



Environmental Effects of Off-Grid Marine Energy

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PNNL is operated by Battelle for the U.S. Department of Energy



Workshop agenda

Start Time	Agenda Topic
10:00	Introductions Purpose of the Workshop
10:15	Presentation Scenarios
10:35	Breakout Discussion #1
11:05	Breakout Discussion #2
11:35	Report Out
11:50	Wrap Up & Next Steps
12:00	Adjourn

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What brought you to this workshop?

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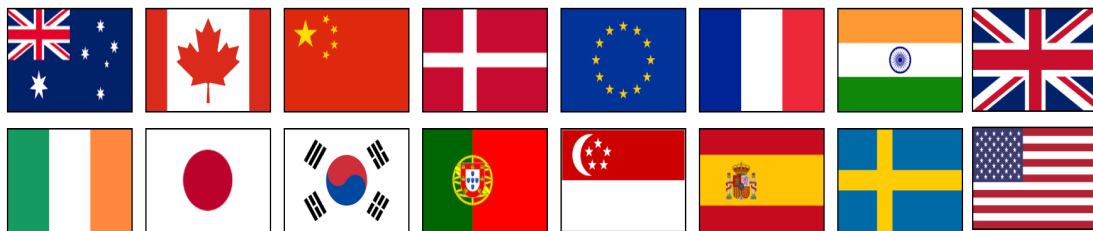
What brought you to this workshop?

Nobody has responded yet.

Hang tight! Responses are coming in.

OES-Environmental

- Established by the IEA-Ocean Energy Systems in 2010
- Examines environmental effects of marine energy development to advance the industry in a responsible manner
- Led by the U.S. Department of Energy Water Power Technologies Office and implemented by Pacific Northwest National Laboratory (PNNL)
- Phase 5 (2024-2028): 15 countries + European Commission
- Publishes syntheses of the current available knowledge on environmental effects (e.g., State of the Science reports)

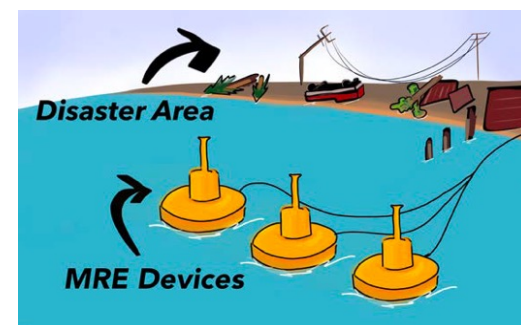
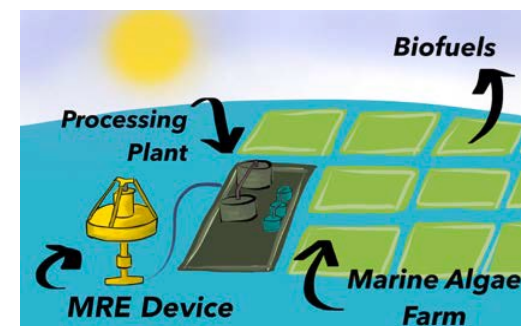


<https://tethys.pnnl.gov/about-oes-environmental>



Why develop off-grid/micro-grid marine energy?

- Marine energy alternatives to utility-scale applications include:
 - Off-grid uses for power-at-sea applications
 - Micro-grid uses for remote coastal or island communities
- Off-grid applications can provide power at sea for:
 - Ocean observation and navigation buoys and platforms
 - Autonomous vehicle charging
 - Marine aquaculture operations
- With energy storage, micro grids can provide:
 - Clean electricity to remote communities
 - Backup generation for disaster recovery
 - Reliable power for water desalination and other uses



Illustrations by Molly Gear, PNNL

Marine energy off-grid/micro-grid applications

Coastal Pioneer Array

- Ocean observatory in southern mid-Atlantic Bight, North Carolina
- Autonomously collects ocean data between surface and seafloor
- Currently relies on solar, wind, and battery systems to power multiple sensors
- Device designed to provide additional power



© WHOI

Igiugig Hydrokinetic Project

- Tribal village of 68 residents in SW Alaska
- Initially relying on fuel generators for power
- 2 cross-flow riverine turbines added in 2019 & 2023, with 10-year FERC license
- Reduced diesel consumption by 60-90%
- Robust adaptive management plan with fish monitoring (sockeye salmon)



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**In order to get devices in the waters,
one must consider:**

Resource
characterization



Resource
characterization




Siting



Tank testing
Resource
characterization



Engineering
design
Siting



Moorings


Tank testing

Resource
characterization

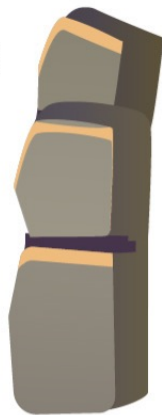


Engineering
design

Siting

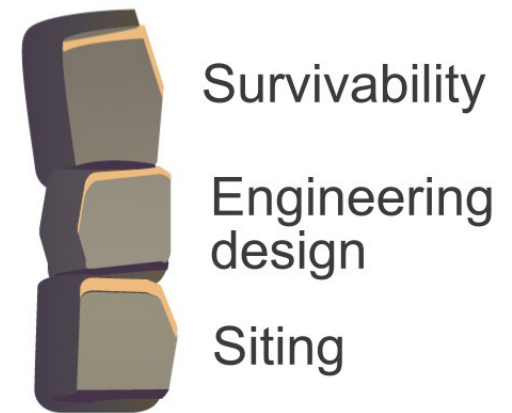
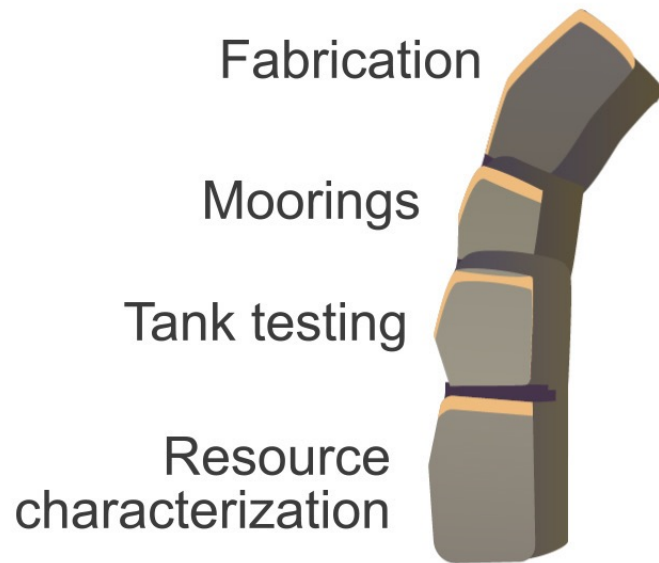


