Completion Report

Period: 2/1/2014 - 1/31/2015

Project: R/COCC-2 - *Acoustic Propagation Measurement and Modeling in Puget Sound to Support Noise Environmental Impact Efforts*

STUDENTS SUPPORTED

Farrell, Dara, daraf@u.washington.edu, University of Washington, Mechanical Engineering, status: cont, field of study: Underwater Acoustics, advisor: Peter Dahl, degree type: PhD, degree date: 2016-06-01, degree completed this period: No
Student Project Title:
Visualization of the noise field due to underwater pile driving
Involvement with Sea Grant This Period:
Research Assistantship under this core grant
Post-Graduation Plans:
Employment in the area of resource management and policy development.

CONFERENCES / PRESENTATIONS

No Conferences / Presentations Reported This Period

ADDITIONAL METRICS

P-12 Students Reached:	**P-12 Educators Trained:**
Participants in Informal Education Programs:	**Volunteer Hours:**
Acres of coastal habitat protected, enhanced or restored:	**Resource Managers who use Ecosystem-Based Approaches to Management:**
Annual Clean Marina Program - certifications:	**HACCP - Number of people with new certifications:**

ECONOMIC IMPACTS

No Economic Impacts Reported This Period

SEA GRANT PRODUCTS

Description	Developed?	Used?	ELWD?	Number of Managers	Names of Managers
Geograhical Information System (GIS) tool to produce site specific maps of acoustic transmission loss associated with	No	Yes	No	1	Navy

pile driving.

HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

ADDITIONAL MEASURES

Number of stakeholders modifying practices:

Sustainable Coastal Development

# of coastal communities:

PARTNERS

Partner Name: US Department of the Navy (US DOD)

IMPACTS AND ACCOMPLISHMENTS

Title: **Washington Sea Grant-supported research develops a better model for predicting underwater noise levels and protecting marine mammals**
Type: accomplishment
Description:
Relevance: Maritime activities and replacing aging infrastructure create construction needs in nearshore marine waters. Because noise from underwater pile driving can injure or disturb marine mammals, regulations limit activity within the “zones of influence,” where the mammals may be vulnerable. But the sound-field models currently used to define these zones do not account for bathymetry and bottom composition, which can affect sound propagation. More accurate models could assist in planning and risk assessment, avoiding unnecessary work stoppages and placing observers and monitoring instruments where needed to prevent harm to whales, dolphins, seals, and other life.
Response: Washington Sea Grant-funded researchers developed a model more consistent with the physics of underwater sound propagation, incorporating it into maps and geographic information systems to better assess noise effects. Following successful trials near Port Townsend, Washington, they measured noise propagation from pile driving near San Diego for comparison with model predictions.
Results: The model showed good agreement with actual operational noise levels measured at benchmark distances. Depth variation affected noise attenuation much more than sediment composition; underwater noise dropped off quickly as it traveled parallel to a sloping beach. The results indicate that observers and monitoring resources could be more efficiently placed to better cover areas where noise levels actually present a risk.
Recap:
Recap: Washington Sea Grant-supported research confirms the accuracy of a new model of underwater sound propagation, identifying an important effect of sloping shores on noise levels and a more effective strategy for protecting marine mammals from construction noise.
Comments:
Primary Focus Area: LME (HCE)

Secondary Focus Area: COCC (SCD)
Associated Goals: Support conservation and sustainable use of living marine resources through effective and responsible approaches, tools, models, and information for harvesting wild and cultured stocks and preserving protected species. (HCE Science)
Assist coastal communities and marine-dependent businesses in planning and making decisions that provide local and regional economic benefits, increase resilience, and foster stewardship of social, economic, and natural resources. (SCD Inter-relation)
Partners:
US Department of the Navy (US DOD)
Related Partners: US Department of the Navy (US DOD)

