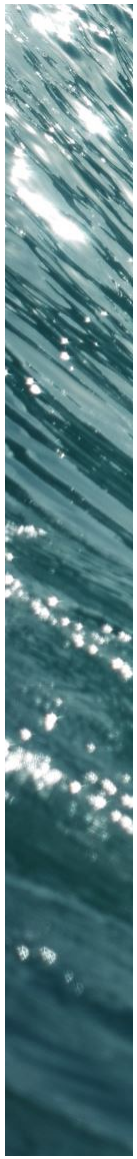

Pacific Northwest NATIONAL LABORATORY

OES ENVIRONMENTAL

Environmental Effects of Off-Grid Marine Energy

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Andrea Copping

Jacob McGrath

Hayley Farr

U.S. DEPARTMENT of ENERGY BATTELLE

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

Go to Poll Everywhere

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What brought you to this workshop?

Go to Poll Everywhere

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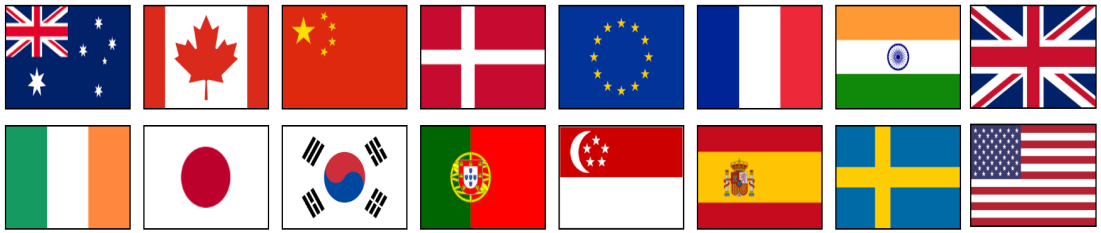
What brought you to this workshop?

Nobody has responded yet.

Hang tight! Responses are coming in.

OES-Environmental

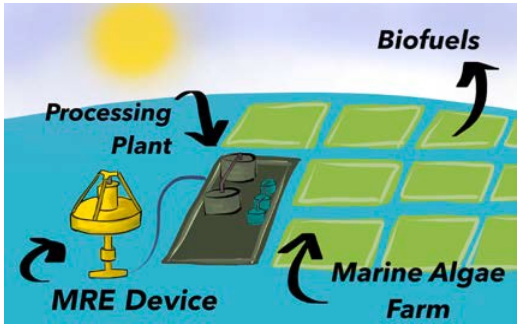
- Established by the IEA-Ocean Energy Systems in 2010
- Examines environmental effects of marine energy development to advance the industry in a responsible manner
- Led by the U.S. Department of Energy Water Power Technologies Office and implemented by Pacific Northwest National Laboratory (PNNL)
- 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)

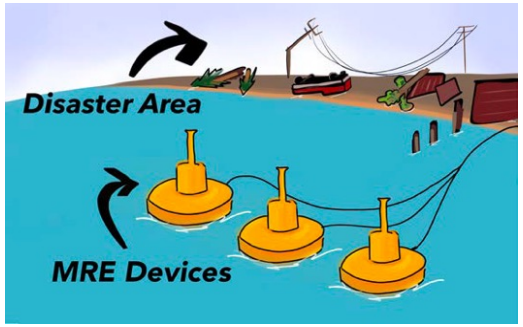


https://tethys.pnnl.gov/about-oes-environmental

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 Grear, PNNL

Marine energy off-grid/micro-grid applications

Coastal Pioneer Array

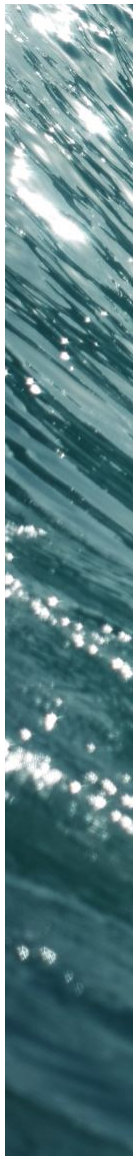
- Ocean observatory in southern mid-Atlantic Bight, North Carolina
- Autonomously collects ocean data between surface and seafloor
- Currently relies on solar, wind, and battery systems to power multiple sensors
- Device designed to provide additional power

