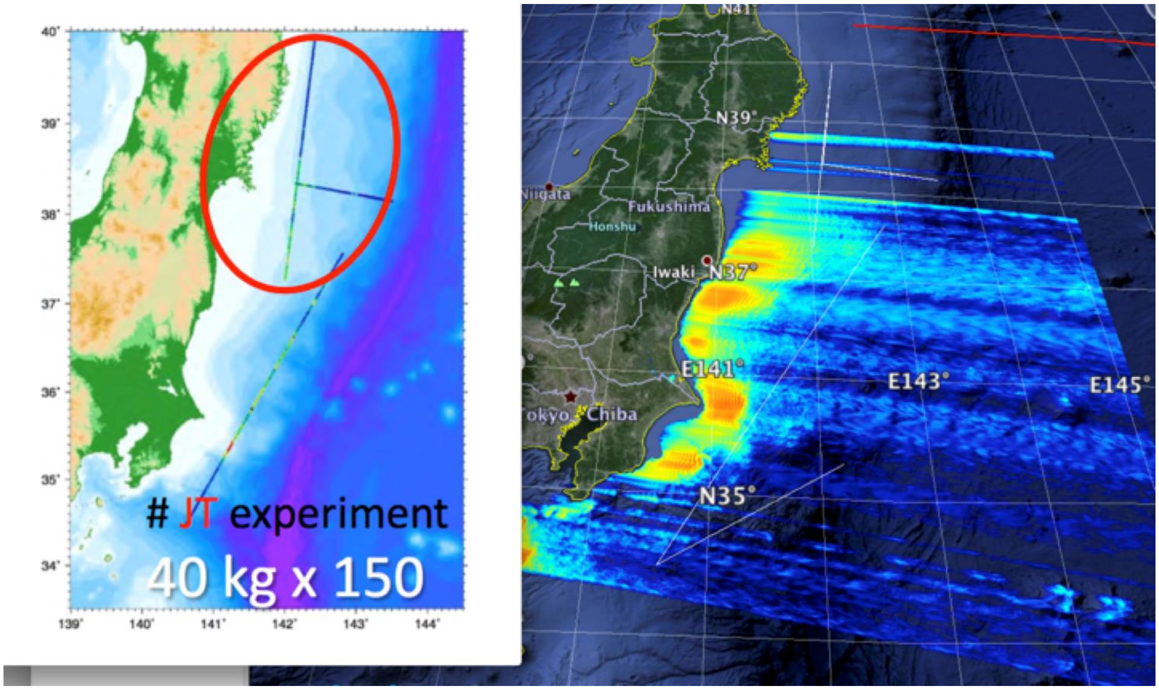

Figure 2. Observed total power (left) compared with the 2D PE modeled total incoherent power (right) for the Japan Trough Experiment. Note the lack of energy in the model at the T-junction east of Japan at 39°N latitude.

The same model computation was performed with the 3D propagation kernel (split-step Pade with 4 Pade terms). These results are shown in Figure 3.