PUBLICATIONS

Title: **The underwater sound field from vibratory pile driving (in review)**
Type: Reprints from Peer-Reviewed Journals, Books, Proceedings and Other Documents Publication Year: 2015
Uploaded File: *none*
URL: *none*
Abstract:
Underwater noise from vibratory pile driving was observed using a vertical line array placed at range 16 m from the pile source (water depth 7.5 m), and using single hydrophones at range 417 m on one transect, and range 207 m and 436 m on another transect running approximately parallel to a sloping shoreline. The dominant spectral features of the underwater noise are related to the frequency of the vibratory pile driving hammer (typically 15 -35 Hz), producing spectral lines at intervals of this frequency. Homomorphic analysis removes these lines to reveal the underlying spectrum. The mean square pressure versus depth is subsequently studied in third-octave bands. Depth and frequency variations of this quantity observed at the vertical line array are well modeled by a field consisting of an incoherent sum of sources distributed over the water column. Adiabatic mode theory is used to propagate this field to greater ranges and model the observations made along the two depth-varying transects. The effect of shear in the seabed, although small, is also included. Bathymetric refraction on the transect parrallel to the shoreline reduced mean-square pressure levels at the 436-m measurement site.
Citation:
[Dahl et. al. 2014] “The underwater sound field from vibratory pile driving”, Dahl, P.H., Dall’Osto. D.R., Farrell, D.M. 2014 submitted to J. Acoust. Soc. Am in press
Copyright Restrictions + Other Notes:
Journal Title: The Journal of the Acoustical Society of America

OTHER DOCUMENTS

No Documents Reported This Period

LEVERAGED FUNDS

Type: influenced Period: 2014-05-05: : 2015-01-08Amount: $3174

Purpose:
Measurement of underwater noise in San Diego Bay
Source: Tierra Data

COMPLETION NARRATIVE

Uploaded File: Dahl_2426_completion_n....4.pdf, 181 kb

Applied Physics Laboratory
University of Washington

1013 NE 40th Street
Box 355640
Seattle, WA 98105-6698

206-543-1300
FAX 206-543-6785
www.apl.washington.edu

Pile driving can produce high levels of underwater sound that must be regulated to protect marine mammals and fish. To that end, various zones of influence (ZOIs) are defined that estimate regions where sound levels can cause injury to or possible disruption of the behavioral patterns of pinnipeds and cetaceans. During marine construction, observers are tasked with ensuring that work is stopped if marine mammals enter the zone where injury is possible. In May and October of 2014 as well as in January 2015, a PhD participated in the collection of measurements of the underwater noise due to impact and vibratory pile driving in San Diego Bay. (Note that approximately 47 % of the funding for this student's effort during this funding period was provided by this Washington Sea grant with remaining covered by other grants and contracts.)

The pile driving measurements were collected to inform placement of marine mammal observers, and adhere to Incidental Harassment Authorization (IHA) requirements for an ongoing marine construction project. Figure 1 shows some real-time monitoring locations for the January measurements. Results from real-time monitoring showed good agreement with the modeled isopleths associated with Level A injury for pinnipeds and cetaceans.

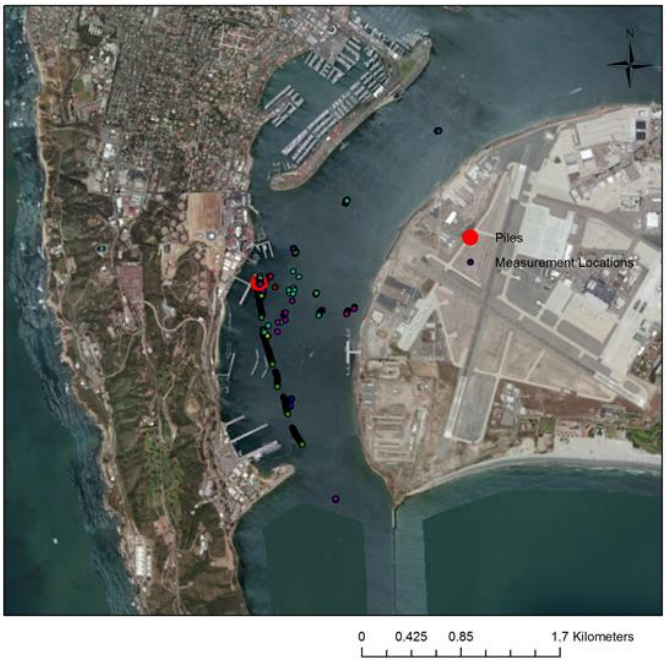

Figure 1. Spatial distribution of measurements of impact pile driving noise during real time monitoring of pile driving noise in San Diego Bay.

An abstract based on the work from the San Diego Bay measurements is planned for submission to the 21st Biennial Conference on the Biology of Marine Mammals to take place in December of 2015. The

planned poster will highlight the modeling of isopleths associated with the 190 dB and 180 dB isopleths (rms level, dB re 1 µPa) that define injury thresholds for pinnipeds and cetaceans, respectively.

Additionally, a paper based on the measurements collected in the WSDOT-funded Port Townsend experiment has been submitted to the Journal of the Acoustical Society of America and is currently under review. This paper discusses results from the PI's modeling of vibratory pile driving for which the student contributed.