© WHOI

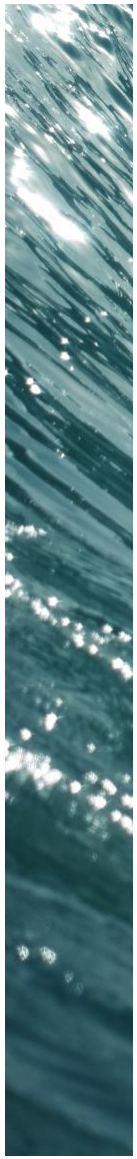
Igiugig Hydrokinetic Project

- 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)

© ORPC



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



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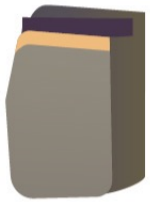

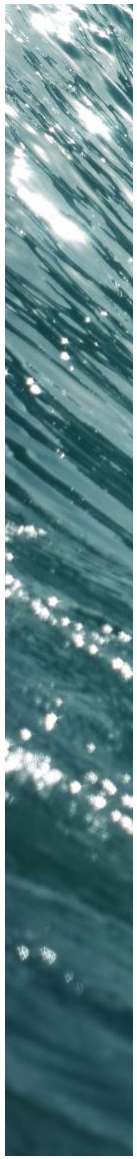

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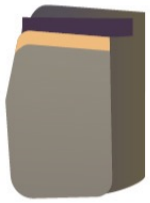

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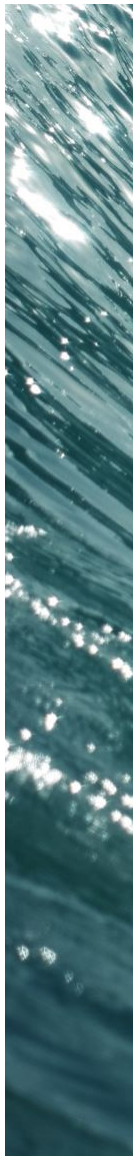
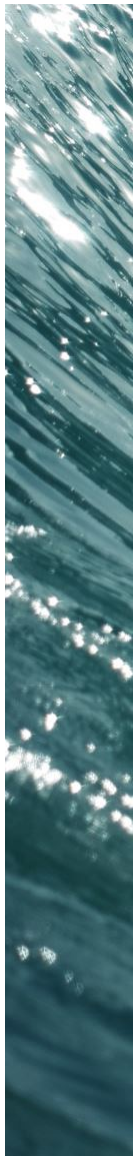


Tank testing

Resource characterization

Engineering design

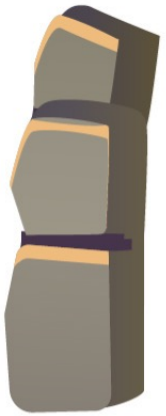
Siting

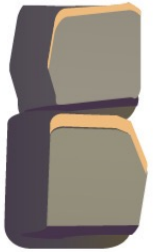


Moorings

Tank testing

Resource characterization





Engineering design

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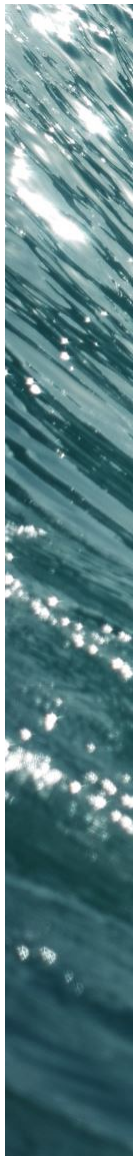

