Update Report

Period 2/1/2013 - 1/31/2014

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 2015-12-01, degree completed this period No
Student Project Title Modeling and visualization of the underwater sound field associated with 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

Farrell, D.M. and Dahl P.H. "Transmission loss modeling and GIS display in Puget Sound", Presented at the Northwest Pile Driving Noise Attenuation Research Workshop, September 2013, Seattle, WA., public/profession presentation, 55 attendees, 2013-09-20
Dahl, P.H., "Overview of Port Townsend Field Research". Presented at the Northwest Pile Driving Noise Attenuation Research Workshop, September 2013, Seattle, WA., public/profession presentation, 55 attendees, 2013-09-20
Dahl, P.H. "Properties influencing the transmission loss and mitigation of the underwater sound from marine pile driving" , Program abstracts of the 166th Meeting of the Acoustical Society of America. Volume 134, 4025-4025 (2013) DOI http //dx.doi.org/10.1121/1.4830693
, public/profession presentation, 30 attendees, 2013-12-03
Farrell, D.M. and Dahl, P.H. "Transmission loss for vibratory pile driving in shallow water modeling and field measurements of a Puget Sound location",Program abstracts of the 166th Meeting of the Acoustical Society of America. Volume 134, 4025-4025 (2013), DOI http //dx.doi.org/10.1121/1.4830694
, public/profession presentation, 30 attendees, 2013-12-03

ADDITIONAL METRICS

K-12 Students Reached	Acres of degraded ecosystems restored as a result of Sea Grant activities
Curricula Developed	Resource Managers who use Ecosystem-Based Approaches to Management

Volunteer Hours	HACCP - Number of people with new certifications
Cumulative Clean Marina Program - certifications	

PATENTS AND ECONOMIC BENEFITS

No Benefits Reported This Period

TOOLS, TECH, AND INFORMATION SERVICES

Description		Developed	Used	Names of Managers	Number of Managers
Geograhical Information System (GIS) tool to map acoustic transmission loss associated with pile driving in inland water bodies like Puget Sound.	Actual (2/1/2013 - 1/31/2014)	1	1	Anurag Kumar, CIV NAVFAC LANT	1
	Anticipated (2/1/2014 - 1/31/2015)	0	0		

HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

ADDITIONAL MEASURES

Safe and sustainable seafood

Number of stakeholders modifying practices
Actual (2/1/2013 - 1/31/2014)
Anticipated (2/1/2014 - 1/31/2015)

Number of fishers using new techniques
Actual (2/1/2013 - 1/31/2014)
Anticipated (2/1/2014 - 1/31/2015)

Sustainable Coastal Development
Actual (2/1/2013 - 1/31/2014)
Anticipated (2/1/2014 - 1/31/2015)

Coastal Ecosystems
Actual (2/1/2013 - 1/31/2014)
Anticipated (2/1/2014 - 1/31/2015)

PARTNERS

Partner Name US Department of the Navy (US DOD)

Partner Name Washington State Department of Transportation

IMPACTS AND ACCOMPLISHMENTS

Title Washington Sea Grant research develops a better model for predicting underwater noise and protecting marine mammals

Type accomplishment

Description Relevance Underwater noise from marine construction can threaten marine mammals such as killer whales and other sensitive species. Developers must establish monitoring plans to protect animals from harmful noise levels. Current monitoring plans are based on a simple model for underwater sound transmission that may not accurately estimate levels within tens of square kilometers. Use of this simple model can add significantly to a construction project's cost and timeline, without improving protection for marine mammals and other species. Response Washington Sea Grant-funded researchers are refining a new noise-propagation model they developed using measurements taken at various distances and depths during recent construction in Puget Sound. This model takes into account bathymetry and seabed sediment composition, which can affect sound propagation. They incorporated sediment maps of Puget Sound into the model and applied it to similar shallow water sites on the East Coast Results Initial results show that the shape of the zone of elevated noise levels can change with the seasons. They demonstrate good agreement between the model and actual underwater noise measurements, in contrast to predictions based on the traditional model. The Washington State Department of Transportation is waiting to adapt its underwater construction protocols to the new model once it is fully tested.

Recap Washington Sea Grant-supported research refines and tests a more accurate underwater sound propagation model, which can be used to protect marine mammals from construction noise.

Comments Primary Focus Area LME (HCE) Secondary Focus Area COCC (SCD) State 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).