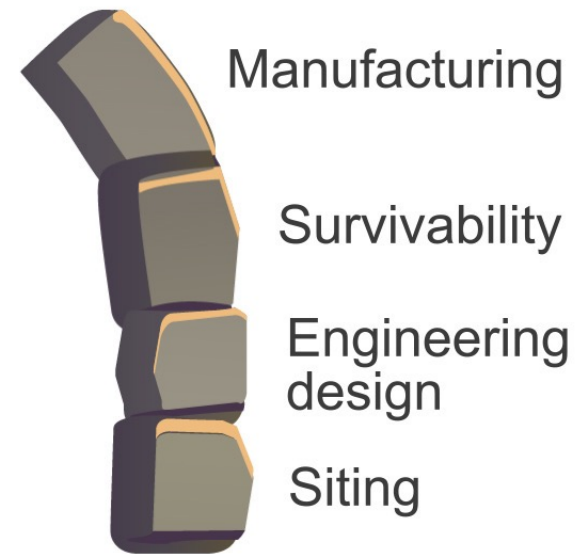
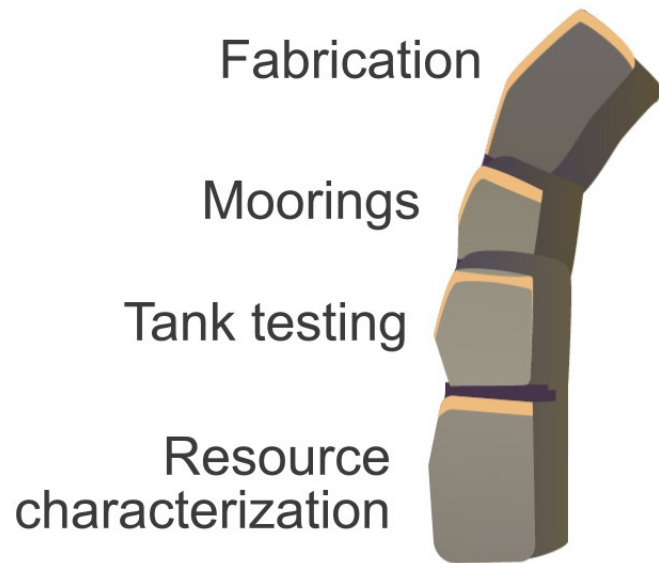
Moorings
Tank testing
Resource
characterization

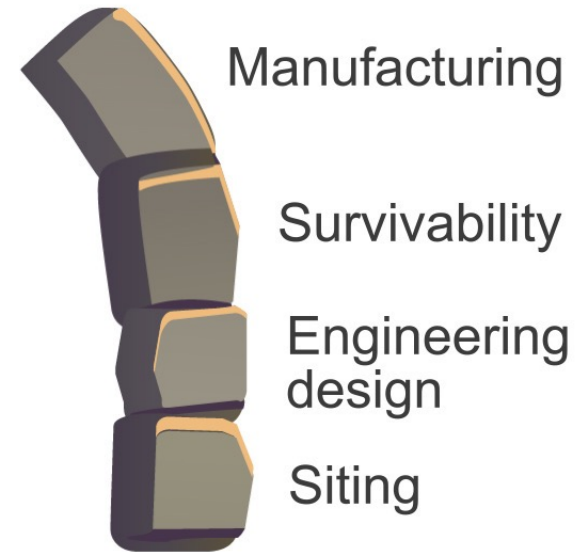
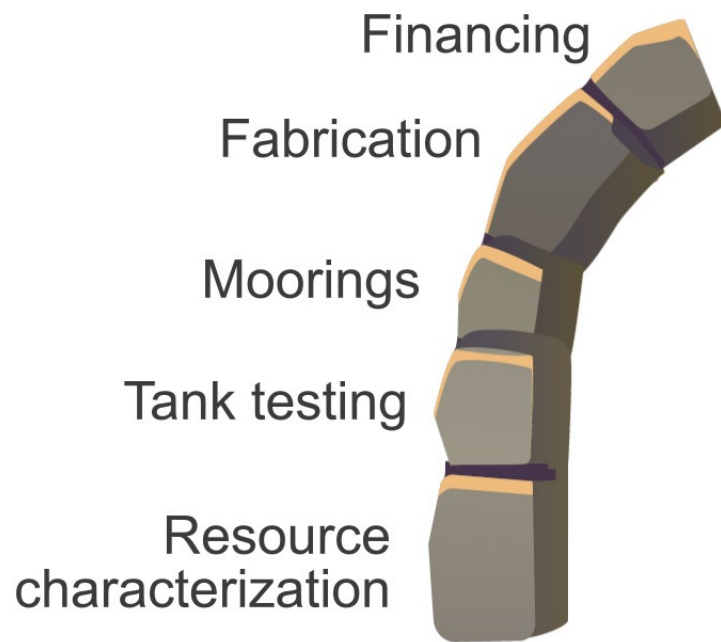