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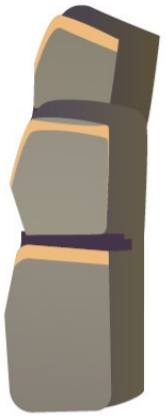
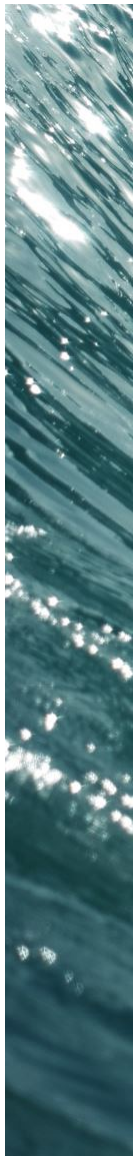
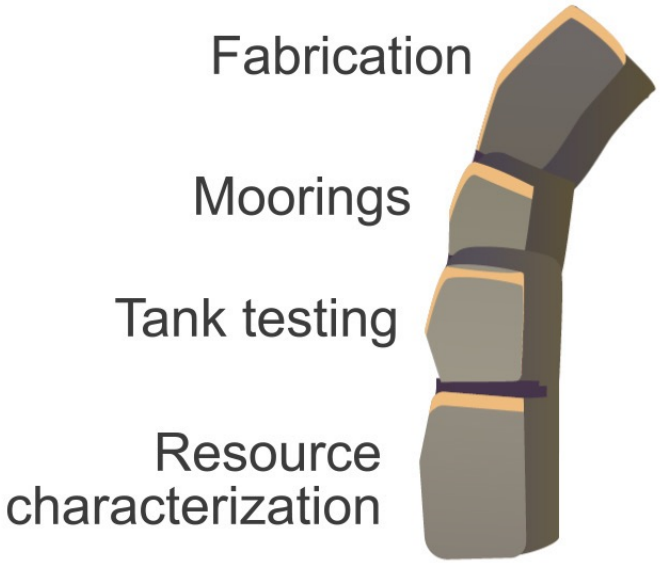


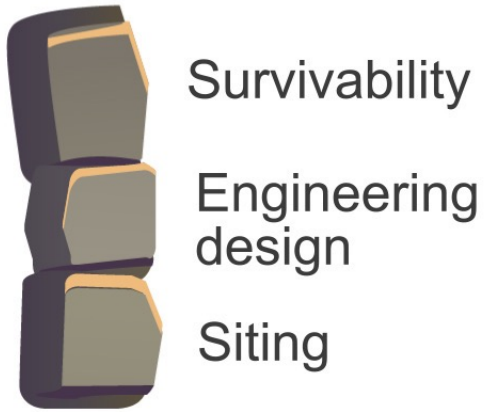
Survivability

Engineering design

Siting




Fabrication
Moorings
Tank testing
Resource characterization


Survivability
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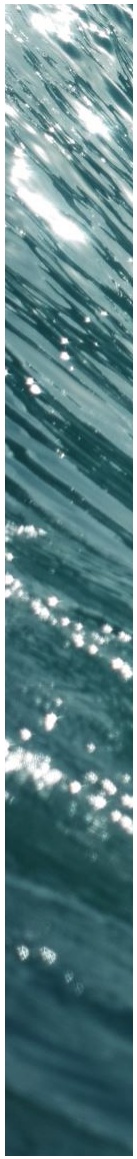

