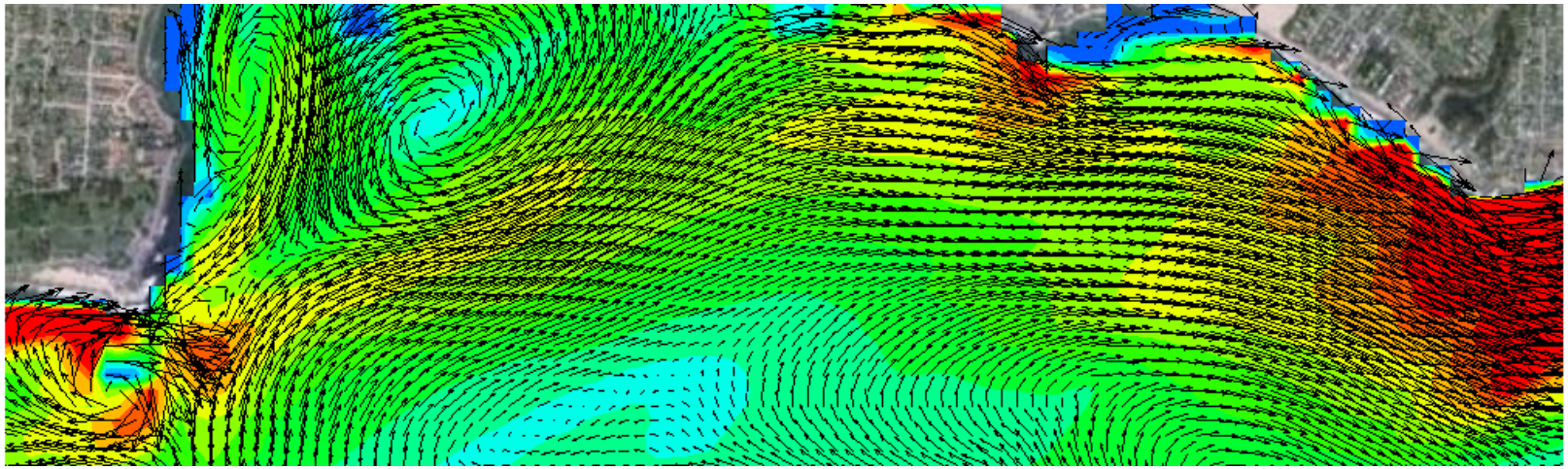


Hydrodynamic and Acoustic Models for Quantitative Environmental Assessment

WBS 2.3.2.701

Marine and Hydrokinetics Program

October 8th, 2019

Jesse Roberts

Sandia National Laboratories

Project Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Project Summary

- Fulfill an industry need for methodologies and open-source software tools that quantify, a priori, the effects of MHK-device interactions and MHK-generated noise in marine environments
- The state-of-the-art modeling tools support accurate characterization, screening, and mitigation of environmental risk while providing for cost-optimized MHK project planning that maintains environmental compliance.
- Quantifying and minimizing uncertainty in regulatory processes increases investor confidence and decreases project risks, thereby improving commercialization outlooks.

Project Objective & Impact

- Develop tools to support screening and/or mitigating environmental risks associated with MHK induced changes to the physical and acoustic environment to reduce costs and time associated with environmental compliance and enable responsible MHK energy development through good stewardship.
- Help developers meet challenging site- and technology- specific environmental assessment needs identified as key reasons projects did not move forward.

Project Information

Project Principal Investigator(s)

Jesse Roberts

WPTO Lead

Simon Gore

Project Partners/Subs

Integral Consulting
Montana State University, Baylor University
H. T. Harvey and Associates
Mott McDonald
Mocean Energy

Project Duration

- FY13
- FY21

Alignment with the Program

Marine and Hydrokinetics (MHK) Program Strategic Approaches

Data Sharing and Analysis

- Foundational and Crosscutting R&D
- Technology-Specific Design and Validation
- Reducing Barriers to Testing

Alignment with the MHK Program

Foundational and Crosscutting R&D

- Improve MHK resource assessments and characterizations needed to optimize devices and arrays, and understand extreme conditions

The hydrodynamic models used here to assess environmental change are the same tools used for characterizing site resource. By combining the two, the models can analyze and inform optimal array designs that maximize power production while minimizing environmental risk.

Alignment with the MHK Program

Reducing Barriers to Testing

- Work with agencies and other groups to ensure that existing data is well-utilized and identify potential improvements to regulatory processes and requirements
- Support additional scientific research as needed, focused on retiring or mitigating environmental risks and reducing costs and complexity of environmental monitoring

The research assesses changes to the physical and acoustic environments incurred by operation of wave energy converter (WEC) and current energy converter (CEC) arrays, including potential stressors to the ecosystem. This foundational work builds the confidence and evidence for quantifying, screening, and mitigating environmental risks while transparently communicating results to improve the regulatory process.

Project Budget

FY17	FY18	FY19 (Q1 & Q2 Only)	Total Project Budget FY17–FY19 Q1 & Q2 (October 2016 – March 2019)	
Costed	Costed	Costed	Total Costed	Total Authorized
$944K	$701K	*$244K	$1,889K	$2,321K

*Costed amount in FY19 (Q1 and Q2) does not include subcontract partner costs due to delays in subcontractor invoicing.