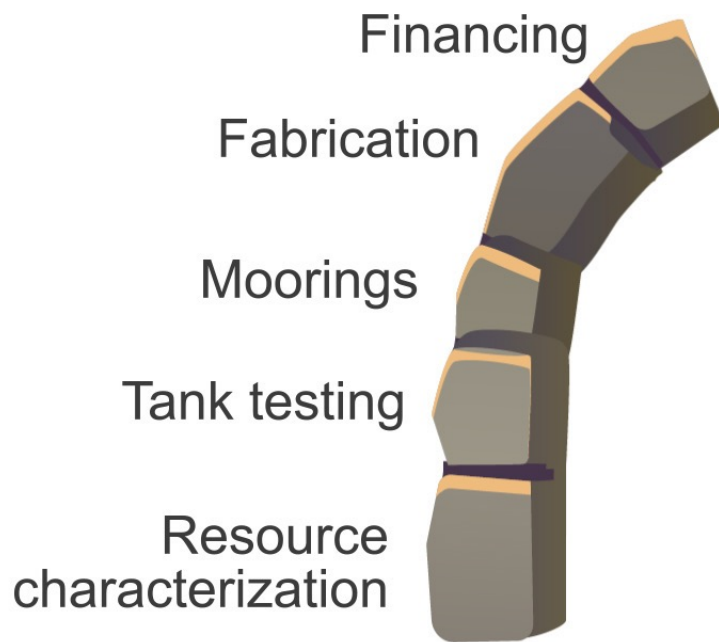
Survivability
Engineering
design
Siting

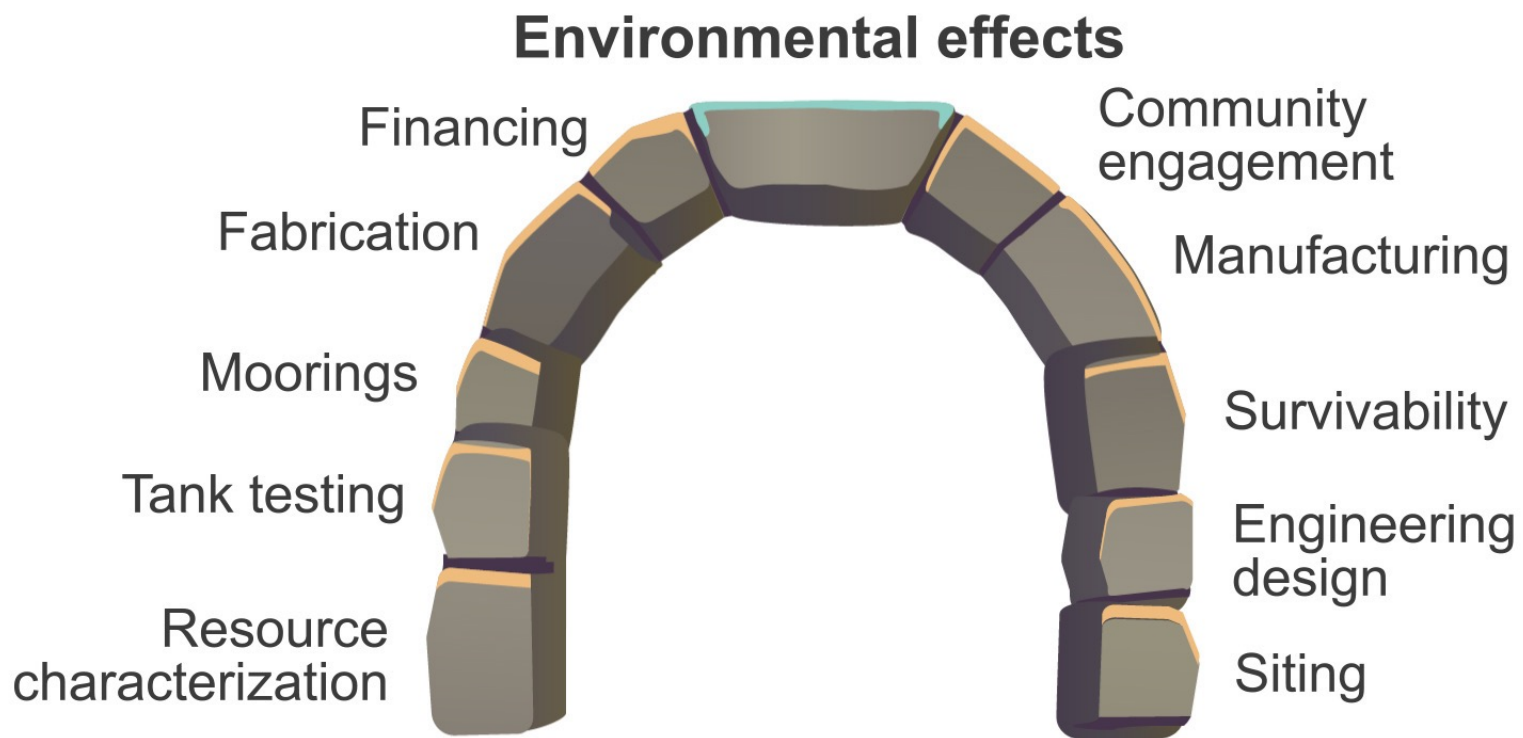








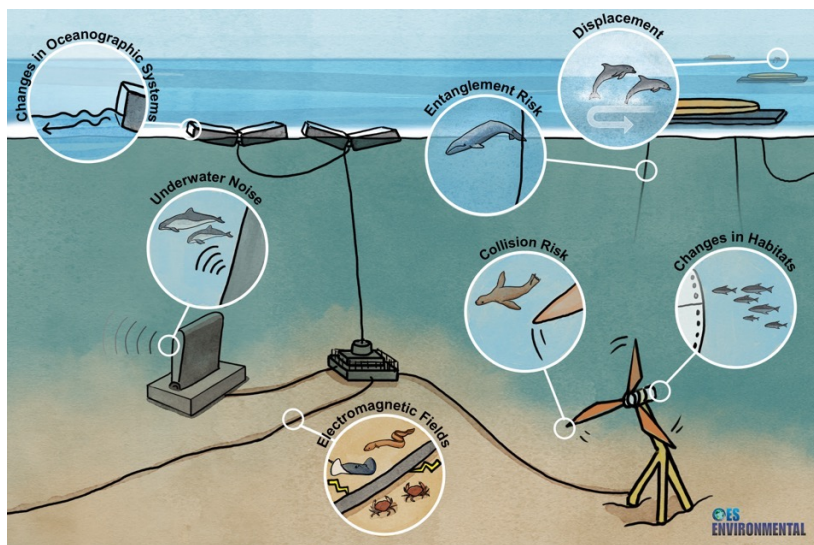




Marine energy environmental effects

Stressors: marine energy devices and systems that may cause harm

Receptors: marine animals, habitats, ecosystem processes



Priority stressor-receptor interactions



Collision risk



Entanglement



Underwater noise



Changes in oceanographic systems



Electromagnetic fields (EMF)



Displacement



Changes in habitats

Is marine energy relevant for powering remote coastal communities and islands?

