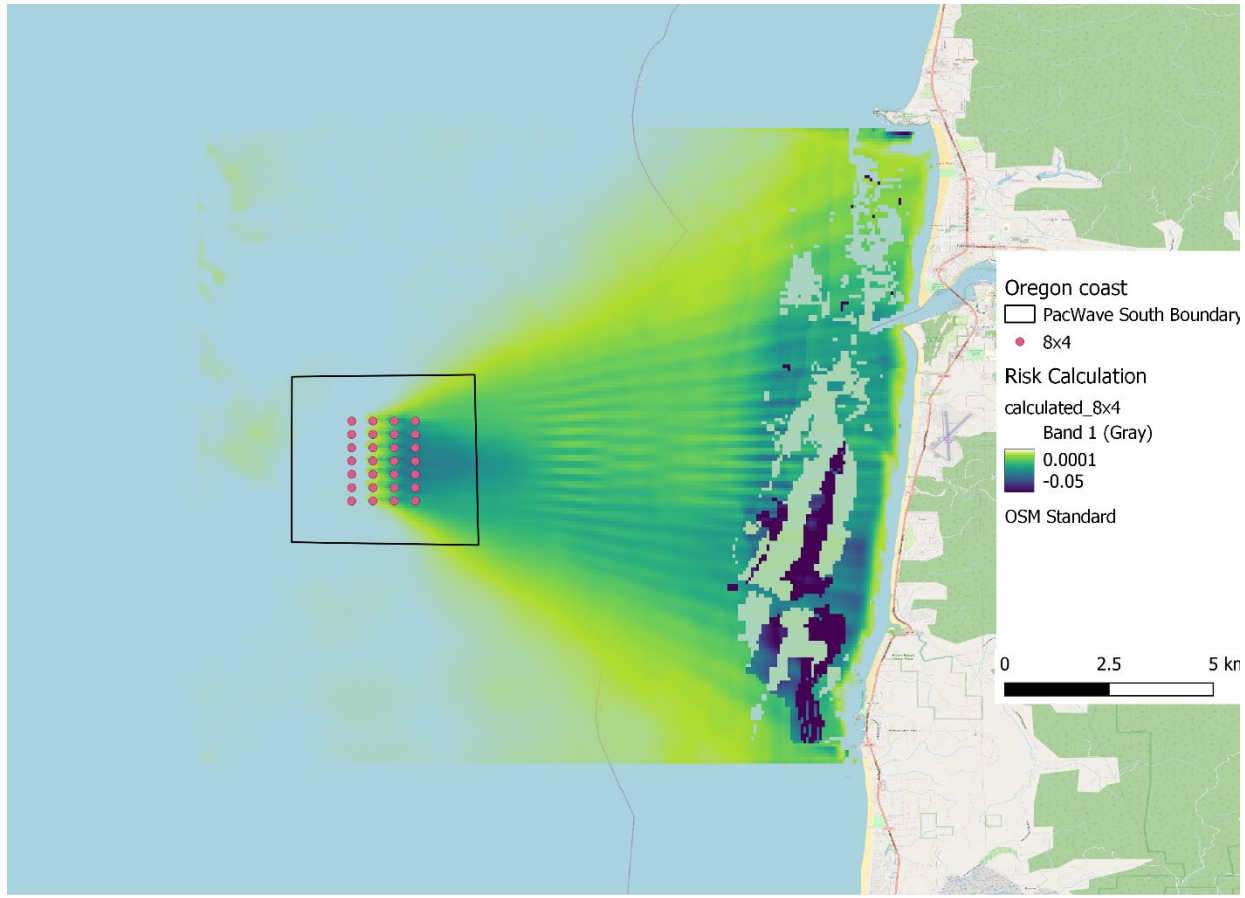
2.3.2.701 – Improvements to Hydrodynamic and Acoustic Models for Environmental Prediction



Jesse Roberts- Sandia National Laboratories

jdrober@sandia.gov;

July 20, 2022

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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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**

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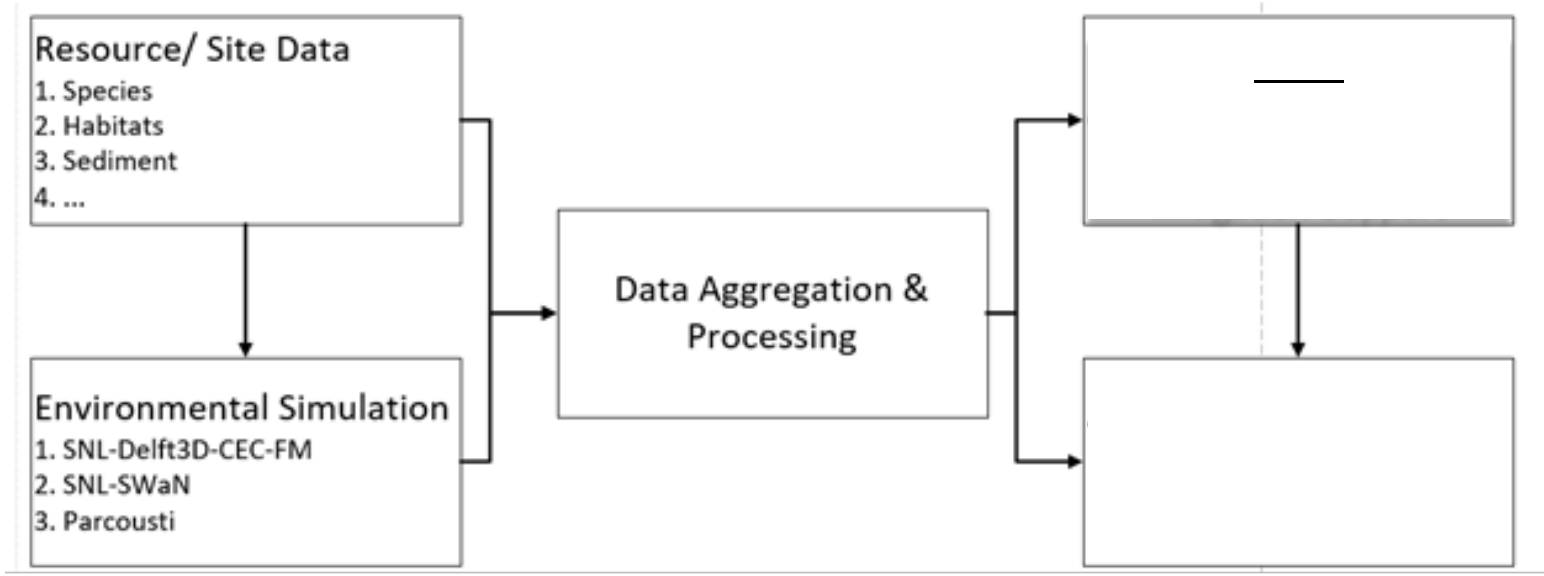
Project Objectives: Approach