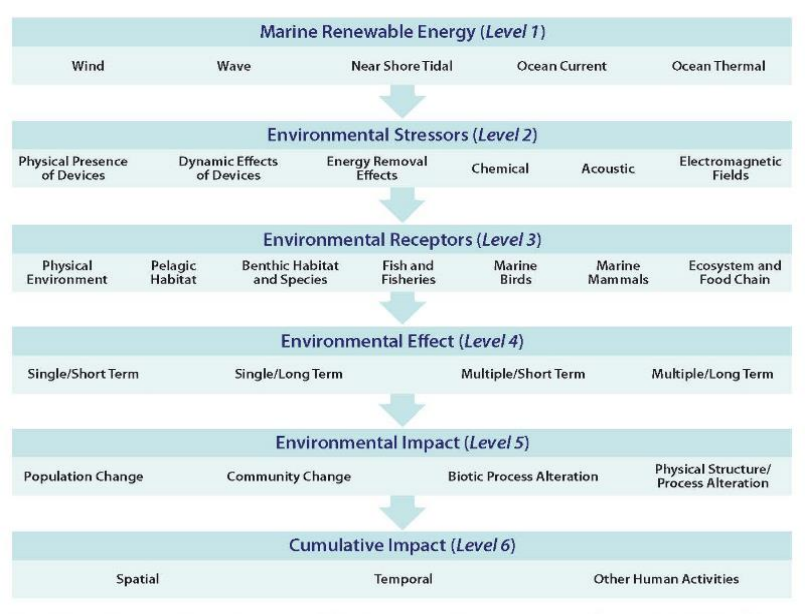
- Actual costs, including subcontractor efforts, is approximately $450K.

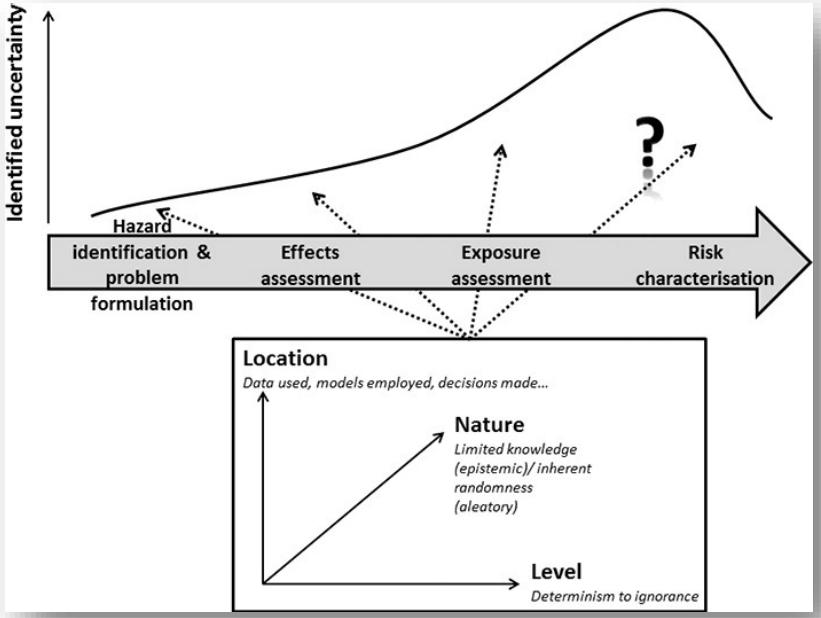
Project Value

FOUNDATIONAL and CROSSCUTTING

Environmental Risk

Characterization and communication of risk can provide **substantial barriers** to site deployment





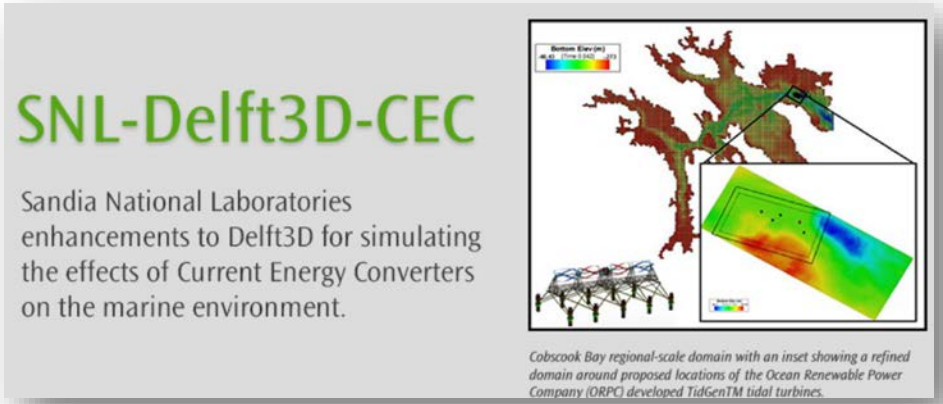
Framework for Assessment

A robust framework populated with state-of-the-science tools allows for enhanced characterization and communication.

End-User Engagement and Dissemination Strategy

Key thrust

"MHK-friendly" numerical modeling tools capable of assessing potential changes to the physical and acoustic environment caused by operation of MHK arrays