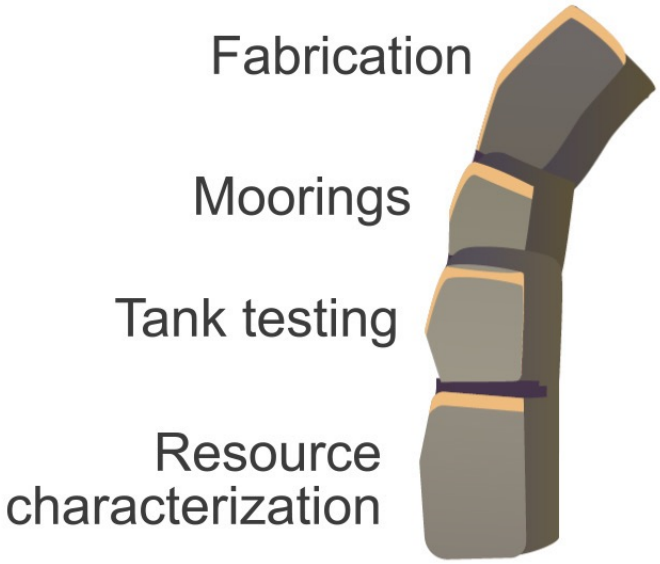
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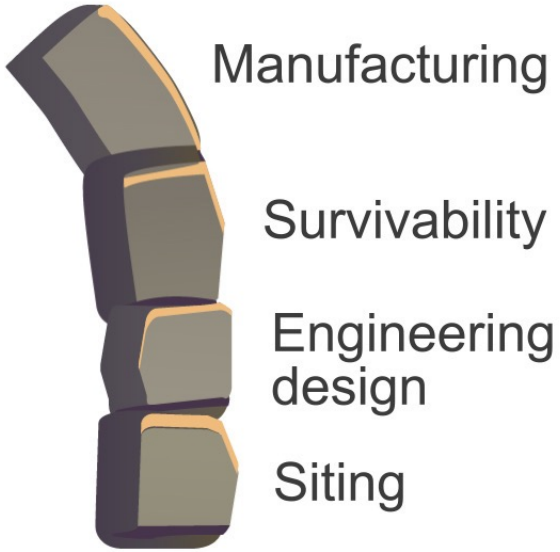
Manufacturing
Survivability
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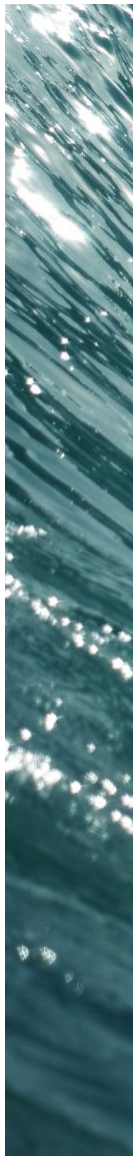