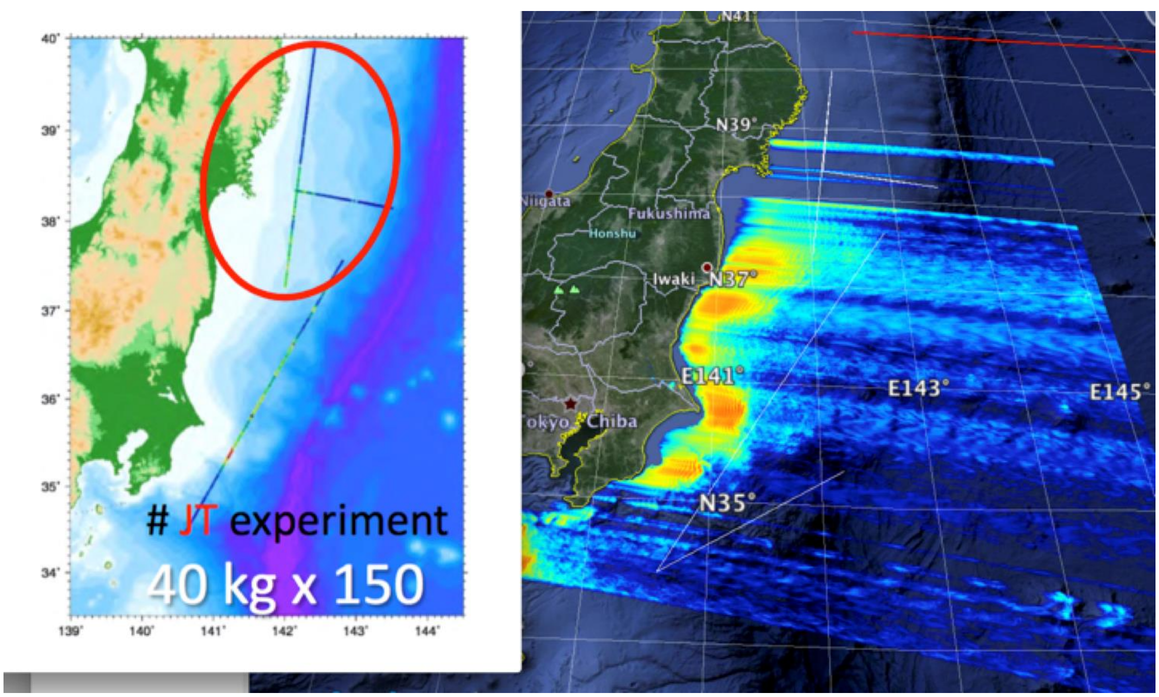

Figure 3. Observed total power (left) compared with the 3D PE modeled total incoherent power (right) for the Japan Trough Experiment. Note the lack of energy in the model at the T-junction east of Japan at 39°N latitude.

The 3D model includes diffraction from the Hawaiian islands, and from the ridge north of the HA03 receiver stations. The resulting field from the Japan coast shows no distinct shadows, entirely consistent with the observations of Yamada. The fall off of received level as the transects move north, as well as east into deeper water is also is also modeled well.

b. Task 2: NPAL PhilSeal0 Data Analysis and Matched Field Processing

No work was done on Task 2 during this period of performance.

3. Future Plans

In the next quarter, the Yamada measurements on the CTBTO HA03 and HA11 receivers will be evaluated in more detail. In particular, estimates of a source spectra will be made using local OBS recordings (ranges of 97-300 km). Arrival time measurements also show the impact of the Hawaiian Island chain, as the travel time for shadowed paths increases, as the sound must go around the islands and cannot follow the geodesic. An attempt at the broadband 3D PE for ranges of 19000 km will be made.

4. Publications and Peer Interactions

"Three-dimensional parabolic equation modeling of mesoscale eddy deflection" by Kevin D. Heaney and Richard L. Campbell, was published by Journal of the Acoustical Society of America on February 20, 2016.

"Bathymetric diffraction of basin-scale hydroacoustic signals" by Kevin D. Heaney, Richard L. Campbell and Mark Prior, was submitted to Journal of the Acoustical Society of America on March 20, 2016.

5. Financial Summary

1172 DEEP WATER ACOUSTICS **N00014-114-C-0172**
POP: 9/27/13-6/6/16

CONTRACT VALUE	Cost	Fee	Total
Contract Value	$368,935	$27,048	$395,983
Funding Value:	**$368,935**	**$27,048**	**$395,983**
Remaining to Fund:	$0	$0	$0

CUMULATIVE SPENDING WITH COMMITMENTS

	DIRECT	OH	MH	TOTL COST	FEE	**TOTAL**
ACTUAL						
OASIS	$138,185	$109,611	$2,569.13	$250,366	$18,777	**$269,143**
COMMITTED						
	$0	$0	$0	$0	$0	**$0**
	$138,185	$109,611	$2,569	$250,366	$18,777	**$269,143**
TOTAL REMAINING TO SPEND:						**$126,840**