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Is marine energy relevant for powering remote coastal communities and islands?

Yes

0%

No

0%

Is marine energy relevant for powering ocean observations buoys at sea?

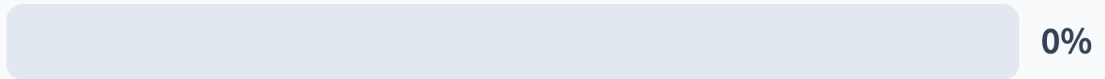
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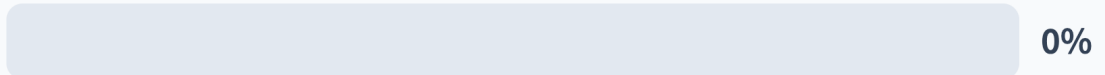
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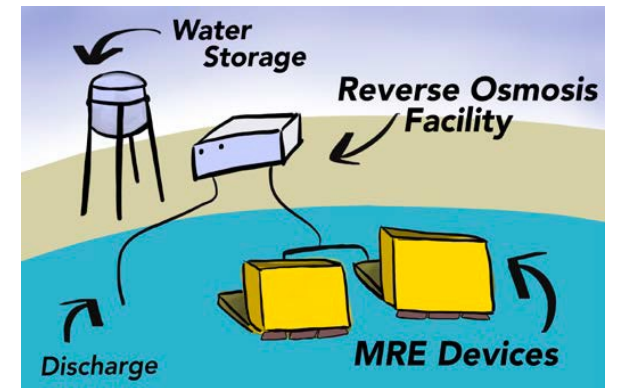
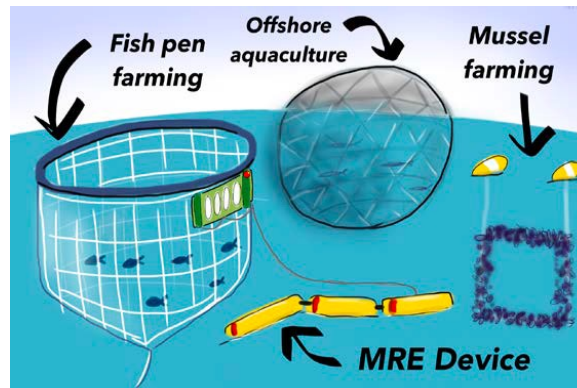
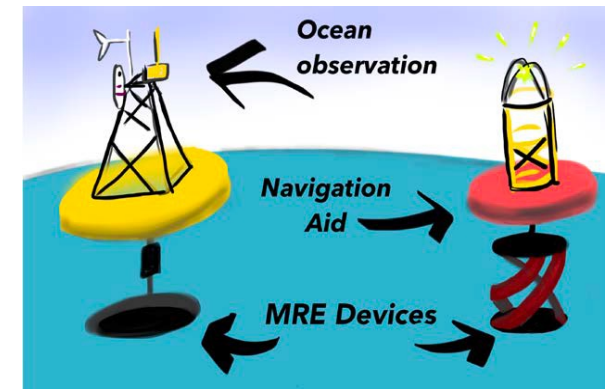
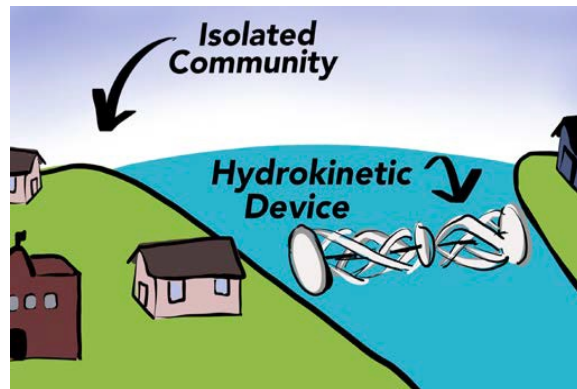
Yes