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



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Project Objectives: Expected Outputs and Intended Outcomes

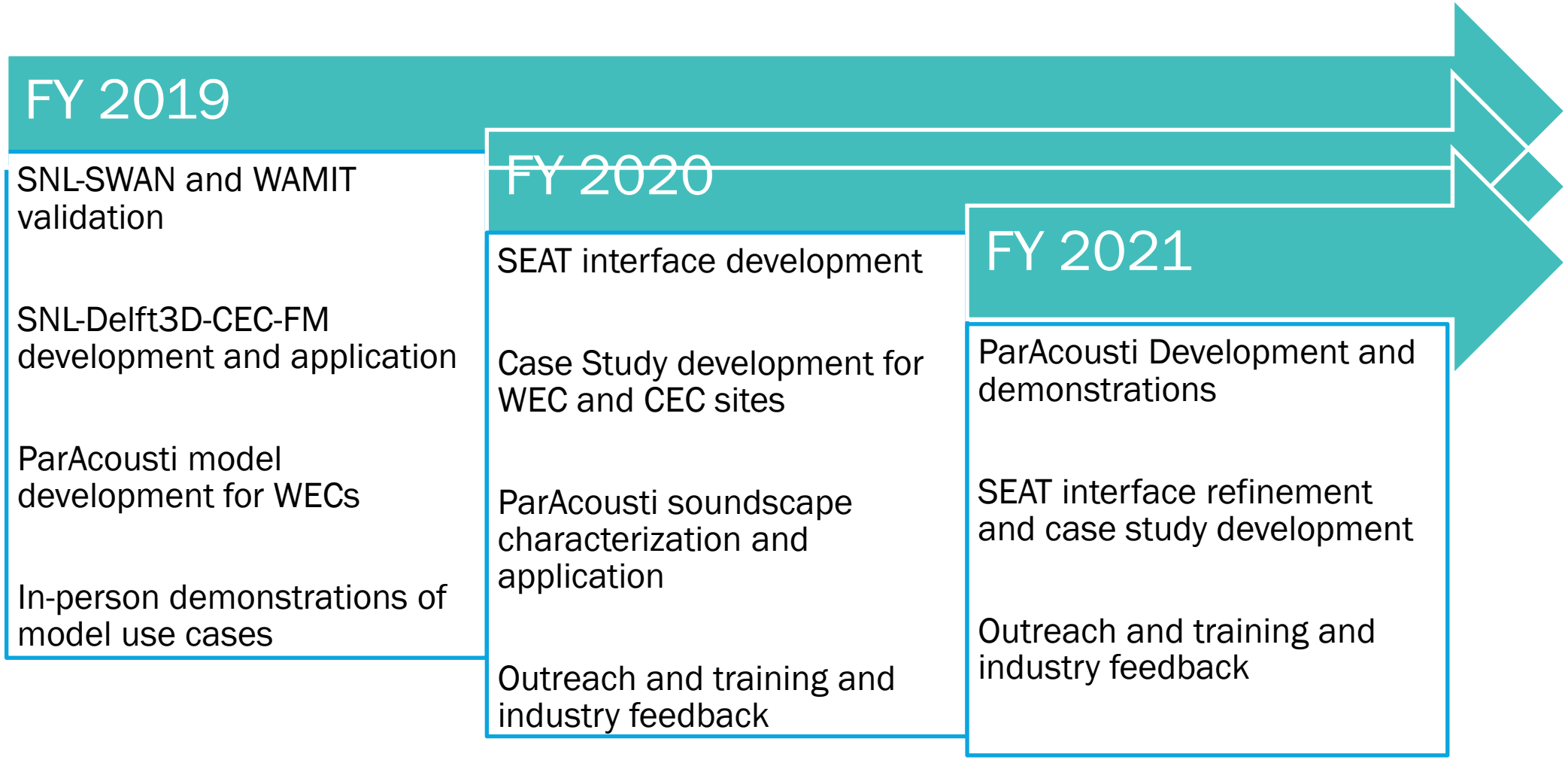
Outputs:

- **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



Project Budget

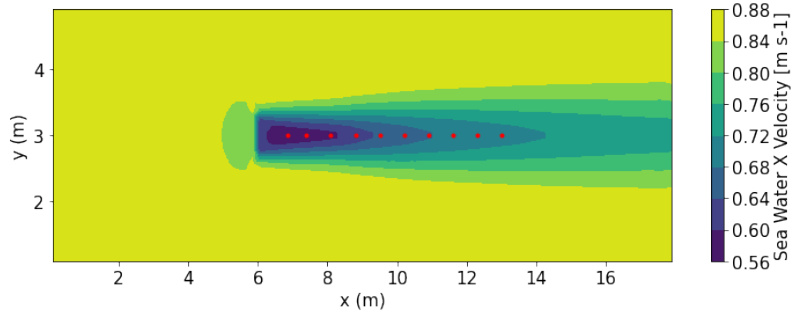
FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$580K	$854K	$751K	$2,184K