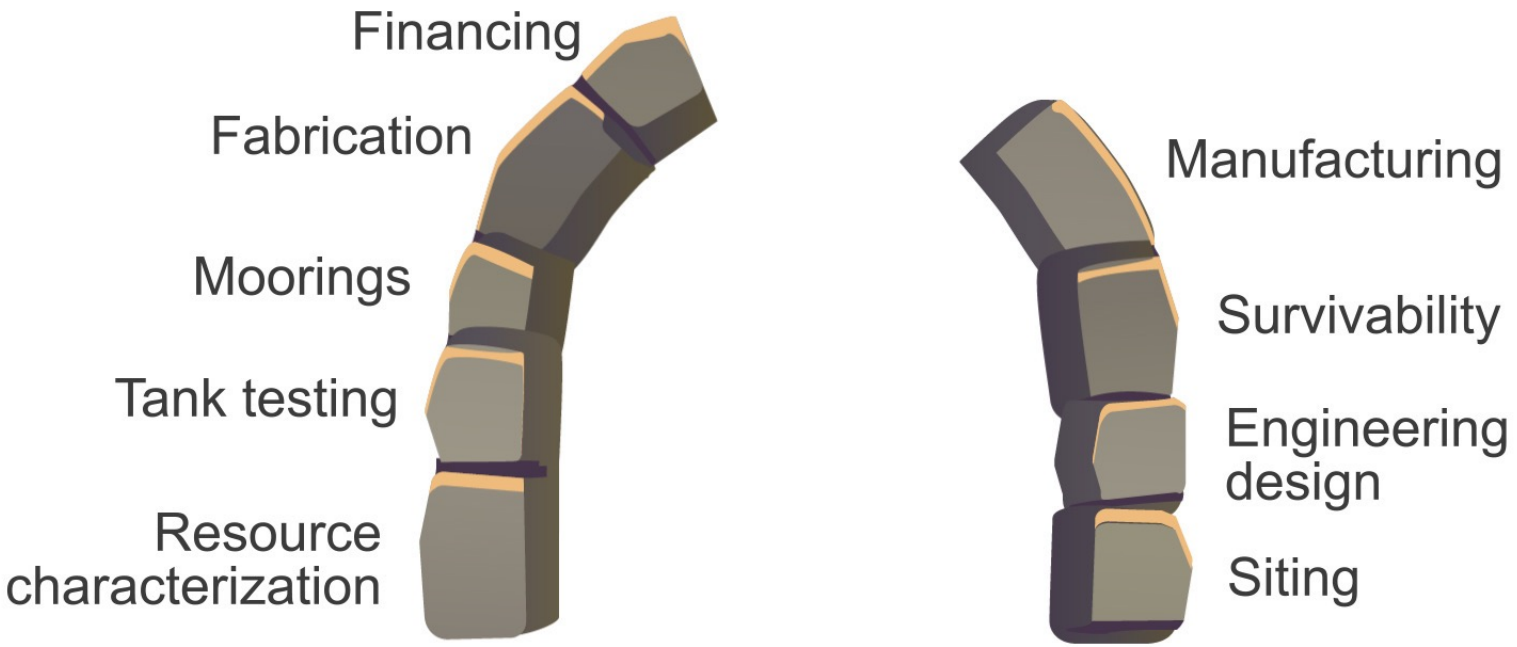
Financing
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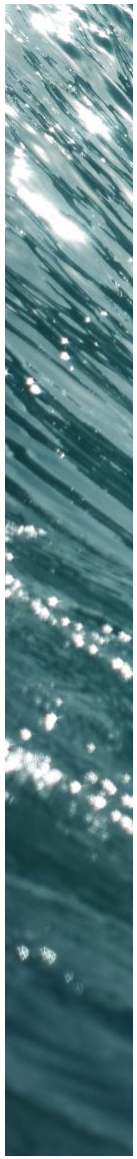