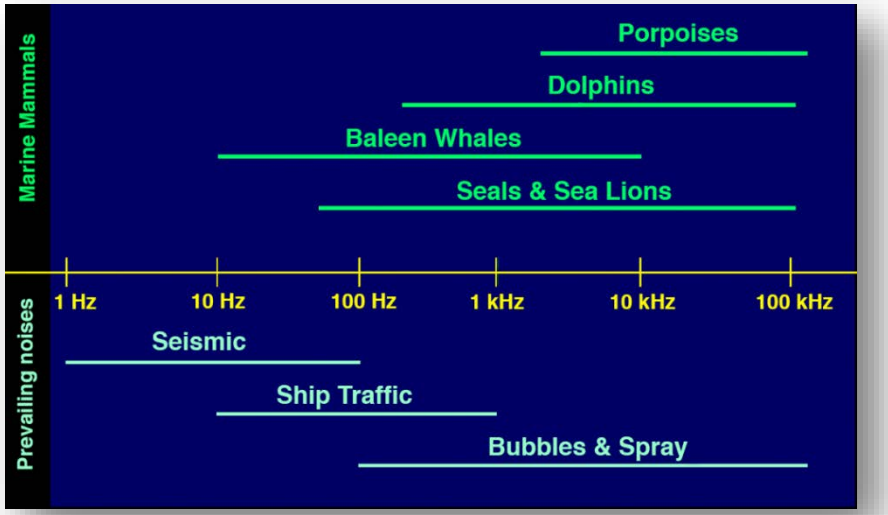


Industry benefits

Urgent need to reduce costs and time associated with meeting regulatory requirements

Regulator Benefits

Build mutual confidence in the tools, methods, and overall findings, helping set a course toward improved licensing and permitting for all MHK projects



Management and Technical Approach

Major Tasks for Research

- Development and outreach with Spatial Environmental Assessment Tool (SEAT)
- Changes to wave propagation, ocean circulation, and sediment dynamics due to the operation of WEC arrays,
- Modifications to near- and far-field hydrodynamics, sediment dynamics, and water quality from CEC arrays, and
- The noise generated and propagated by multiple MHK device archetypes (CECs and WECs).

EXAMPLE SMART Milestones

Task 1 – WEC Array Model Improvements

Publish results from expanded numerical modeling comparison of WEC arrays using WEC module in SWAN and WAMIT. Publish full integration of SNL-SWAN, SNL-Delft3D, and SEAT models and the evaluation of environmental stressor-receptor relationships.

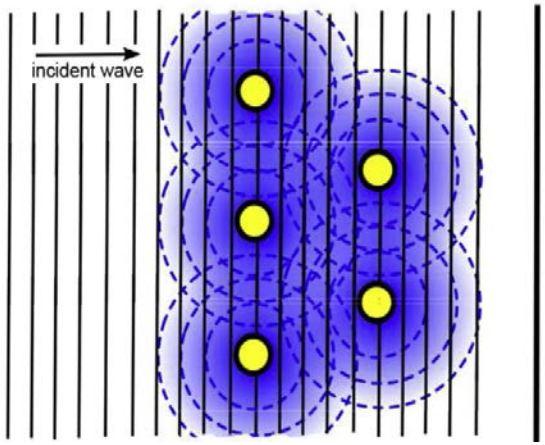
Task 2– CEC Array Model Improvements

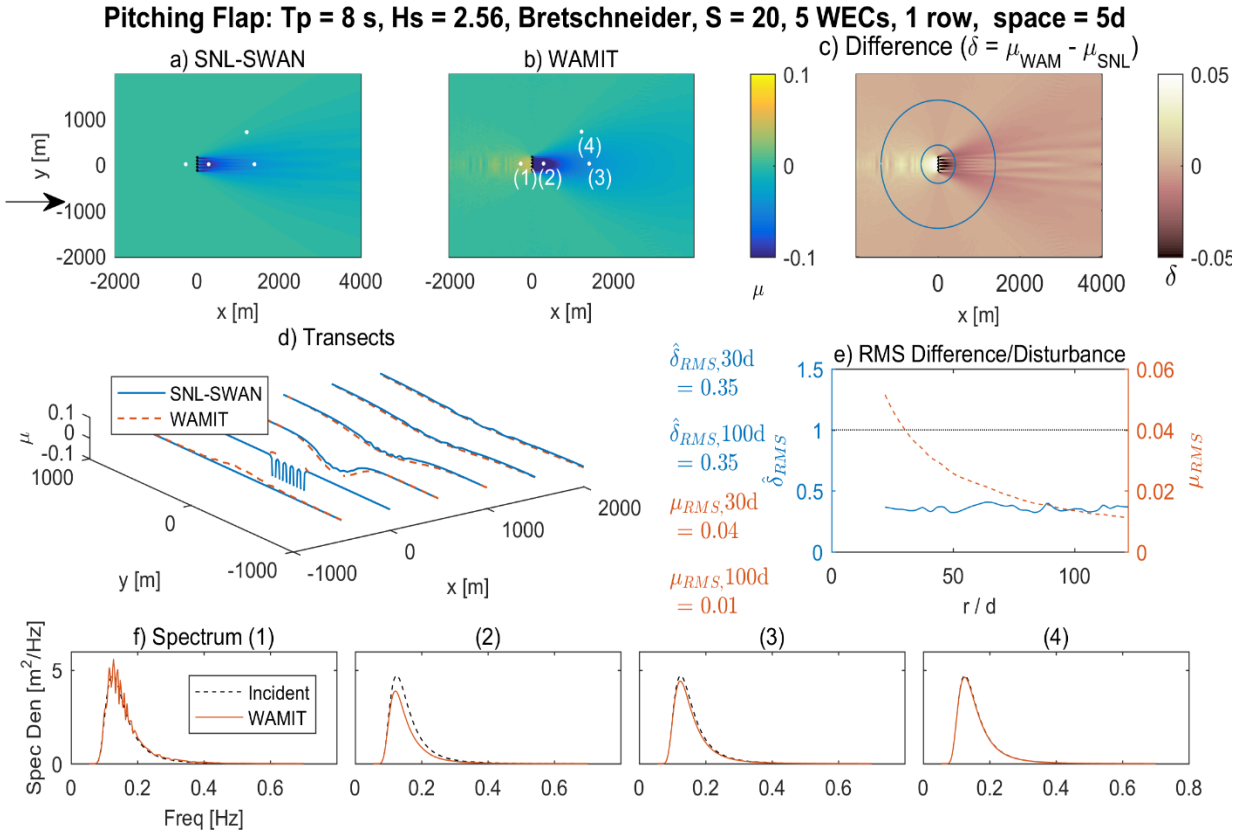
SNL-Delft3D-FM turbulence results show good agreement (within 25%) to the model implemented in the structured Delft3D. Illustrate that SNL-Delft3D-FM results can be incorporated into an effective SEAT application.