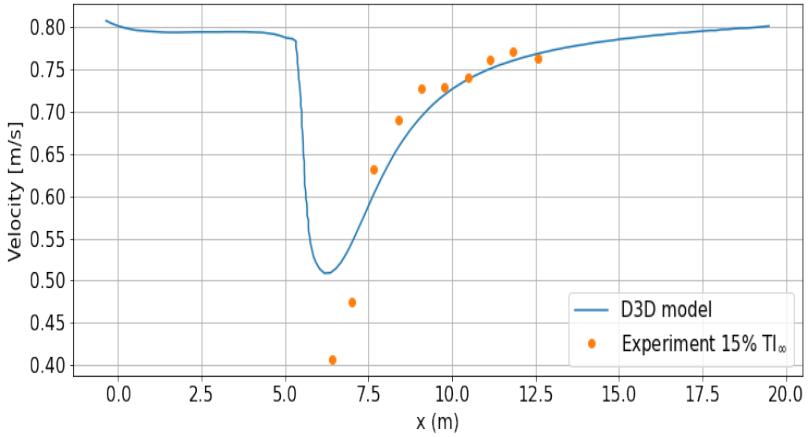
End User Engagement and Dissemination

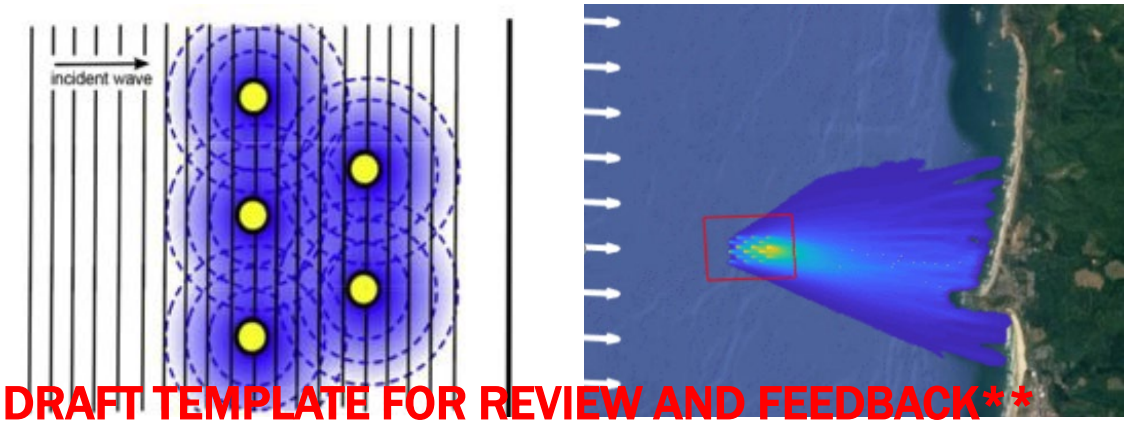
End Users	Outreach	Dissemination
• Technology Developers • Environmental Scientists • Regulators • Other Researchers	• In-person workshops and demonstrations • Developer Feedback	• Conference Presentations • Peer Reviewed Publications • Publicly available models and tutorials via GITHUB