No



Use cases

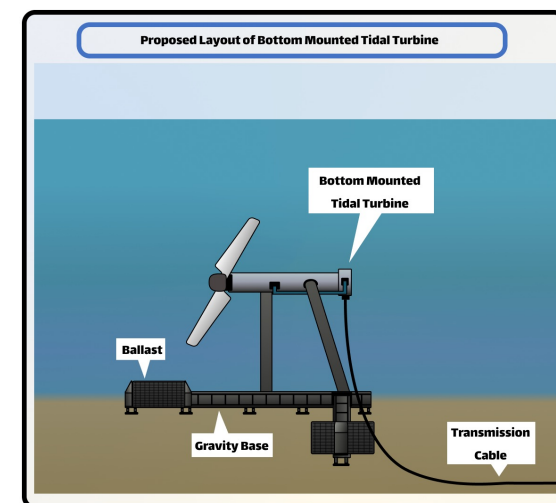
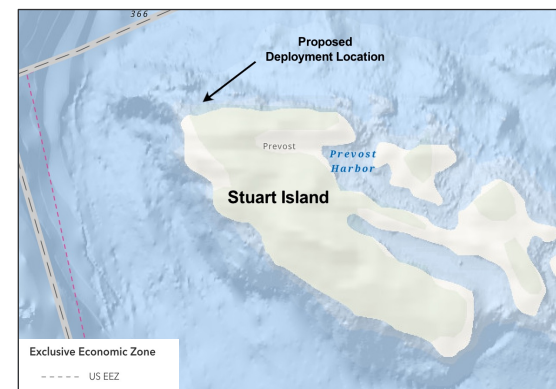
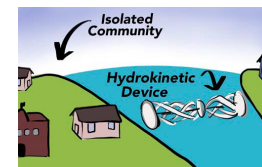


Illustrations by Molly Gear, PNNL

Coastal community & tidal energy

The Hypothetical Project

- Off-grid use – Provision of secure and reliable power to support the remote community of Stuart Island in the San Juan archipelago, WA
- Existing power sources – All electricity is generated by residents using wind, solar, and/or diesel generators
- Power needs – Micro grid for Stuart Island school, houses, services (e.g., emergency, harbors, airstrips, etc.)
- Technology – 1 bottom-mounted two-bladed tidal turbine, rated 400 kW
- Infrastructure development –
 - Tidal turbine installed as part of a hybrid micro-grid system with battery storage and solar panels
 - Turbine installed on gravity base and cabled to shore
- Site characteristics – 50-70 m depth, sedimentary bedrock and unconsolidated gravel, ≈ 1 m/s tidal current

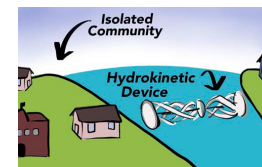




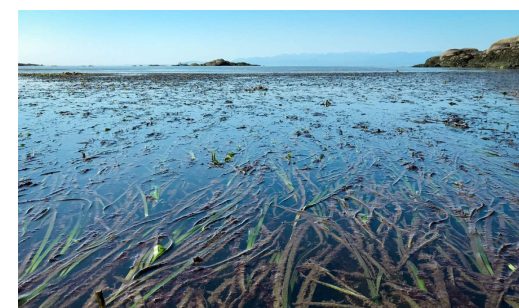
Coastal community & tidal energy

Environmental Considerations

- Species of concern – Killer whales, other whale species, bocaccio, other rockfish species, various salmonid species, sunflower sea star
- Commercial/recreational species – Salmon (sockeye, pink, chinook), shellfish (clams, mussels, and oysters)
- Important habitats – Nearshore eelgrass & kelp beds, critical habitat for killer whales, essential fish habitat for groundfish, Stuart Island Marine State Park
- Environmental stressor-receptor interactions –
 - Collision risk with operational turbines (marine mammals, fish, diving seabirds)
 - Underwater noise & EMF emissions during operation
 - Benthic impacts (scour, artificial reef)
- Indigenous people/locations – Descendents of the Coast Salish indigenous people; traditional reef netting; rights to traditional fishing grounds reserved under Treaty of Point Elliott and United States v. Washington
- Other uses – Tourism, fishing (recreational and cultural), boating (recreation and transportation), conservation, scuba diving



Sunflower sea star

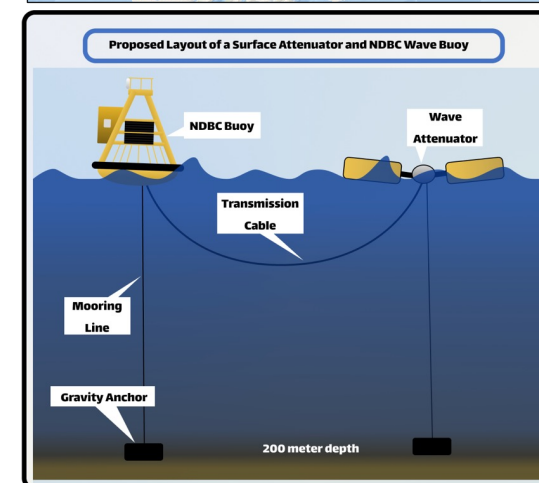
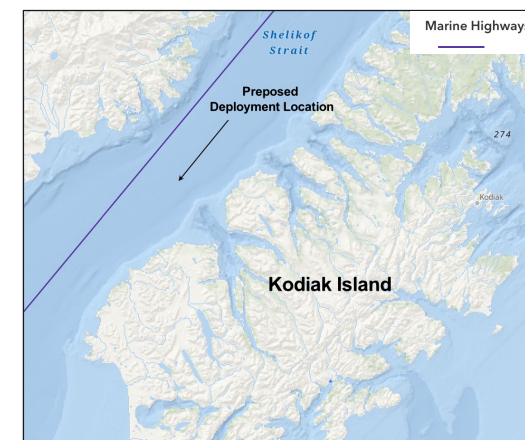
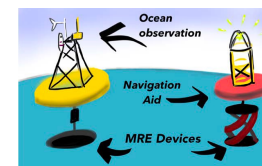