Task 3– Acoustic Generation and Propagation Model Improvements

Completion of validation cases, course materials, and publication of those materials. Summary of user feedback and recommendations on training material and model development.

WEC Model Development

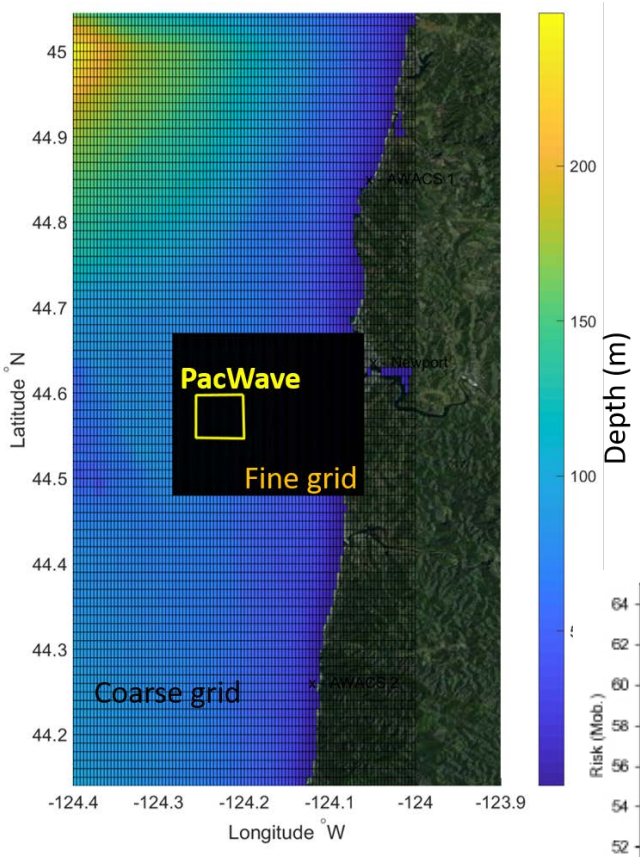


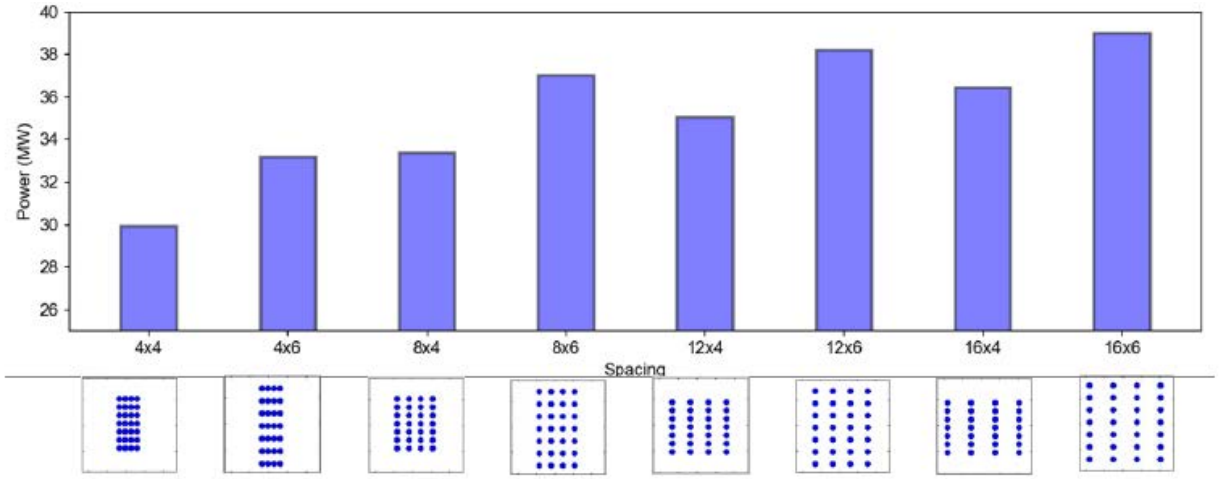


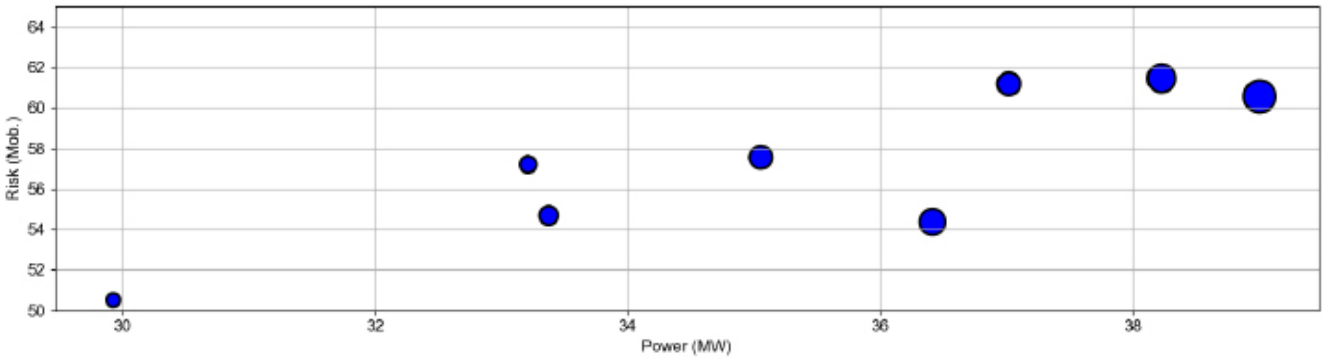
Model Development

The modeling team has conducted rigorous validation and characterization of the trade offs between near and far field modeling. This foundational work provides a better real-world understanding and confidence in how WECs are simulated in the marine environment.