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

Metocean Conditions

SNL-SWAN

SNL-Delft3D-FM-CEC

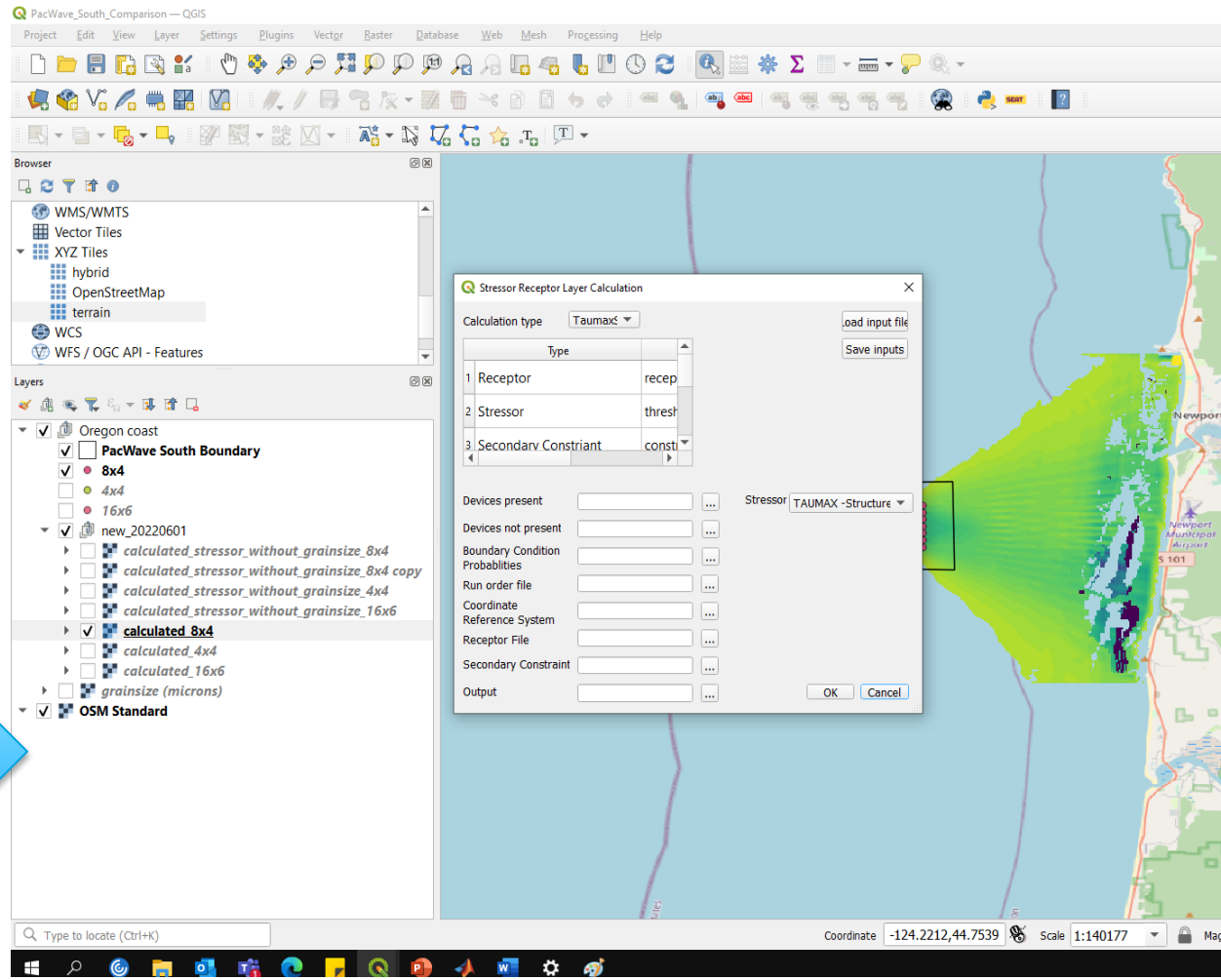
Paracousti

Thresholds

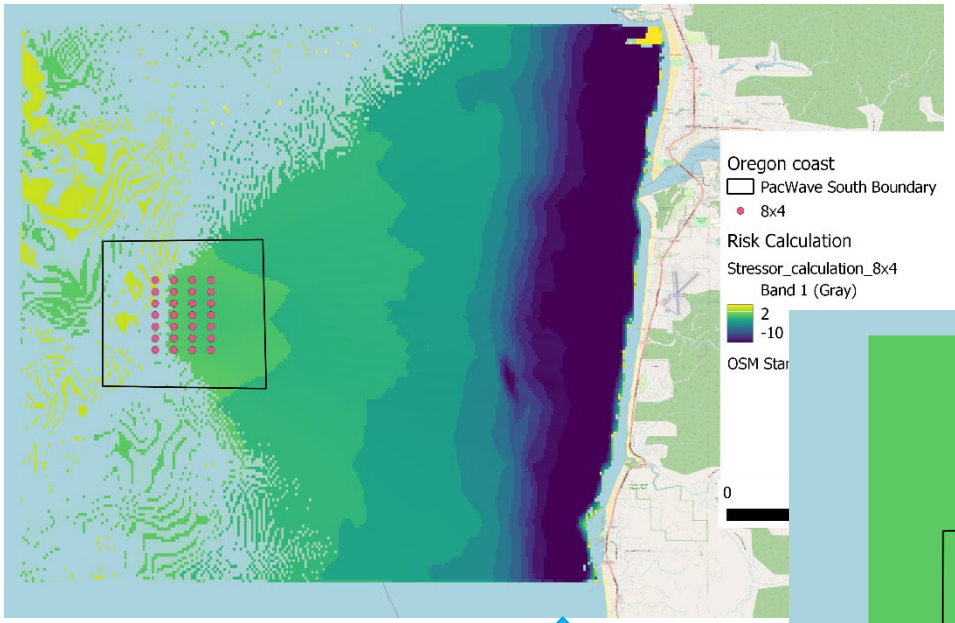
Site Specific Receptors

Spatial Risk vs Power Evaluation

SEAT Results

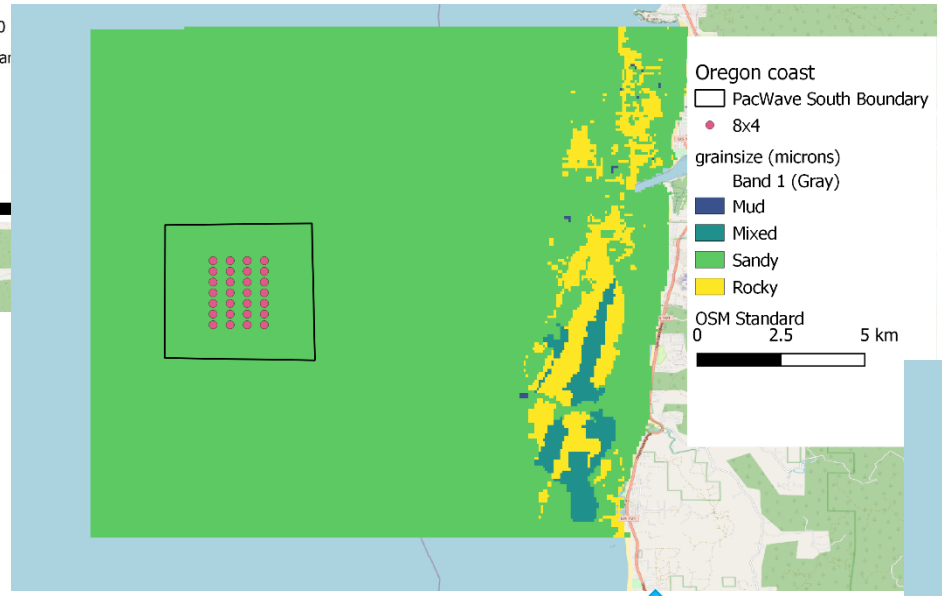


PacWave South WEC Array-Case Study



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

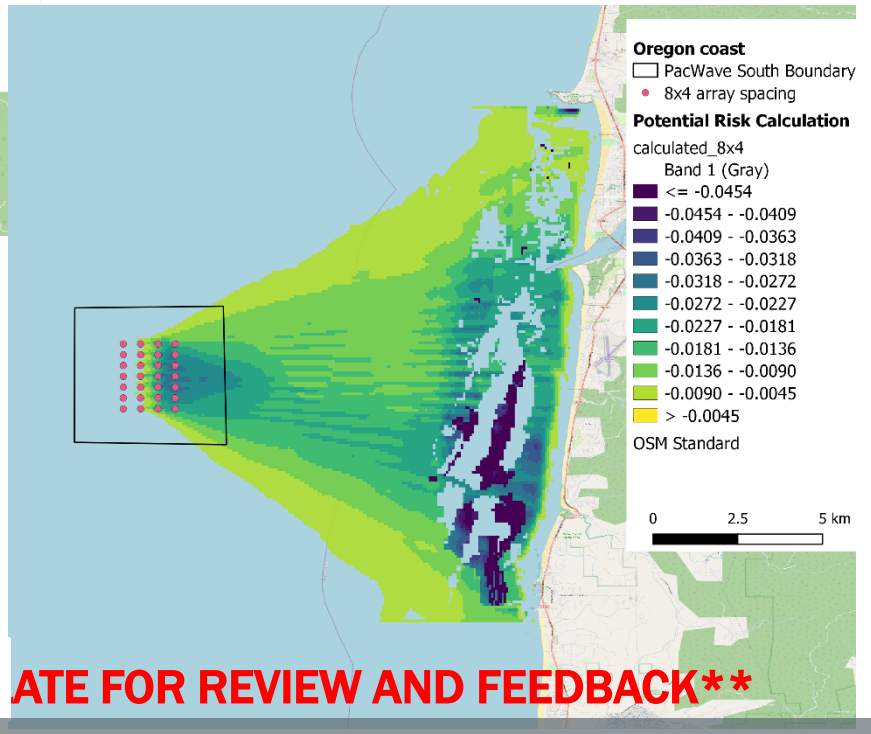
- Map of Site-specific feature of interest

Receptors could include

- Benthic habitat/bed type (seen here)
- Larval distribution potential
- Marine mammal density