Related Partners Washington State Department of Transportation, US Department of the Navy (US DOD)

PUBLICATIONS

No Publications Reported This Period

OTHER DOCUMENTS

No Documents Reported This Period

LEVERAGED FUNDS

Type influenced Period 2013-02-01 2014-01-01Amount $3904

Purpose Student RA salary 15 October 2013 to 15 December 2013

Source U.S. NAVFAC Mid-Atlantic

Type influenced Period 2013-02-01 2014-01-01Amount $300

Purpose Travel award to Dara Farrell for conference attendance, 3 December, 2013

Source University of Washington, Graduate School Fund for Excellence and Innovation, Graduate Student Travel Awards

UPDATE NARRATIVE

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The underwater noise generated from pile driving during marine construction has great potential to impact marine mammals. It therefore falls under the canopy of activities that are of social and regulatory concern and is regulated under the Marine Mammal Protection Act and the Endangered Species Act. Regulatory requirements continue to evolve in response to the best available scientific knowledge. For example, in the recent NOAA Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals (December 2013), NOAA has updated the acoustic threshold levels for the onset of both temporary (TTS) and permanent hearing threshold shifts (PTS) and has presented new protocols for estimating PTS and TTS onset levels for impulsive (e.g., impact pile drivers) and non-impulsive (e.g., vibratory pile drivers) sound sources. Thus it is essential to have accurate models that capture the characteristics underwater sound propagation at a given construction site, for planning and risk assessment.

In order to proceed with marine construction, all governmental agencies, including Washington State, are required to adhere to stipulations outlined in an Incidental Harassment Authorization (IHA) received from the National Marine Fisheries Services (NMFS). These stipulations often require monitoring in an area that falls within a zone of influence where underwater sound levels are above 120 dB (referenced to 1 micro Pascal of sound pressure). For example, sound levels exceeding 120 dB are significant with some action required, such as reducing construction activity or temporarily halting construction.

To predict the extent of this zone a simple model for underwater sound transmission, known as the practical spreading model (PSM), is often applied. The practical spreading model is as follows:

Transmission Loss (dB) = 15 * log10 (R/R_o), [1]

where transmission loss (also called propagation loss) is a quantity describing the reduction of sound level in decibels (dB), where R_o equals the reference range at which reference measurements were made (typically 10 m), and R equals the range to which a new estimate of sound level is desired. For example, if R = 1000 m, then the PSM would predict a 30 dB reduction in the sound level compared to the level measured at range 10 m since $15\log_{10}\left(\frac{1000}{10}\right)=30\,\text{dB}$. For a source level of 175 dB re: 1μPa at 10 m in order to reach the 120 dB (referenced to 1 micro Pascal of sound pressure) isopleth –that is a 55 dB reduction, this would require monitoring to a maximum of about 4600 m, or until the first land mass is encountered. In many cases this is not an accurate description of the size of the zone of influence.

A physics-based model that incorporates site-dependent characteristics (e.g. sediment type, bathymetry, etc.), however, is able to calculate transmission loss more accurately thus providing a more realistic estimation of the size of the zone of influence, reducing monitoring costs, improve assessment of risk, and simply provide better protection of marine mammals.

Comparison with field measurements and accurate site data (e.g. bathymetry) are key to validation of model accuracy. Measurements of vibratory pile driving noise were made at the Port Townsend ferry terminal in January, 2013 in an exercise supported by the Washington State Department of Transportation (WSDOT). The January experiment presented a unique opportunity for collection of synoptic measurements at varying ranges. In support of January's WSDOT funded experimental work, in June 2013, a PhD student funded under this Sea Grant participated in a detailed bathymetric survey of the experimental area. This provided more accurate bathymetry for use in modeling of the January data (Figure 1).

A preliminary model for this site and the data show good agreement as shown in Figure 2. Figure 3 shows a preliminary map of received levels at the Port Townsend site compared with PSM. The area of lower TL is influenced by the up-sloping bottom. At approximately 3000 m from the pile driving site the model predicts a received level of 146 dB compared to PSM prediction of 136 dB as a result of the up-sloping bottom at this location.