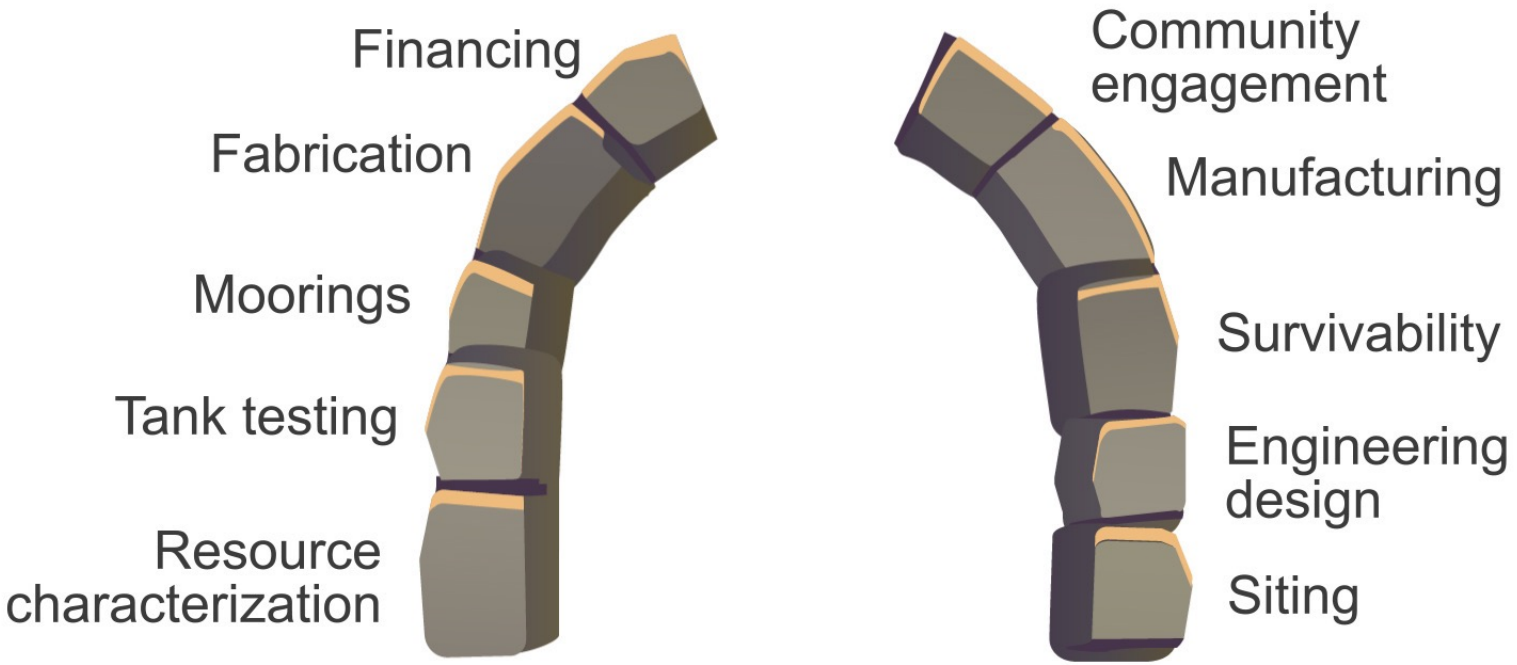
Financing
Fabrication
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Resource characterization
Community engagement
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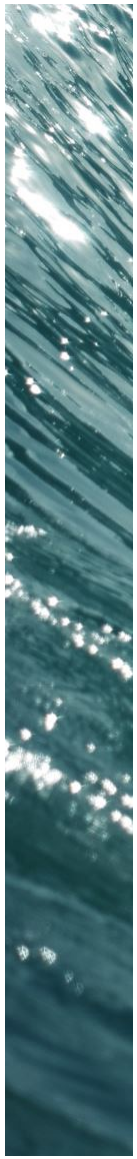