Risk Layer

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



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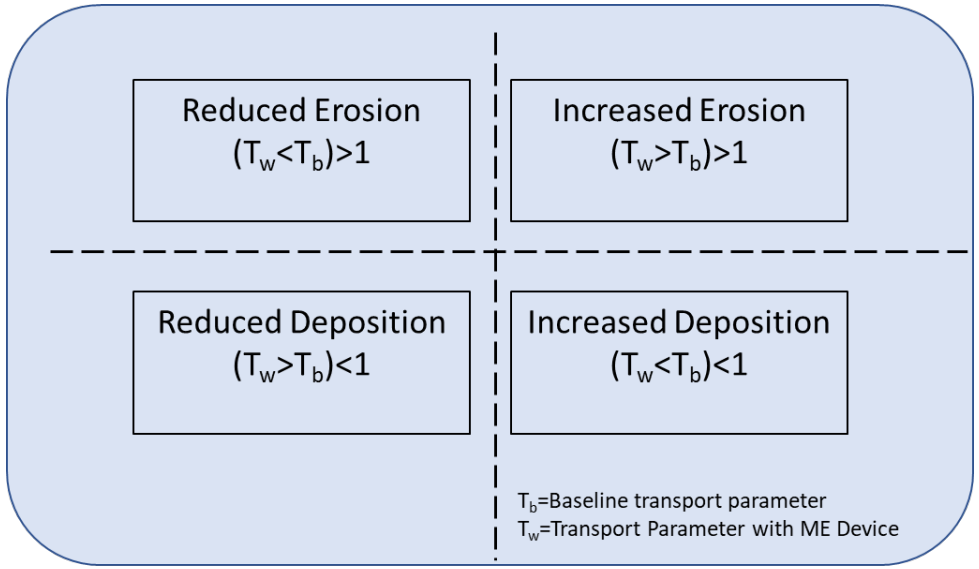
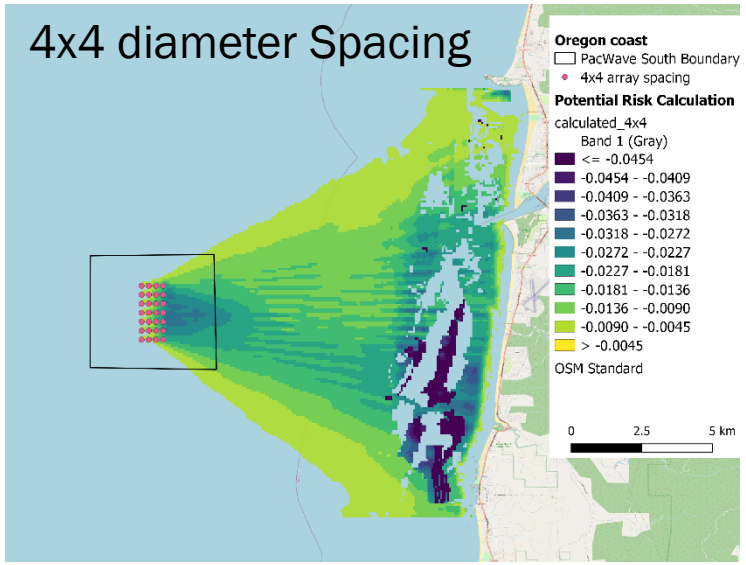
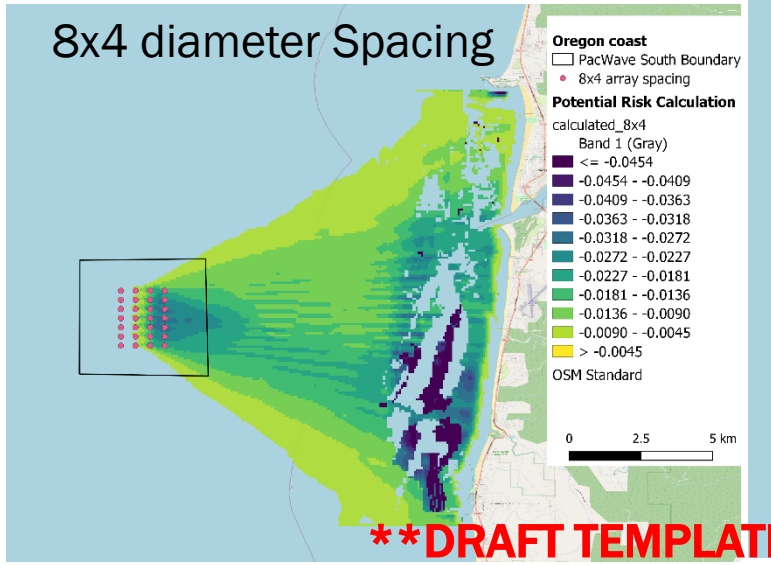
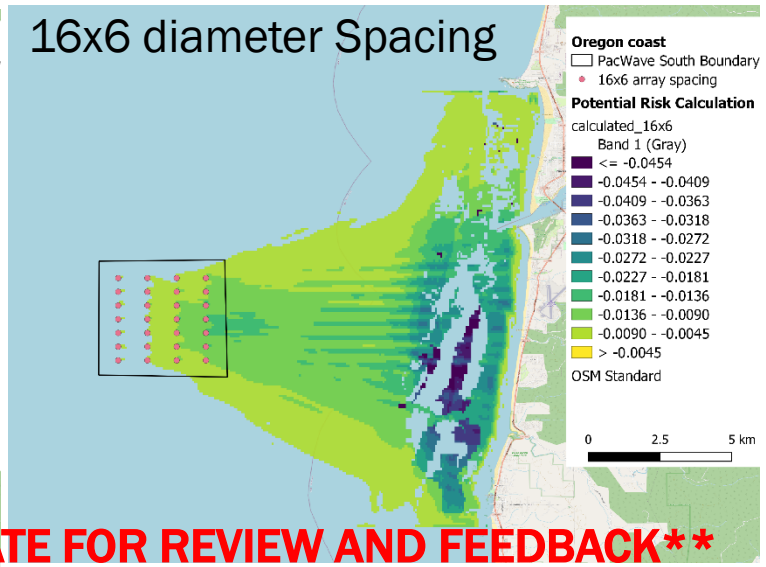
Pacwave South-Case Study



Risk Value	Description	% Coverage		
		4x4	8x4	16x6
<-1	Decreased Mobility	0.9	0.9	0
-1 to 0	Increased Deposition	54.5	52.6	60.1
0	No Change	43.4	45	38.8
0-1	Decreased Deposition	1.2	1.5	1.1
1	Increased Mobility	0	0	0







