2.3.2.701 – Improvements to Hydrodynamic and Acoustic Models for Environmental Prediction

Jesse Roberts- Sandia National Laboratories

drober@sandia.gov;
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**Project Overview**

### Project Summary
- The project leverages SNL-enhanced open-source numerical models to investigate the interaction of marine energy devices with the surrounding environment.
- Tools to characterize and visualize the affected wave fields, current patterns, and hydroacoustic soundscapes modified by ME devices have been developed.
- Application of these tools can better inform stakeholders, regulators, and developers how to optimize power production and coastal resiliency while minimizing unwanted environmental effects.

### Intended Outcomes
- Tools developed by the project can be leveraged to produce quantitative and comparable metrics on the potential for marine energy device related environmental changes.
- The goal is to provide not only the tools but the methods for appropriate application that meet industry standards and promote effective communication among key parties.
- The highest-level outcome is intended to reduce permitting and regulatory costs.

### Project Information
- **Principal Investigator(s)**
  - Jesse Roberts
- **Project Partners/Subs**
  - Sandia National Laboratories
  - Integral Consulting
  - Montana State University
  - H.T. Harvey and Associates
  - Baylor University

### Project Status
- Ongoing

### Project Duration
- 2019
- 2021

### Total Costed (FY19–FY21)
- $2,184K

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**Draft Template for review and feedback**
Project Objectives: Relevance

**Foundational R&D**
- Develop numerical and experimental tools and methodologies to understand fluid-structure interactions.
- Improve ME resource assessments and characterizations to optimize devices and arrays and understand extreme conditions.

**Reducing Barriers to Testing**
- Mitigate environmental risks and reduce costs and complexity of environmental monitoring.
- Engage in relevant coastal planning processes for equitable consideration of marine energy.

**Outcomes**
- Use of improved resource assessments and characterization to effectively design and deploy devices.
- Increased inclusion of marine energy in both coastal and energy resource planning processes.
- Reduced environmental risks for marine ecosystems and biodiversity from the deployment of large-scale renewable energy systems.

**DRAFT TEMPLATE FOR REVIEW AND FEEDBACK**
Project Objectives: Approach

Integrating disparate Marine Energy environmental data using a coherent framework (SEAT) provides innovative support for mitigating environmental risk and optimizing ME array design.

**TASKS**
1. Design SEAT
2. Develop Functionality
3. Apply to Case Studies
4. Outreach and Engagement

**DRAFT TEMPLATE FOR REVIEW AND FEEDBACK**
### Project Objectives: Expected Outputs and Intended Outcomes

#### Outputs:
- Improvements to SNL-Delft3D-CEC-FM, SNL-SWAN and Paracousti
  - Models optimized for support of environmental assessment and ME site characterization
- The Spatial Environmental Assessment Tool (SEAT)
  - Quantitative risk metrics for environmental assessment
  - Spatial mapping linked with array modeling tools to support planning for risk mitigation and array performance optimization.
  - Facilitates collaboration and communication

#### Outcomes:
- Tools provide **quantitative metrics to evaluate risk** to the environment due to different array shapes, devices, and locations.
- Application of tools that can **improve project planning and communication and reduce uncertainty in project risks**
**Project Timeline**

**FY 2019**
- SNL-SWAN and WAMIT validation
- SNL-Delft3D-CEC-FM development and application
- ParAcousti model development for WECs
- In-person demonstrations of model use cases

**FY 2020**
- SEAT interface development
- Case Study development for WEC and CEC sites
- ParAcousti soundscape characterization and application
- Outreach and training and industry feedback

**FY 2021**
- ParAcousti Development and demonstrations
- SEAT interface refinement and case study development
- Outreach and training and industry feedback
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<th>FY19</th>
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### End User Engagement and Dissemination

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<th><strong>Outreach</strong></th>
<th><strong>Dissemination</strong></th>
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<tbody>
<tr>
<td>• Technology Developers</td>
<td>• In-person workshops and demonstrations</td>
<td>• Conference Presentations</td>
</tr>
<tr>
<td>• Environmental Scientists</td>
<td>• Developer Feedback</td>
<td>• Peer Reviewed Publications</td>
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<td>• Regulators</td>
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<td>• Publicly available models and tutorials via GITHUB</td>
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<tr>
<td>• Other Researchers</td>
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Performance: Accomplishments and Progress

• Development of CEC module for the open source DFlow-FM for approval by Deltares and integration into publicly maintained version of Delft3D code

• Refinement of Paracousti sound field modeling for WEC array characterization and Case Study at PacWave South

• Developing Spatial Environmental Assessment Tool interface in QGIS for evaluating ME array's environmental risk potential.

• Presented findings at the Offshore Technology Conference and held model demonstrations for potential end-users.

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Spatial Environmental Assessment Tool

Site Characterization

Device Parameters

Array Layouts comparison

SNL-SWAN
SNL-Delft3D-FM-CEC
Paracousti

Metocean Conditions

Thresholds

Site Specific Receptors

Spatial Risk vs Power Evaluation

SEAT Results

**DRAFT TEMPLATE FOR REVIEW AND FEEDBACK**
**Stressor Layer**
- Spatial Map of Modeled forces
- Represents range of conditions (24)
- Difference between conditions present and absent
- Condition weighted by probability
- Map is sum of weighted results

**Receptor Layer**
- Map of Site-specific feature of interest
- Condition weighted by probability
- Map is sum of weighted results

**Risk Layer**
- SEAT integrates model (CEC, WEC, or acoustic) and receptor information
- Generates spatial estimate of risk

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**PacWave South WEC Array-Case Study**

**Risk Layer**
- SEAT integrates model (CEC, WEC, or acoustic) and receptor information
- Generates spatial estimate of risk
Pacwave South Case Study

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<th>Description</th>
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<tbody>
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<td>0.9 0.9 0</td>
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<tr>
<td>-1 to 0</td>
<td>Increased Deposition</td>
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<td>Decreased Deposition</td>
<td>1.2 1.5 1.1</td>
</tr>
<tr>
<td>1</td>
<td>Increased Mobility</td>
<td>0 0 0</td>
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**DRAFT TEMPLATE FOR REVIEW AND FEEDBACK**
Pacwave South-Case Study

4x4 diameter Spacing

8x4 diameter Spacing

16x6 diameter Spacing

**DRAFT TEMPLATE FOR REVIEW AND FEEDBACK**
3D Sound Propagation
Noise approximated from
- 15 kW point absorbers
- 118–131 dB (re 1 μPa)

Risk Metrics
- Sound Pressure Levels (SPL) – total and octave bands
- Signal to Noise (SNR) – above ambient levels
- Sensation Level (SnL) – perception by specific marine species
Tanana River- Current Energy Converter Case Study

- Use of SNL-Delft3D-FM-CEC (unstructured grid)
- Demonstrated tool’s capability to simulate range of flows and array configurations

**DRAFT TEMPLATE FOR REVIEW AND FEEDBACK**
Future work

• Disseminate a beta version of SEAT and Guidance/Use Documentation that highlights comparison of environmental risk with potential power outputs
• Develop additional risk metrics that meet regulatory standards
• Provide online training materials
• Conduct end-user feedback and outreach

https://ecoquants.shinyapps.io/nrel-uses/
Q&A