Technical Accomplishments
WEC Model Developments







Real-World Cases

Example sites have been developed and validated for testing and demonstration of tool capabilities. These quantitative tools enable the balancing of power production and risk.

Technical Accomplishments
CEC Model Developments

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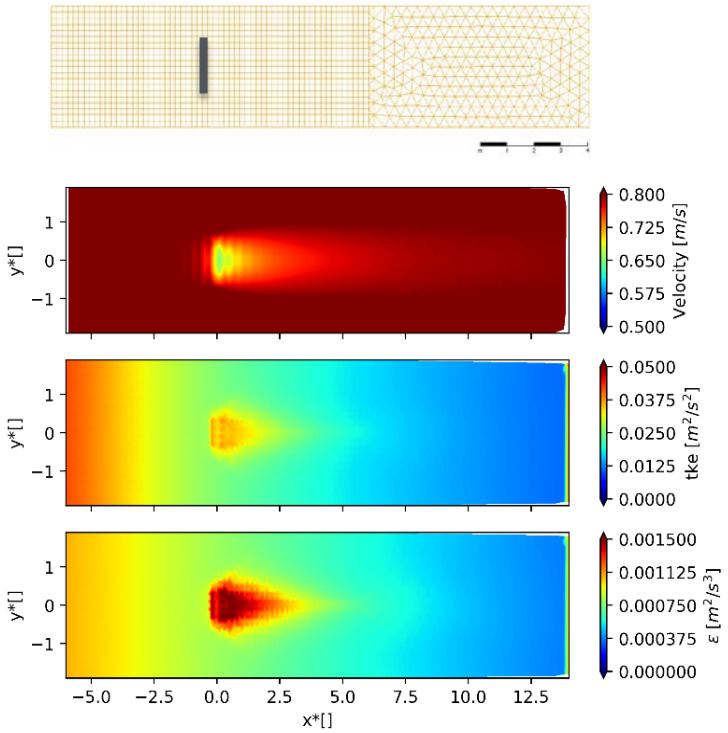
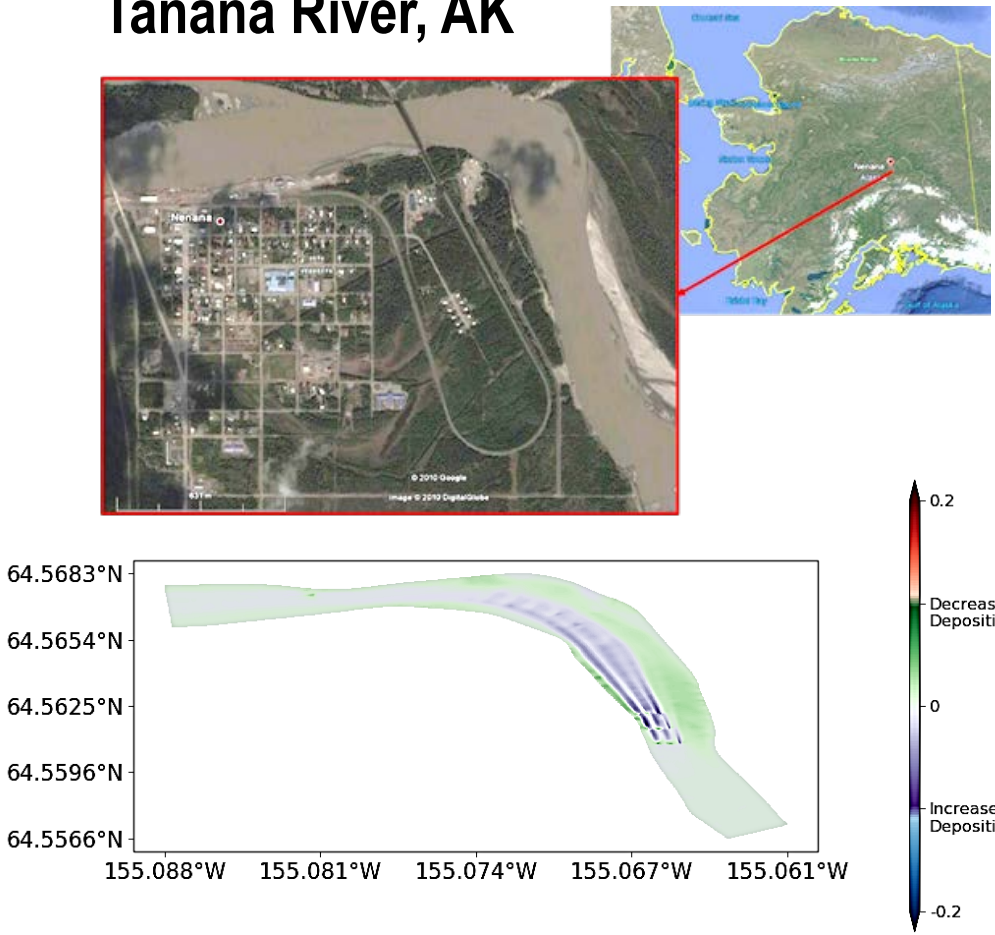
Validation Cases



Tanana River, AK



Validations of industry standard open source CEC modules provides industry and regulatory confidence. Further, using state-of-the-art flexible mesh modeling tools provides this level of modeling to all user bases.