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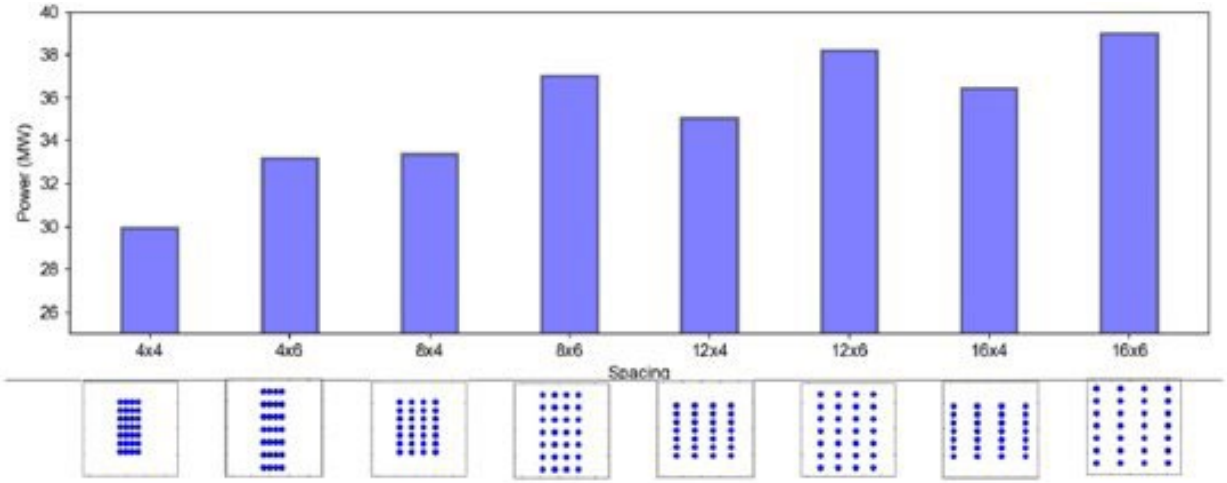
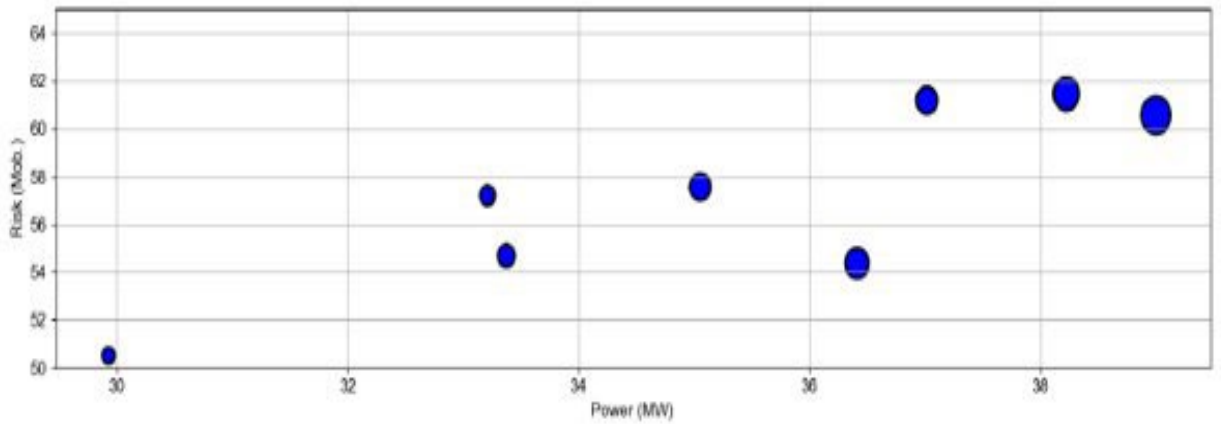
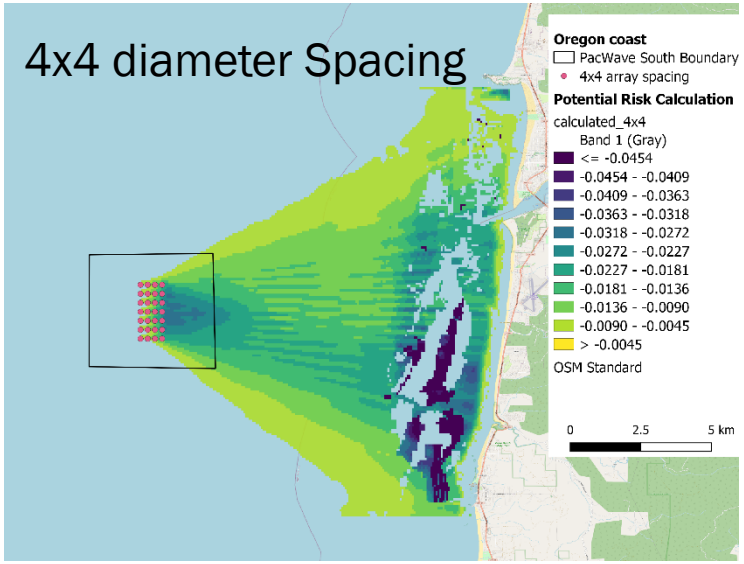
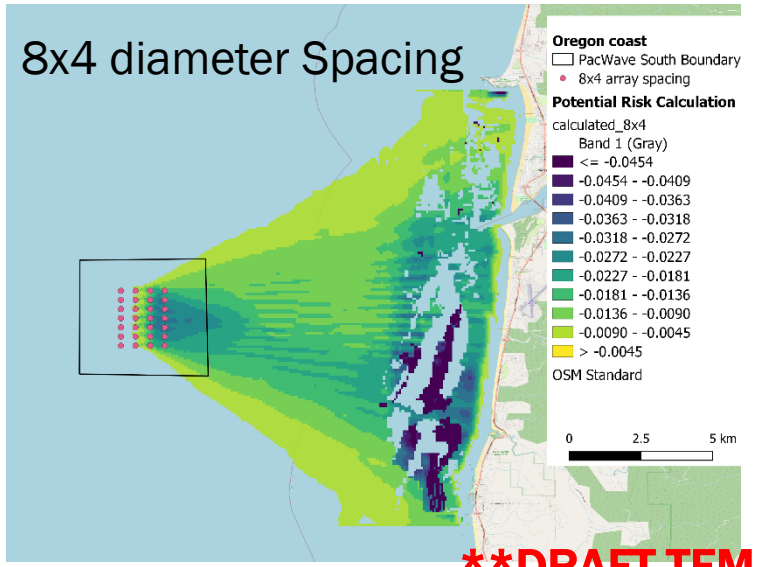
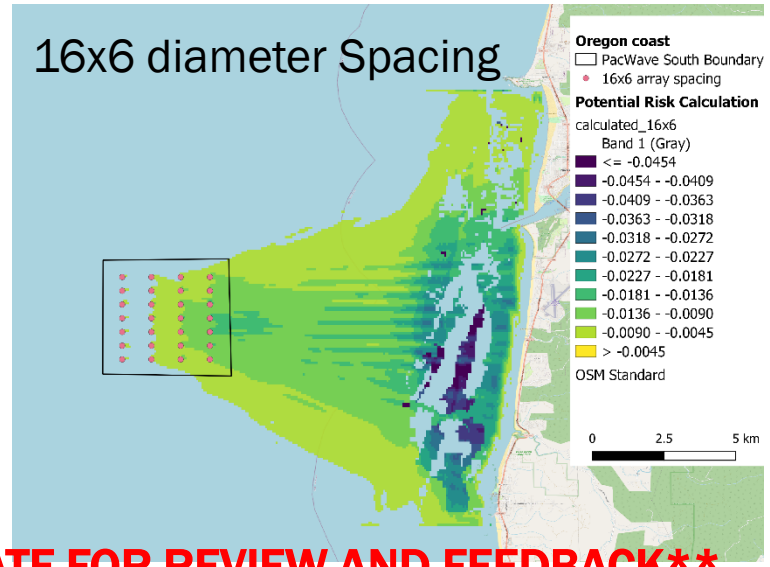
Pacwave South-Case Study