Eelgrass bed

Power at sea & wave energy

The Hypothetical Project

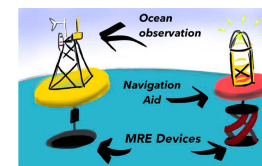
- Off-grid use – Power NDBC buoy in Shelikof Strait, AK
- Existing power sources –
 - 120 W solar PV panels with battery banks
 - Some buoys also equipped with wind turbines
- Power needs –
 - 5 W continuous (limited solar energy availability)
 - Additional power would increase number of sensors or sample times
- Technology – Surface attenuator WEC, rated 50 W
- Infrastructure development – All at sea, no cable to shore; WEC moored to a gravity anchor and cabled to NDBC buoy with a draped transmission cable
- Site characteristics –
 - Annual average significant wave height of 1.2 m and annual average wave period of 4.5 s
 - Sloping central plateau, 200 m depth
 - Silt and clay seafloor



Power at sea & wave energy

Environmental Considerations

- Species of Concern – Steller sea lions, north Pacific right whale, other whale species, seals, sea otters
- Commercial/recreational species – Salmon species (sockeye, chinook, coho), rockfish, Dungeness and Tanner crabs
- Important habitats – Steller sea lion critical habitat, essential fish habitats, multiple wildlife refuges and preserves nearby
- Environmental stressor-receptor interactions –
 - Underwater noise from device PTO
 - EMF of dynamic draped cable
 - Displacement and attraction
 - Entanglement with draped cable
- Indigenous people/locations – The Aluttiq/Sugpiag traditionally harvest marine resources for subsistence
- Other uses – Fishing (commercial, recreational, subsistence), tourism (whale watching), maritime shipping



Steller sea lions



North Pacific right whale

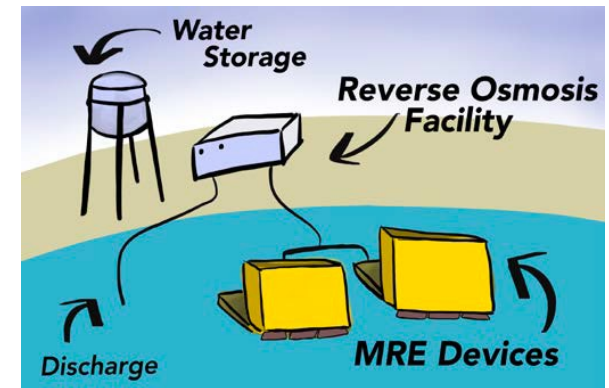
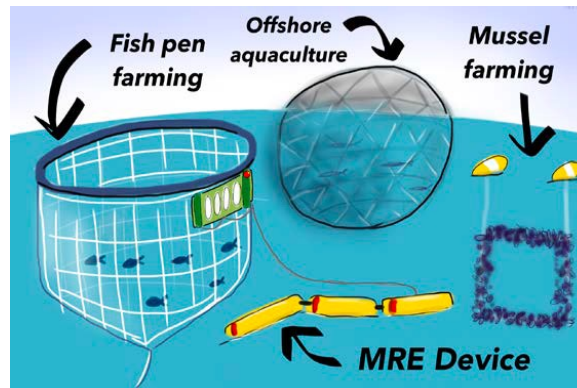
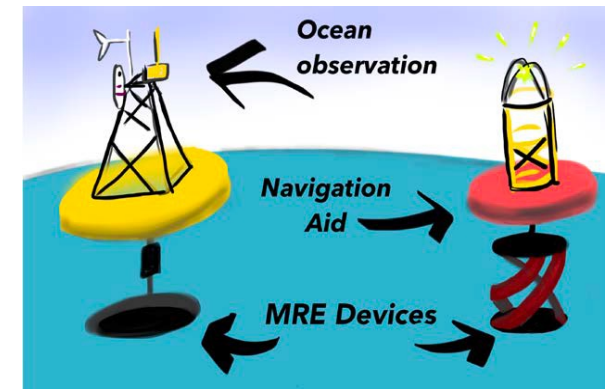
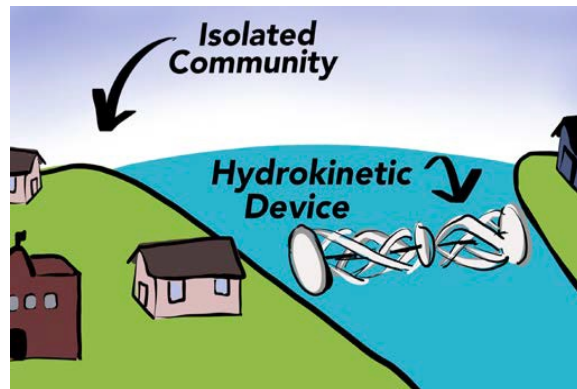
Questions for breakout group discussions

Questions we will address today:

1. What environmental effects would be of greatest concern?
2. How would the environmental effects of small off-grid applications compare to those of utility-scale applications with (multiple) large devices?
3. Would off-grid applications be easier to implement than utility-scale projects? Why?
4. How would regulatory processes address smaller-scale applications differently?
5. What challenges do you think that off-grid applications may be facing?



Report out



Illustrations by Molly Gear, PNNL

What stood out from your group?