Technical Accomplishments
Spatial Environmental Assessment

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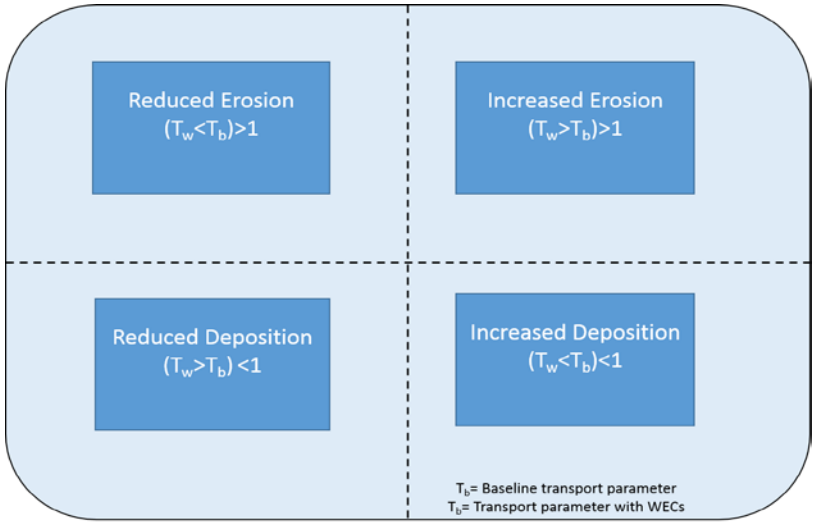
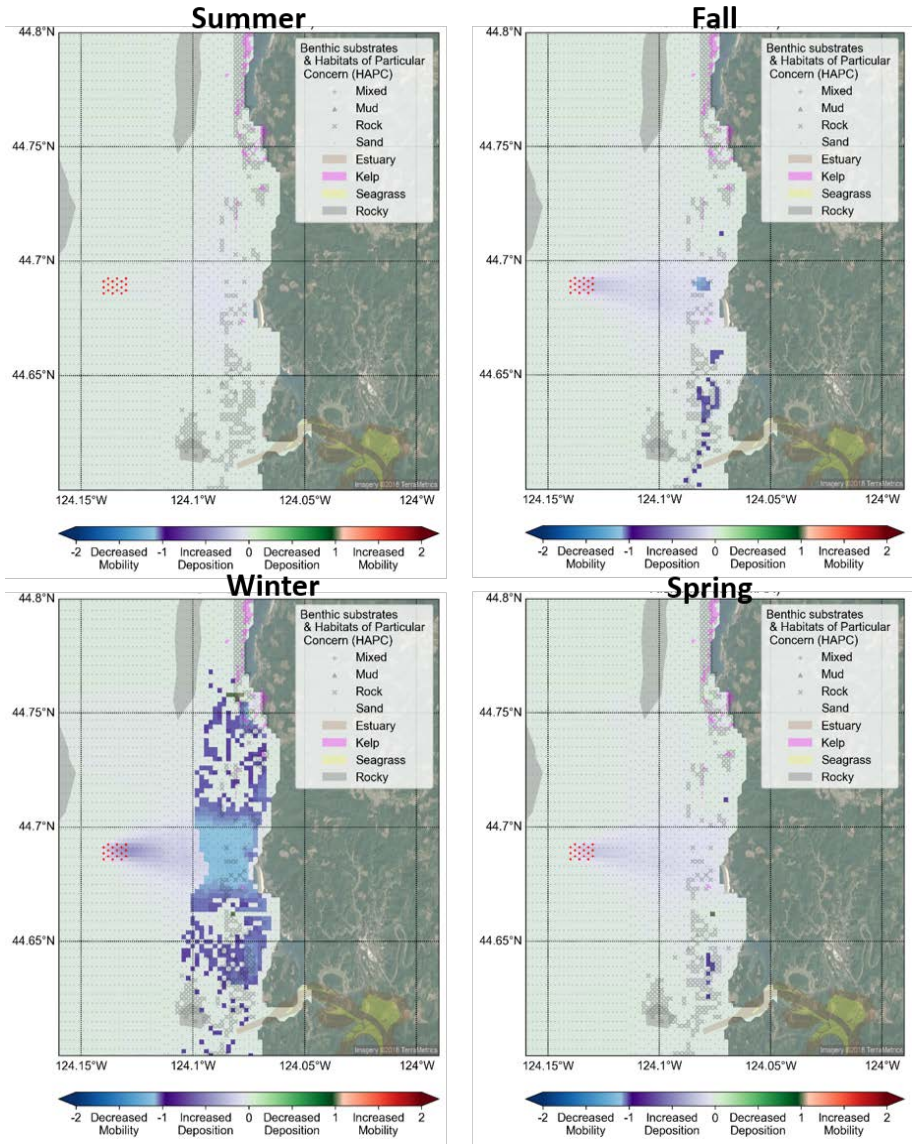