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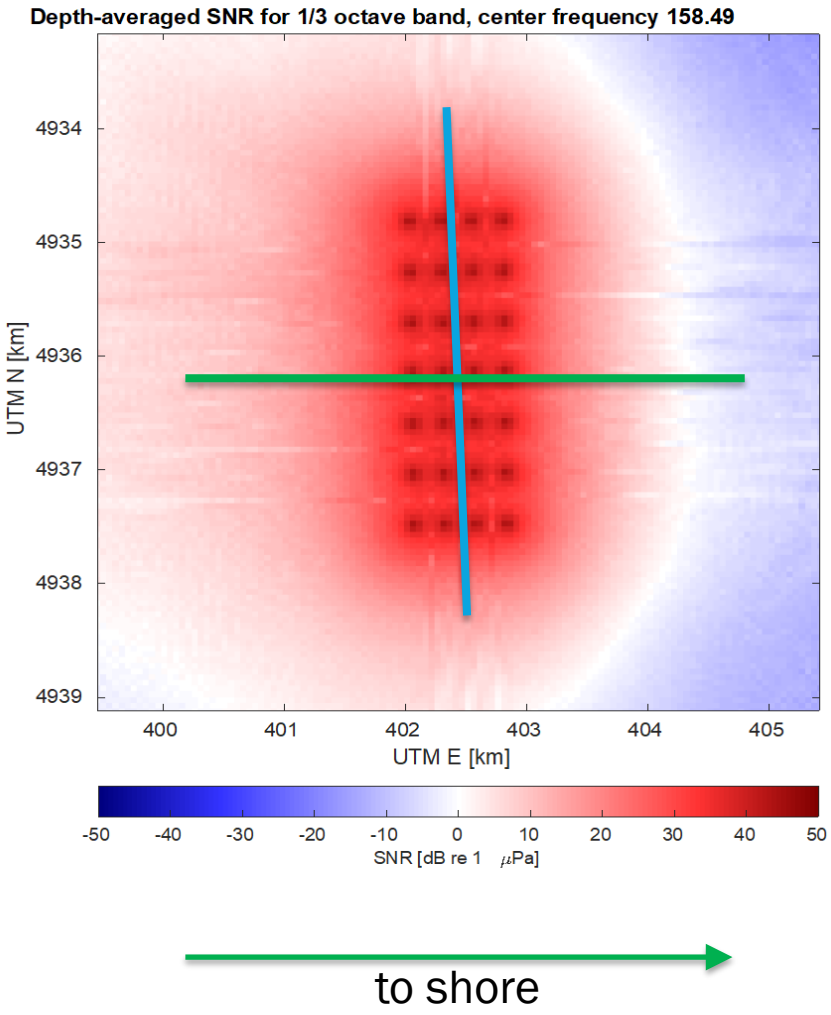
PacWave South Case Study: Acoustic Results



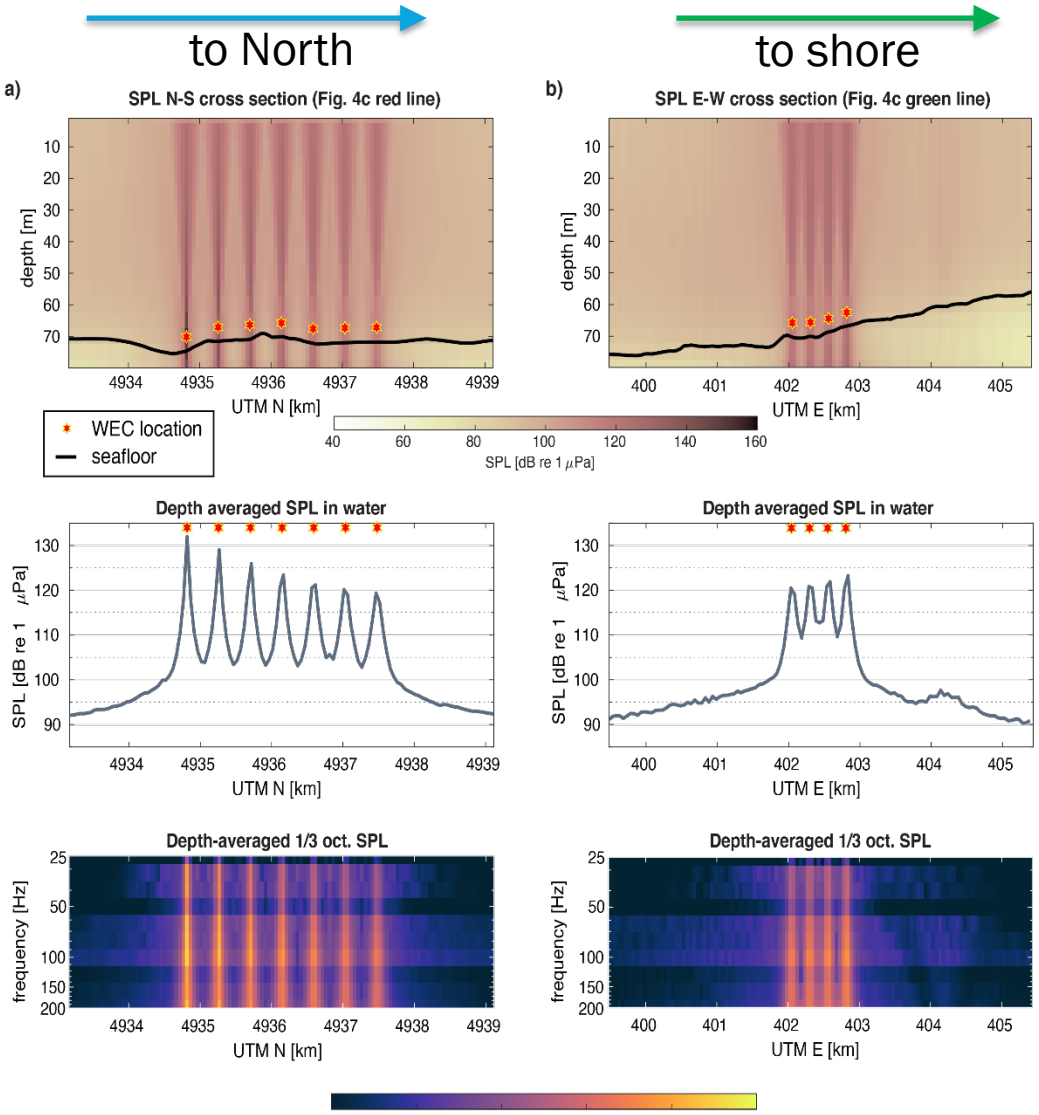
3D Sound Propagation

Noise approximated from

- 15 kW point absorbers
- 118–131 dB (re 1 μPa)