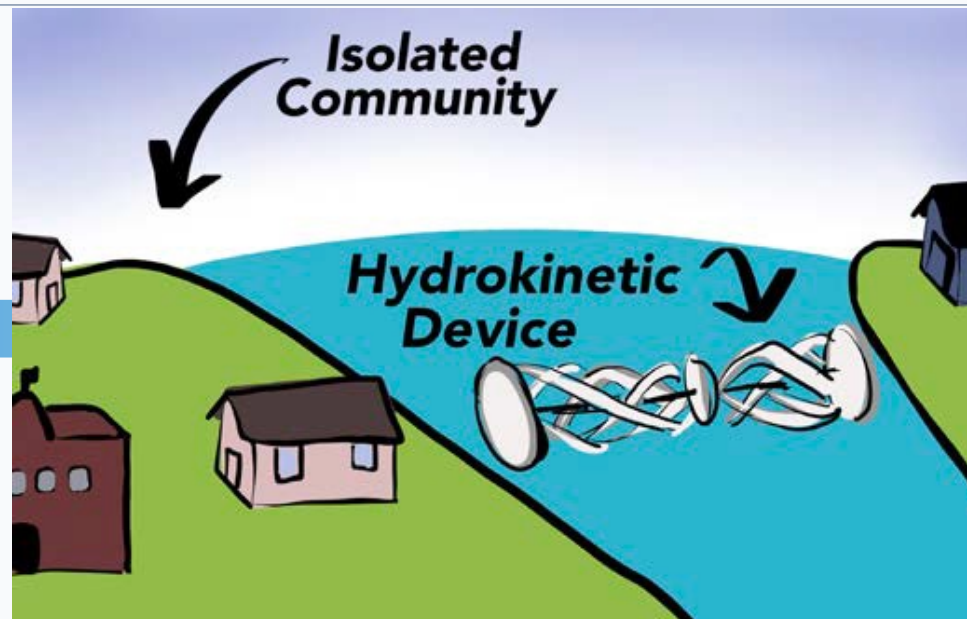
Coastal community & tidal energy use case

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Breakout Discussion - Coastal Community Tidal



What stood out from your group?

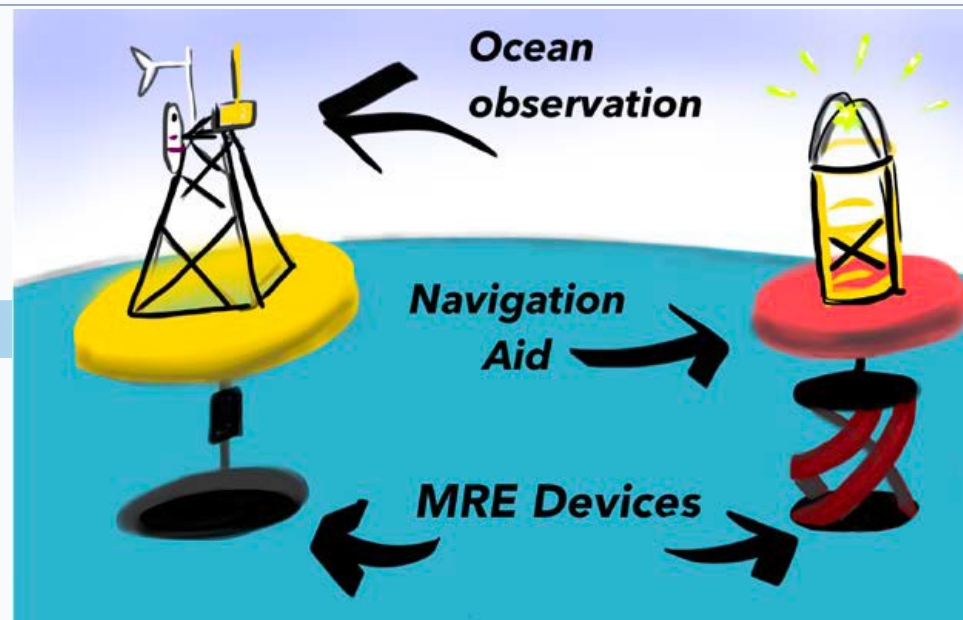
Power at sea & wave energy use case

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[PollEv.com/tethyspnnl296](https://pollEv.com/tethyspnnl296)

Breakout Discussion - Weather Buoy Wave



OES-Environmental resources

Moving from Science to Permitting



Scaling up our understanding of environmental effects of marine renewable energy development from single devices to large-scale commercial arrays

David J. Spurgeon¹, Lindsay G. Henry², Andrew K. Cropping³, Elizabeth A. Fulton⁴, Jennifer Fox⁵, Andrew B. Gell⁶, Kate Pilger⁷

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Received: 15 November 2023; Accepted: 15 November 2023; Published: 15 November 2023

Abstract: Marine renewable energy (MRE) development has the potential to provide clean, sustainable energy sources for industrial and commercial use. However, the environmental effects of MRE development on marine ecosystems are still largely unknown. This report provides a comprehensive overview of the current state of knowledge on the environmental effects of MRE development, including the potential for both positive and negative impacts. The report also discusses the need for further research and the development of effective management strategies to minimize potential negative impacts and maximize potential benefits.

Keywords: marine renewable energy; environmental effects; risk assessment; data transferability

1. Introduction

The global distribution and demand for fossil fuels is steadily rising, leading to the depletion of natural energy resources around the world. This has led to the development of alternative energy sources, such as MRE, as a sustainable and renewable source of energy.

MRE development has the potential to provide clean, sustainable energy sources for industrial and commercial use. However, the environmental effects of MRE development on marine ecosystems are still largely unknown. This report provides a comprehensive overview of the current state of knowledge on the environmental effects of MRE development, including the potential for both positive and negative impacts.

The report also discusses the need for further research and the development of effective management strategies to minimize potential negative impacts and maximize potential benefits.

2. Methods

This report was developed through a series of workshops and consultations with experts in the field of MRE development and environmental effects. The workshops were held in 2022 and 2023, and involved experts from a variety of disciplines, including biology, engineering, and policy.