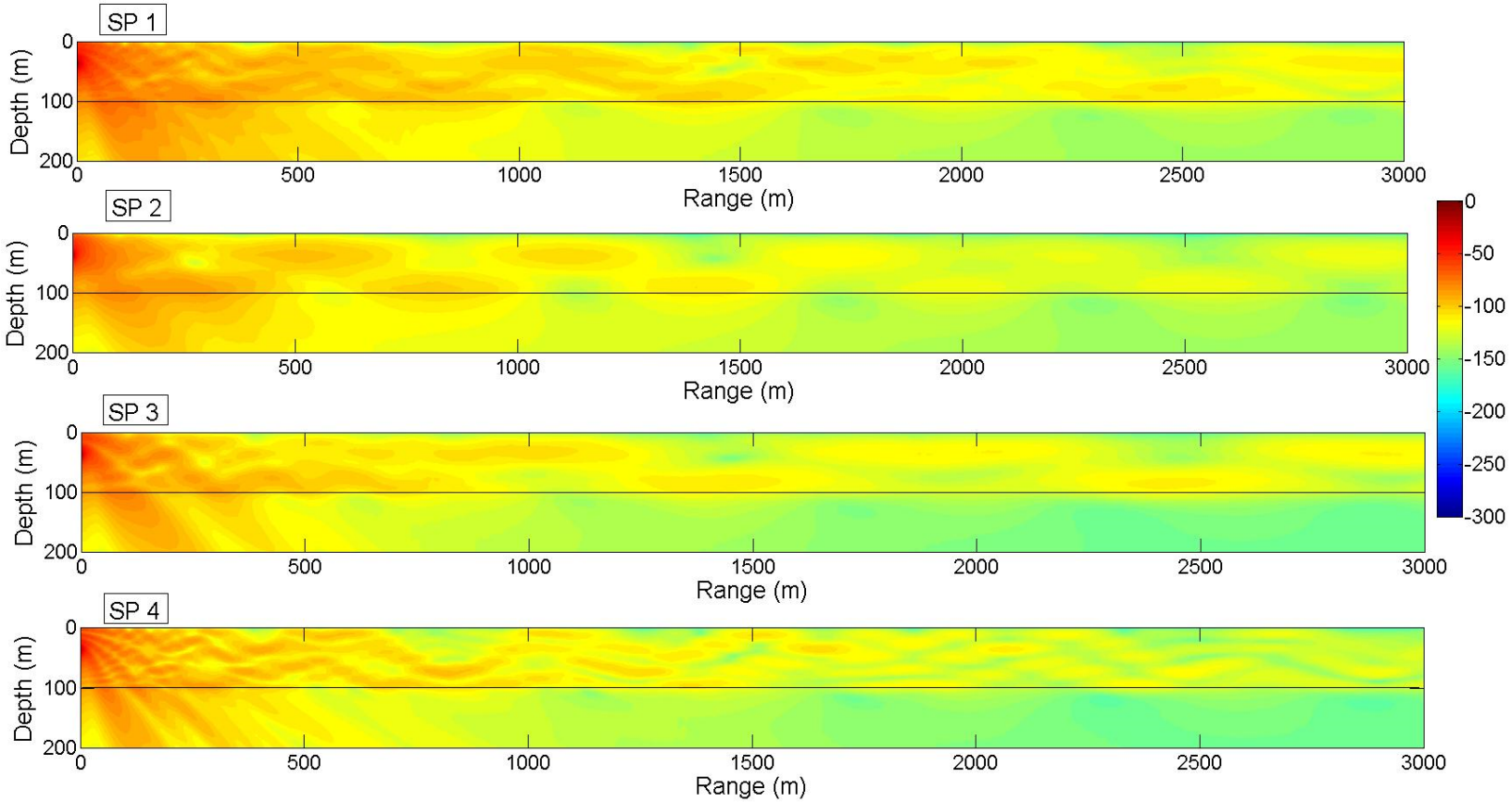
Linking the results from the physical modeling tools to real-world risk provides a clear and robust way for developers, scientists, and regulators to communicate with confidence.