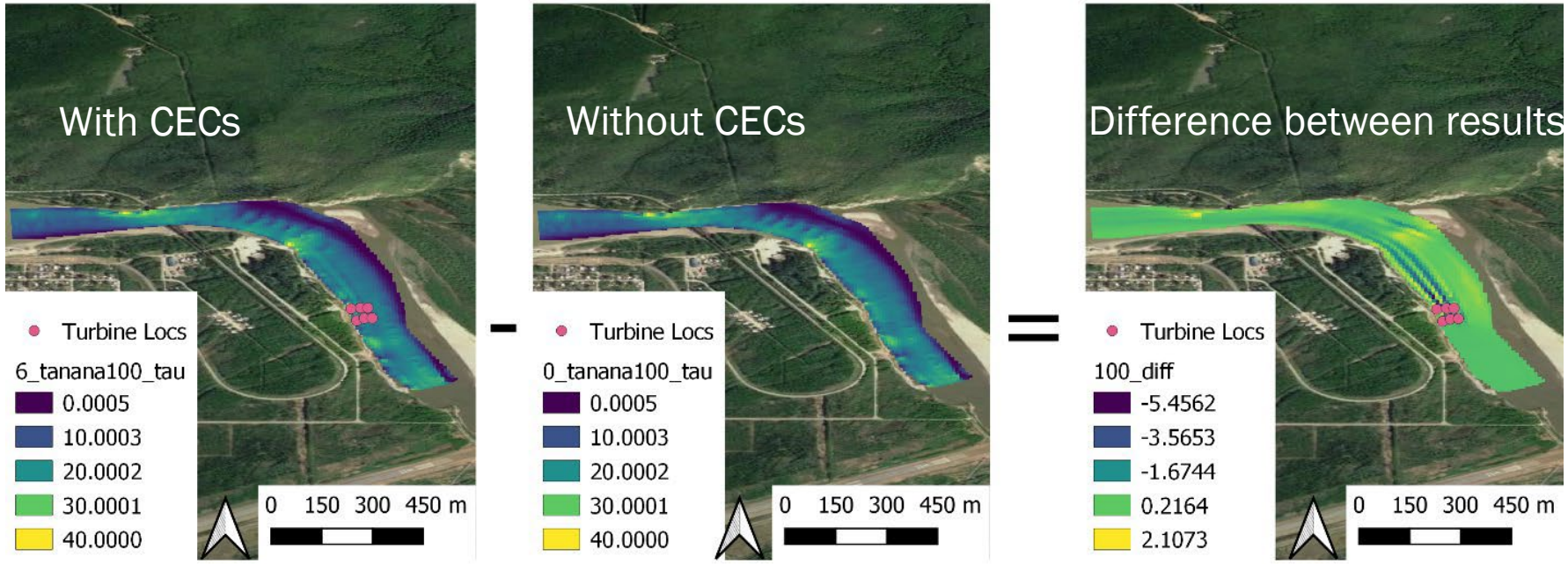
Risk Metrics

- Sound Pressure Levels (**SPL**) – total and octave bands
- Signal to Noise (**SNR**) – above ambient levels
- Sensation Level (**SnL**) – perception by specific marine species



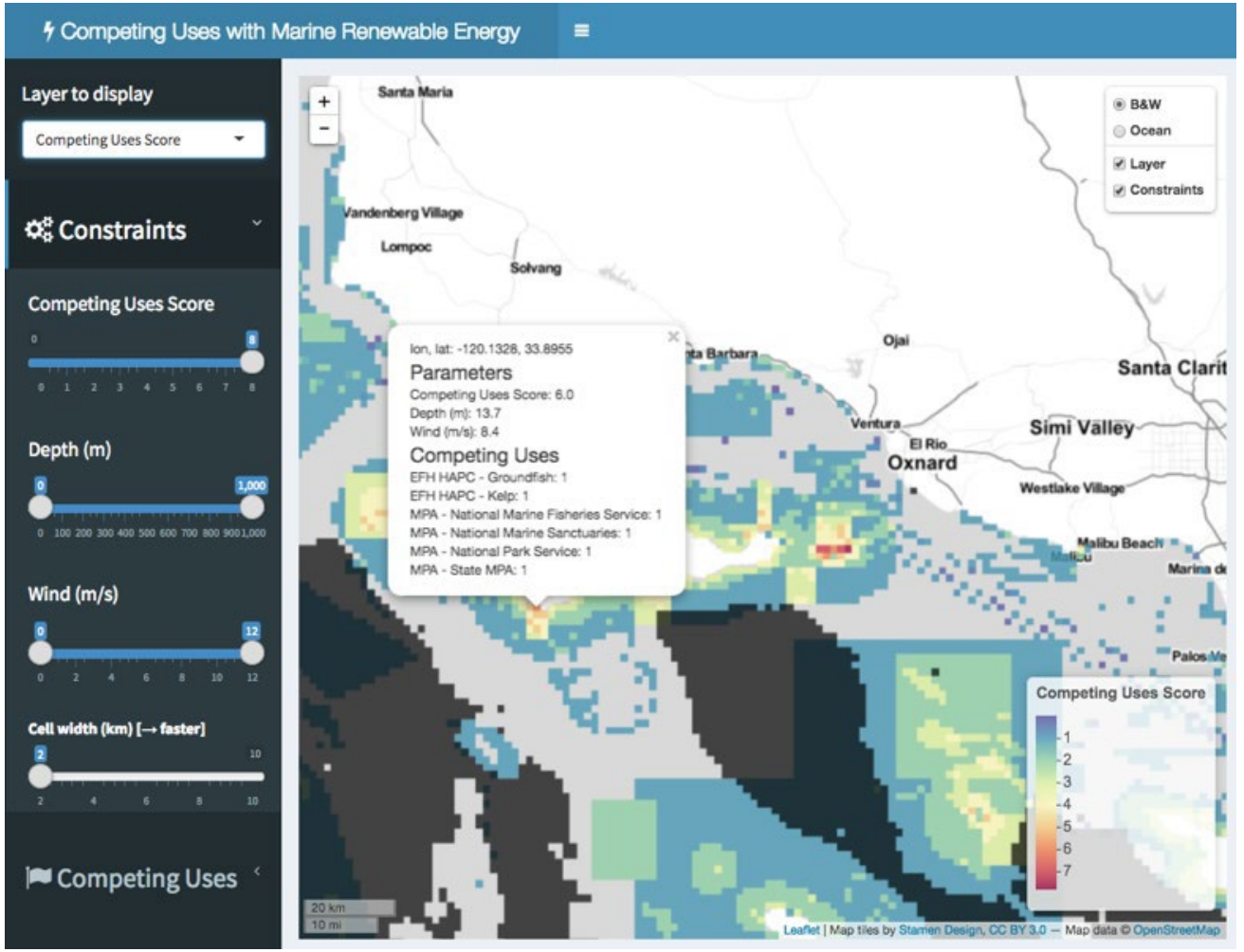
Tanana River- Current Energy Converter Case Study

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



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