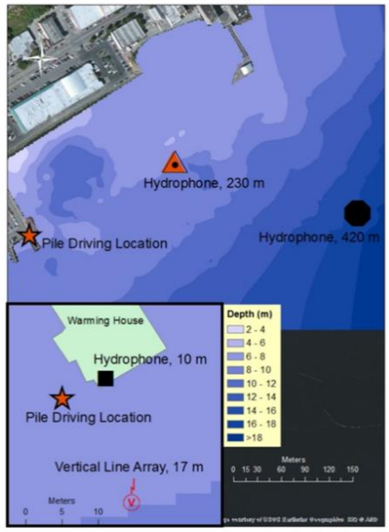


Figure 1. Port Townsend January 2013 experimental set-up and bathymetric contours from survey conducted in June, 2013.

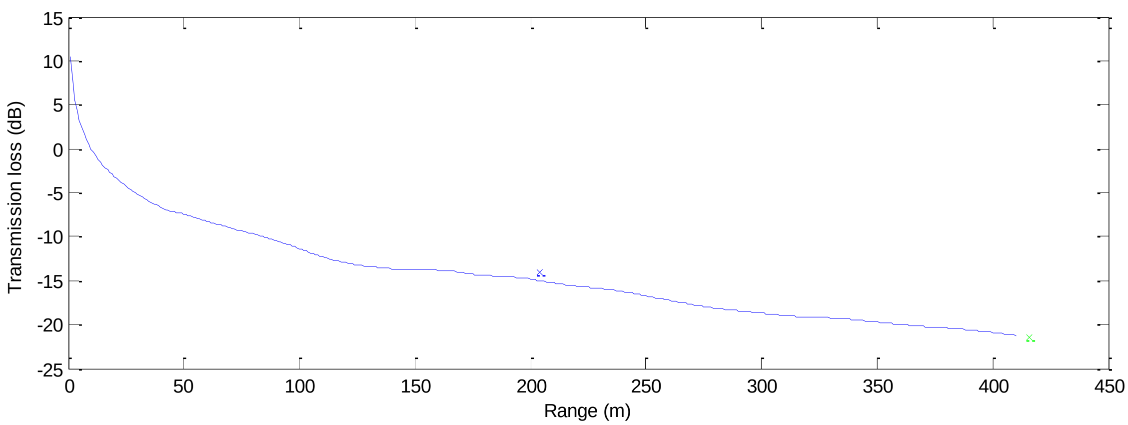
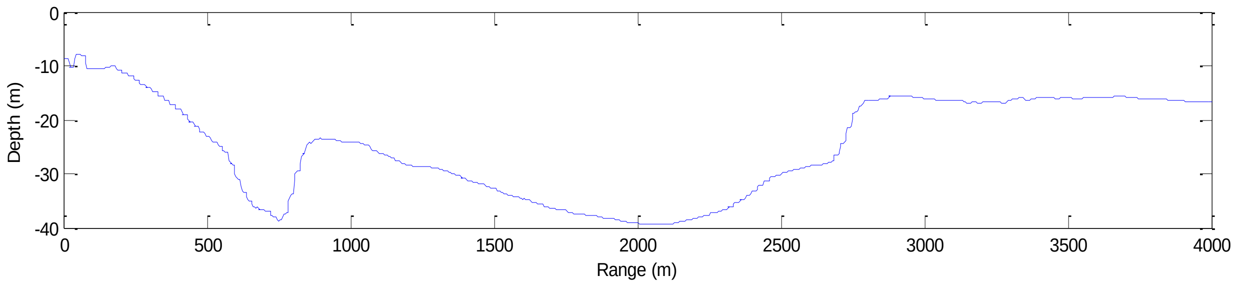


Figure 2. Predicted model transmission loss (referenced to 17 m) and measurement results along the transect between the pile driving location (red star in Figure 1) and the 420 m hydrophone (black octagon in Figure 1). The model shows good agreement with experimental data (the green and blue x's).

As in 2012, this modeling approach was also applied to other shallow water inlet locations. This work further demonstrated the model's capacity to respond to the site and seasonal-dependent nature of transmission loss in shallow water environments. Figure 2 shows the received levels for one east coast site where the increased transmission loss in summer months is clearly shown.

In 2014, work continues at this site fitting model and experimental data from the Port Townsend exercise, exploring source spectral characteristics and depth dependence and depth dependence of the noise. Informed by this analysis the model continues to evolve and a new modeling method related to vibratory pile driving data is being explored that characterizes the vibratory source in a novel way.



