Update Report
Period: 2/1/2012 - 1/31/2013
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:new, field of study:Underwater Acoustics, advisor:Peter Dahl, degree type:PhD, degree date:2014-06-01, 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

Reinhall, P.G., and P.H. Dahl. 2012. On the Mach wave effect in impact pile driving, its observation, and its influence on transmission loss. In the Journal of the Acoustical Society of America: Program Abstracts of the 164th Meeting of the Acoustical Society of America. Volume 132, Issue 3, pp. 2033-2033 (2012); (1 page), public/profession presentation, 1000 attendees, 2022-10-12

Reinhall, P.G., and P.H. Dahl. 2012. Modeling and visualization of the underwater sound field associated with underwater pile driving. In the Journal of the Acoustical Society of America: Program Abstracts of the 164th Meeting of the Acoustical Society of America. Volume 132, Issue 3, pp. 2061-2061 (2012); (1 page), public/profession presentation, 1000 attendees, 2022-10-12

Reinhall, P.G., and P.H. Dahl. 2012. Attenuation of pile driving noise using a double walled sound shield. In the Journal of the Acoustical Society of America: Program Abstracts of the 164th Meeting of the Acoustical Society of America. Volume 132, Issue 3, pp. 2034-2034 (2012); (1 page), public/profession presentation, 1000 attendees, 2012-10-22

:: 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. R/COCC-2	**Actual** (2/1/2012 - 1/31/2013) :	1	1	Anurag Kumar, CIV NAVFAC LANT Mitchell Perdue, CIV NAVFAC SW	2
	Anticipated (2/1/2013 - 1/31/2014) :	1	1		

:: HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

:: ADDITIONAL MEASURES

Safe and sustainable seafood

Number of stakeholders modifying practices
Actual (2/1/2012 - 1/31/2013) :
Anticipated (2/1/2013 - 1/31/2014) :

Number of fishers using new techniques
Actual (2/1/2012 - 1/31/2013) :
Anticipated (2/1/2013 - 1/31/2014) :

Sustainable Coastal Development
Actual (2/1/2012 - 1/31/2013) :
Anticipated (2/1/2013 - 1/31/2014) :

Coastal Ecosystems
Actual (2/1/2012 - 1/31/2013) :
Anticipated (2/1/2013 - 1/31/2014) :

:: PARTNERS

Partner Name: US Department of the Navy (US DOD), type: government, scale: federal

Partner Name: Washington State Department of Transportation

:: IMPACTS AND ACCOMPLISHMENTS

Title: **Washington Sea Grant research delivers a better model for predicting underwater sound**

propagation and protecting marine mammals

Type: accomplishment

Description:
Relevance: Marine construction is increasing on Puget Sound as population grows and aging infrastructure gets replaced, and the noise from underwater pile driving can harm marine life. Federal regulations prohibit the harassment of marine mammals and require that construction stop when these animals cross a regulatory noise threshold called the “zone of influence.” But the “practical spreading model” that agencies use to estimate sound levels and delineate this zone fails on many measures of accuracy. A more accurate and precise model might prevent unnecessary work stoppages, reduce construction delays and monitoring costs, and better protect marine mammals.
Response: Using measurements taken at various distances and depths during recent construction at Port Townsend, WSG-funded researchers have developed a new model that is more consistent with the physics of underwater sound propagation. This model takes into account bathymetry and seabed sediment composition, which can affect sound propagation; its developers are currently working to incorporate sediment maps of Puget Sound.
Results: Researchers have represented the new model in GIS map format so stakeholders can visualize spreading noise. They tested it against the old model at a recent Navy construction project in San Diego, and found that the actual zone of influence often differed from what the practical spreading model predicted.

Recap:
Washington Sea Grant supports development of a more accurate sound-propagation model for determining when to restrict underwater construction to protect marine mammals.

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).

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

:: PUBLICATIONS

Title: **Mitigating Supersonic Underwater Noise Studies of Impact and Vibratory Pile Driving in Marine Environments: Vibratory Pile Driving Experiment in Port Townsend (2013)**

Type: Videos / DVDs Publication Year: 2013
Uploaded File: *none*

URL: http://www.apl.washington.edu/project/project.php?id=supersonic_noise

Abstract:
Applied Physics Lab clip of experiment conducted in Port Townsend in January 2013.