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Potential Environmental Effects of Marine Renewable Energy Development—The State of the Science

Andrew K. Cropping¹, Lindsay G. Henry², Elizabeth A. Fulton³, Jennifer Fox⁴, Andrew B. Gell⁵, Kate Pilger⁶

¹Department of Biology, University of Guelph, Guelph, Ontario, Canada; ²Department of Biology, University of Guelph, Guelph, Ontario, Canada; ³Department of Biology, University of Guelph, Guelph, Ontario, Canada; ⁴Department of Biology, University of Guelph, Guelph, Ontario, Canada; ⁵Department of Biology, University of Guelph, Guelph, Ontario, Canada; ⁶Department of Biology, University of Guelph, Guelph, Ontario, Canada

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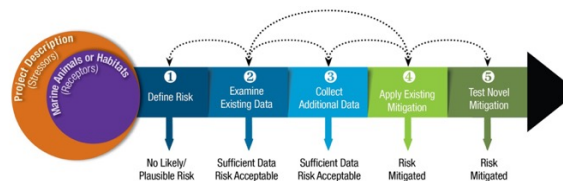
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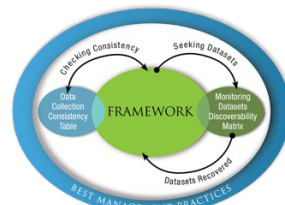
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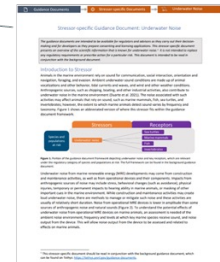
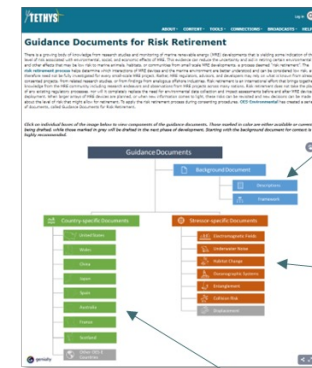
Evidence bases



Risk retirement



Data transferability



Guidance documents

Available data and information

Feedback from marine energy community

OES-Environmental resources

Management Measures Tool

- Provides a reference to help manage potential risk that are not well understood and before they can be retired
- Online tool collates measures used and tried for current and previous marine energy projects

<https://tethys.pnnl.gov/management-measures>

The screenshot shows the TETHYS website header with navigation links: ABOUT, CONTENT, TOOLS, CONNECTIONS, BROADCASTS, HELP. The main title is "Management Measures Tool for Marine Energy". Below the title, there is a brief description of the tool's purpose: "Accounting Management Measures that Support Deployment of Wave and Tidal Energy Devices". It mentions that the tool is used to assess the potential impacts of marine energy devices on the marine environment and to develop management measures to avoid, minimize, or compensate for those impacts. A search filter is visible with dropdown menus for "Filter by Technology", "Management Measure", "Project Phase", "Stressor", and "Receptor". Below the filter, there is a table with columns: Technology, Project Phase, Stressor, Receptor, Management Measure, Implications of Measure, Advantages, Challenges, and Project Documents. The table contains four rows of data related to marine energy projects and their management measures.

Monitoring Datasets Discoverability Matrix

- Makes datasets from existing projects accessible to transfer data and inform future projects
- Interactive online tool to find available data based on project characteristics and environmental interactions

<https://tethys.pnnl.gov/monitoring-datasets-discoverability-matrix>

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OES-Environmental resources

Educational Resources

Materials and resources for **students of all ages**

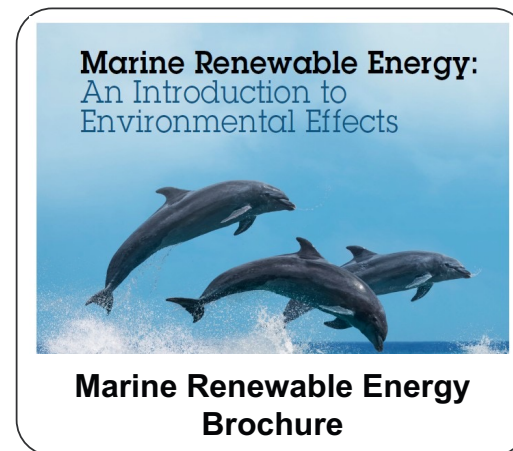
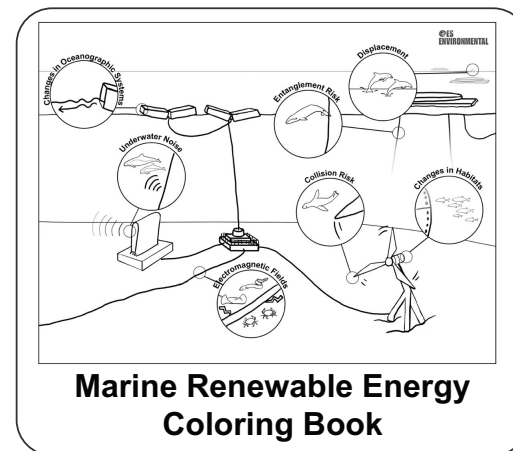
- To increase awareness and understanding of research on environmental effects of marine energy
- To support the future workforce

<https://tethys.pnnl.gov/marine-renewable-energy-educational-resources>

Marine Energy Brochure

A primer on the environmental effects of marine energy development for **regulators and advisors** new to the industry

<https://tethys.pnnl.gov/mre-brochure>



What tools or products you would like OES-Environmental to create, to make off-grid applications easier to develop & permit?

Go to Poll Everywhere



PollEv.com/lenaighe_mery402

What tools or products you would like OES-Environmental to create, to make off-grid applications easier to develop & permit?

Nobody has responded yet.

Hang tight! Responses are coming in.

Wrap up & next steps

Workshop report written from breakout group discussions

- Shared with you for review/feedback
- Leveraged in future OES-Environmental work

OES-Environmental Phase 5 task “Off-Grid Applications”

- Remote coastal and island communities, power at sea
- Assess scale of environmental effects of off-grid & micro-grid devices
- Adapt knowledge gained from utility-scale devices to smaller scale

And please take our post-workshop survey!



NOAA weather buoy



C-Power



Sea cage aquaculture, Australia



Thank you

Lenaïg Hemery
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Please fill out our short survey!



<https://www.surveymonkey.com/r/XXPZMDJ>