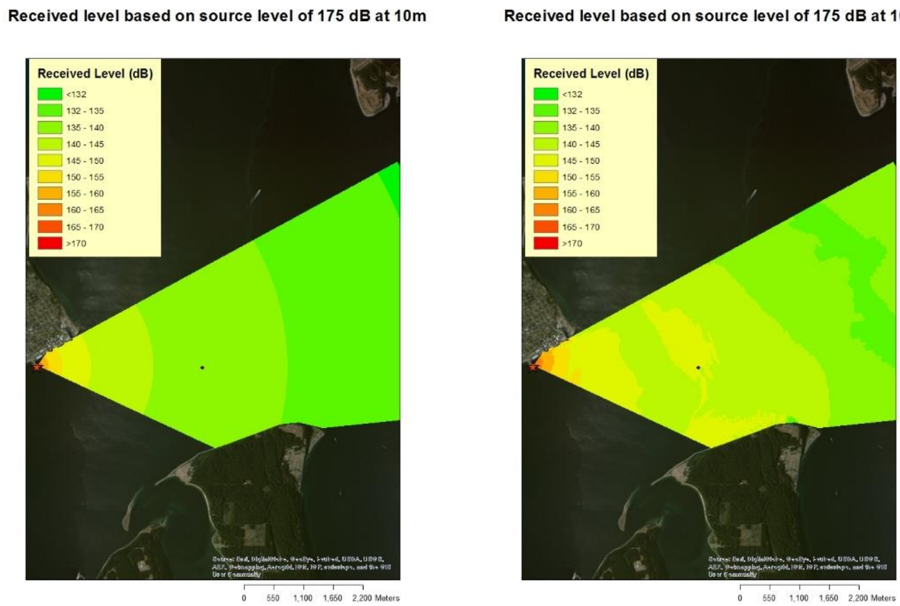


Figure 3 shows a GIS map of the predicted received levels (in dB) according to the practical spreading model (PSM) for the noise source located at the ferry dock. The area of lower TL shown here is influenced by the up sloping bottom.

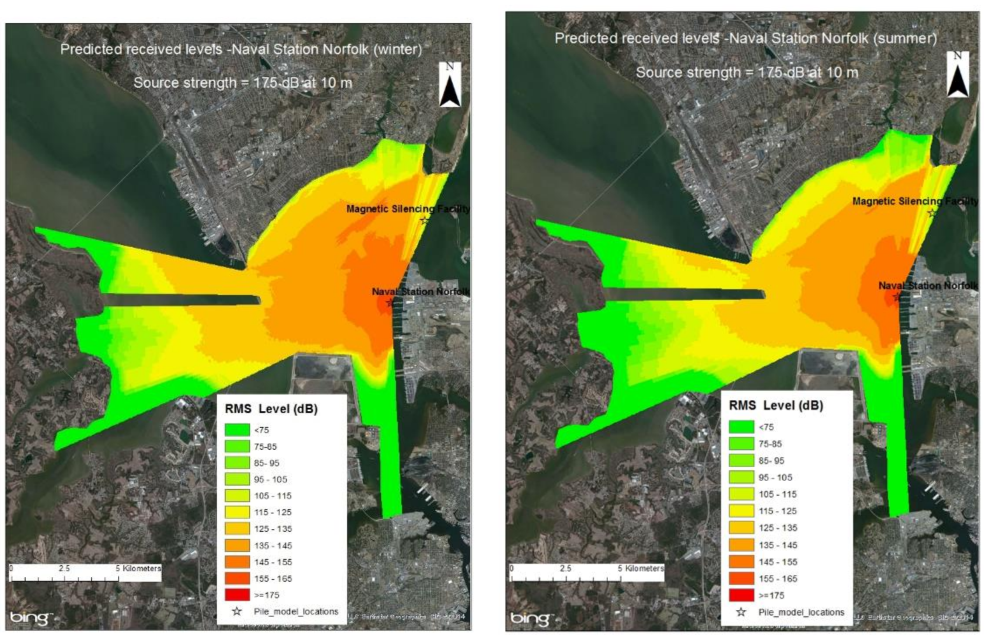


Figure 4. Predicted transmission loss levels at an east coast site for both summer and winter conditions. In summer, the warmer waters mean that transmission loss is higher. The 120 dB isopleth would not be reached with the practical spreading model.