Citation:
Washington Sea Grant. 2013. Mitigating Supersonic Underwater Noise
Studies of Impact and Vibratory Pile Driving in Marine Environments: Vibratory Pile Driving Experiment in Port Townsend. http://www.apl.washington.edu/project/project.php?id=supersonic_noise

Copyright Restrictions + Other Notes:

Journal Title: *none*

:: OTHER DOCUMENTS

No Documents Reported This Period

:: LEVERAGED FUNDS

No Leveraged Funds Reported This Period

:: UPDATE NARRATIVE

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Worldwide, construction is on the rise to meet the demands of a rising population and ageing infrastructure. Even with this mandate, however, regulators are mindful of the ever present need to balance the costs of construction with environmental impact. Pile driving for marine construction (e.g. bridge expansions, ferry expansions etc.) is a prime example of a construction activity with potential to do harm to marine life if improperly managed. In the Puget Sound area (as elsewhere) several projects of this type exist. For such activities with potential for significant impact on marine mammals, Washington State governmental agencies are required to adhere to stipulations outlined in the Incidental Harassment Authorization that they receive from National Marine Fisheries Services (NMFS). These guidelines require monitoring in an area that falls within a zone of influence where underwater sound levels are above the 120 dB received level threshold that NMFS has set. Sound levels exceeding 120 dB are significant with some action required, such as reducing construction activity or temporarily halting construction.

In order 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:

$$\text{Transmission Loss (dB)} = 15 * \log10 (R/R_o), \qquad [1]$$

where transmission loss (also called propagation loss) is a quantity describing the reduction of sound level in decibels (dB), R_o equals the reference range at which reference measurements were made (typically 10 m), and R equals the range to which acoustic transmission loss is estimated. For example, if R = 1000 m, then the PSM would predict a 30 dB reduction in the sound level compared to that which was measured at range 10 m.

The use of this model can result in a zone of influence that may extend to thousands of kilometers. Figure 1 gives an example of one such monitoring zone from activities carried out by Washington State Ferries in 2010. It is clear that the monitoring zone is of a significant size, resulting in concomitant demands on personnel and the project's budget.

In January 2013 a PhD student funded under this Sea Grant participated in a field exercise at the Port Townsend ferry site with a goal of obtaining additional data to augment data collected in 2010 (Stockham, Dahl, and Reinhall, 2010) . The deployed equipment included two remote sensing underwater hydrophones (acquired and field tested in 2012) at nominal distances of 200m and 400m in conjunction with a vertical line array of hydrophones (spanning a depth of 6.5m) at a distance 17m from the vibratory pile driving exercise.

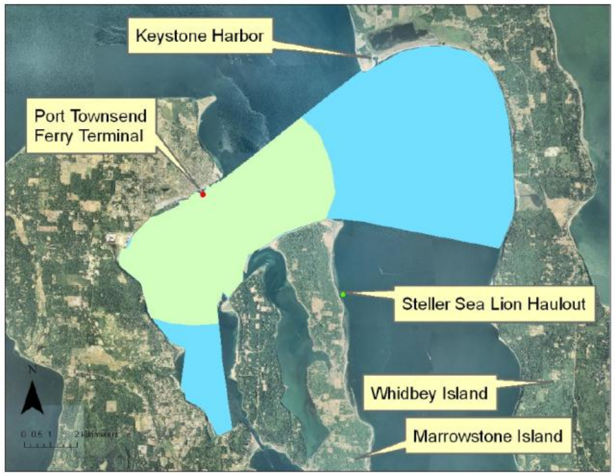

Figure 1 The zone (green and blue shaded areas) originating from the Washington State Ferry dock Keystone, where monitoring is necessary to obtain permit from NMFS for marine construction. May 2010 plan. Figure courtesy of Rick Huey, Washington State Ferries.