$$R_\tau = int\left(\frac{T_w - T_b}{|T_w - T_b|}\, T_w\right) + [T_w - T_b]$$





Technical Accomplishments
Paracousti Developments



Paracousti is an **open-source** tool for 3D underwater acoustics that solves for the time-history soundscape from multiple devices in complex bathymetry. It is the **first, publicly available MHK acoustics tool** with this capability and has been released with tutorials and webinars.

Technical Accomplishments
Paracousti Developments

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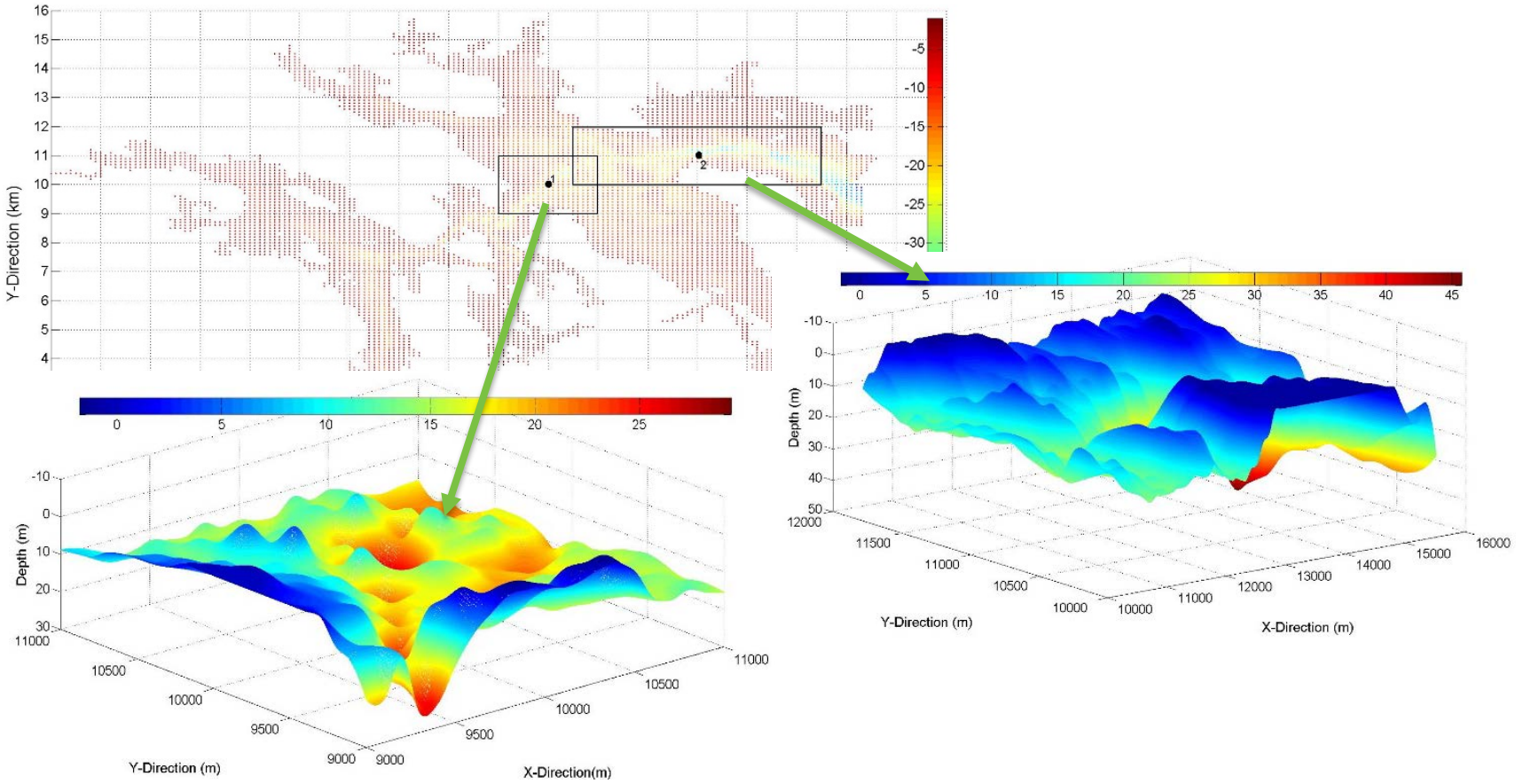
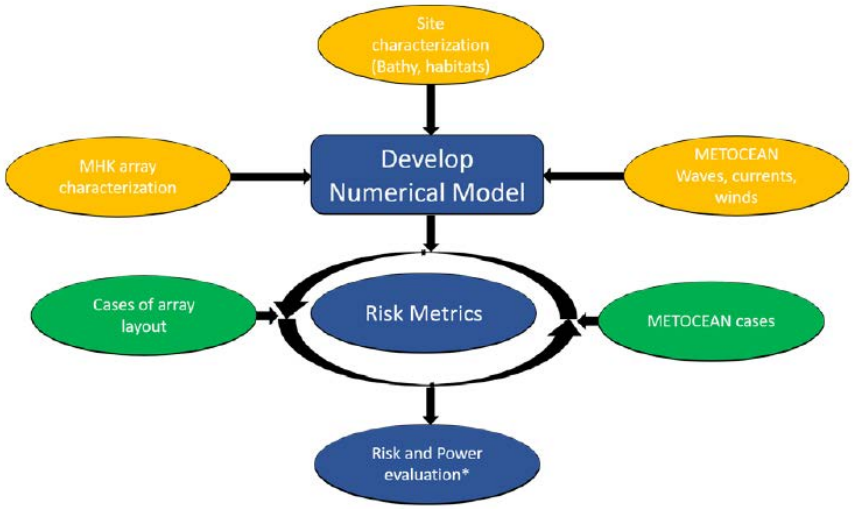


Real-World Cases

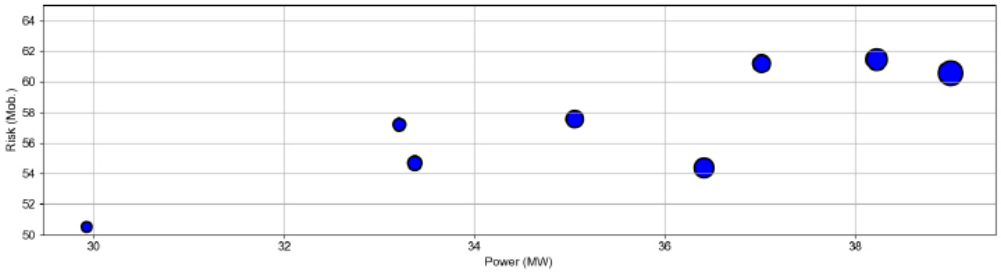
Example sites have been developed and validated for testing and demonstration of tool capabilities. These cases provide outreach materials for end users.

Future Work



Key Thrust

"MHK-friendly" numerical modeling tools capable of assessing potential changes to the physical and acoustic environment caused by operation of MHK arrays



Future Work

Automation of optimization tools

Extension of case studies across DOE project

Increase user base through "easy" tools and training

Build mutual confidence through aggressive outreach