Figure 2 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. A peak sound level of 178 dB was recorded 10 m from the source. Practical spreading predicts 159 dB and 154 dB at 200 and 400 m respectively however measured values fall off much more steeply than would be indicated by a 15logr relationship. Additionally the error between measured and PSM predicted values increases with increasing distance. Since the received level is being overestimated by the PSM, this overestimates the size of the monitoring area, extending to a maximum of roughly 75 km for the source in this instance or (as is the current practice) until rays from the source encounter a land mass-a maximum distance of roughly 12 km from the source in this case. This is compared to a distance of around 1km if the trend of the two measured data points at 200 and 400 m is applied.

In order to develop a model (ideally easily translatable to GIS format for better utility to stakeholders) that better estimates transmission loss in shallow water with application to pile driving, work in 2013 will focus on investigation of this new data set in conjunction with the 2010 data set, utilizing new tools that would facilitate the inclusion of shear and varying sediment types.

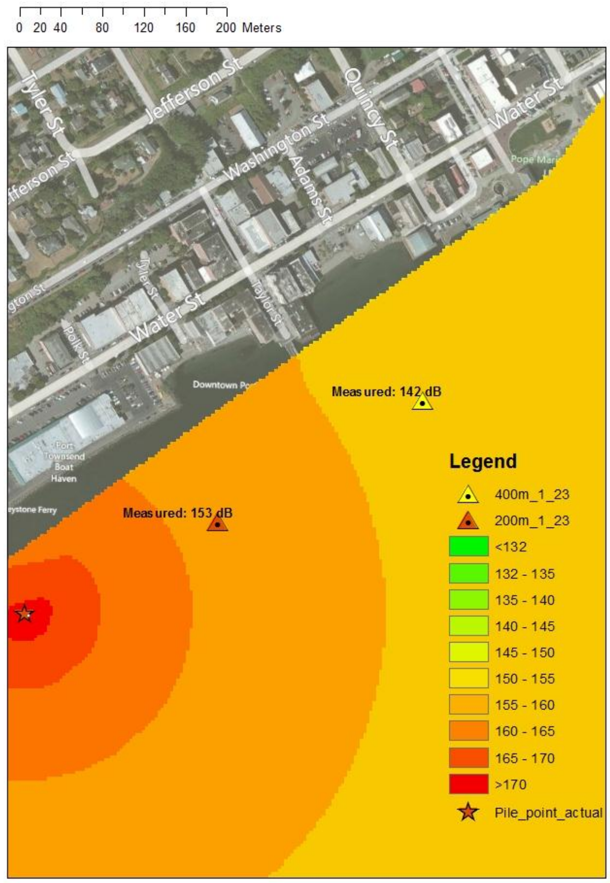

Figure 2. Practical spreading model prediction of sound pressure level at the Port Townsend site associated with vibratory pile driving source located at the Port Townsend ferry dock; received level at 10 m was 178dB.

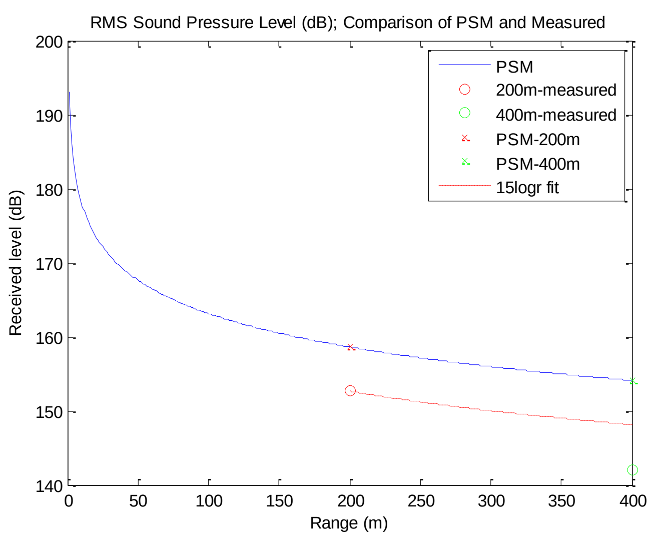

Figure 3. Comparison of measured and predicted values from practical spreading model of sound pressure level associated with vibratory pile driving at Port Townsend ferry dock; received level at 10 m was 178dB.