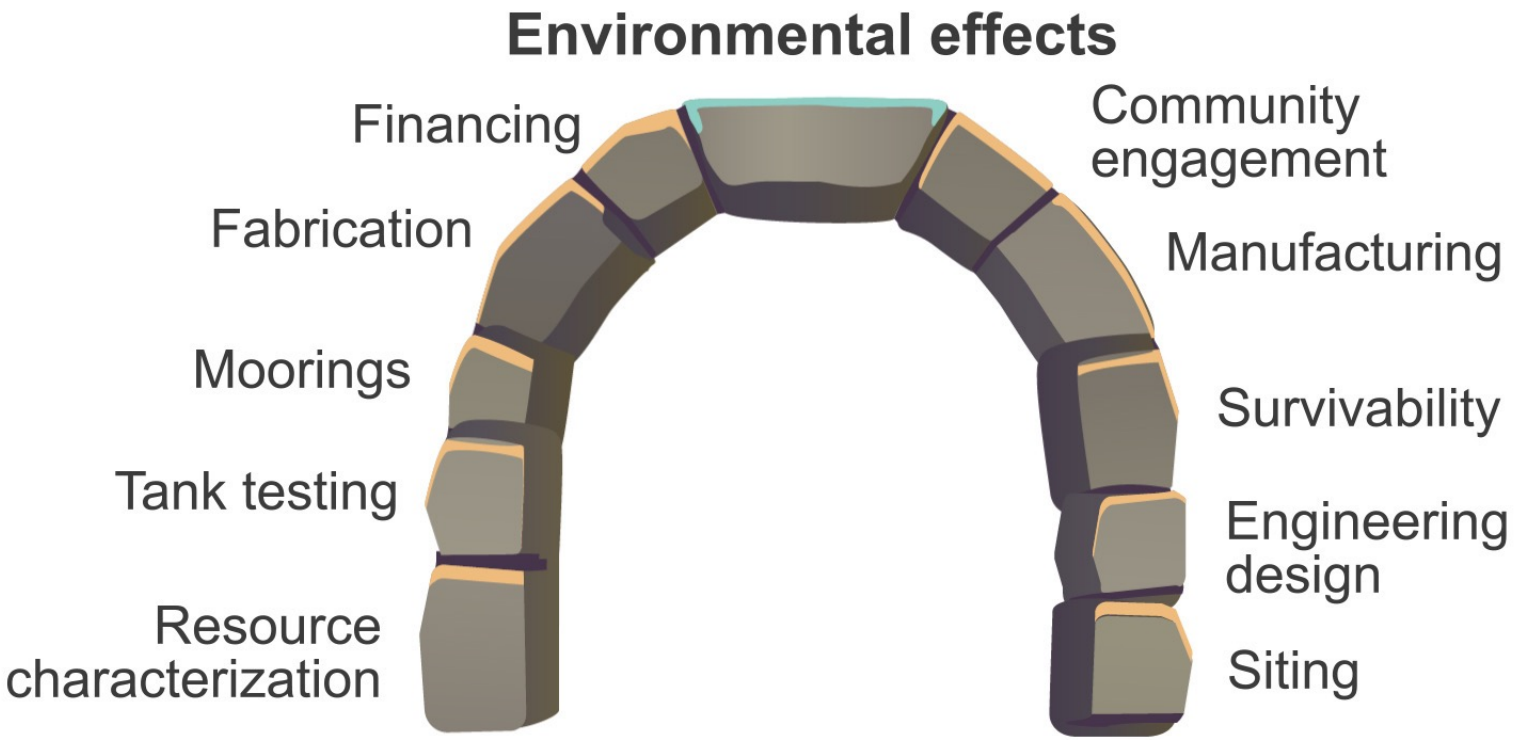
Environmental effects
Financing
Fabrication
Moorings
Tank testing
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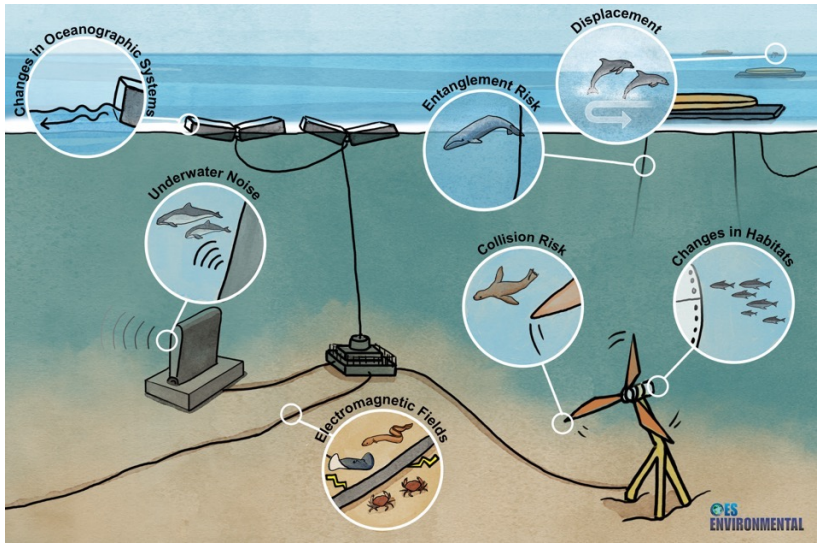
Survivability
Engineering design
Siting

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
- Underwater noise
- Electromagnetic fields (EMF)
- Changes in habitats
- Entanglement
- Changes in oceanographic systems
- Displacement

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

Go to Poll Everywhere

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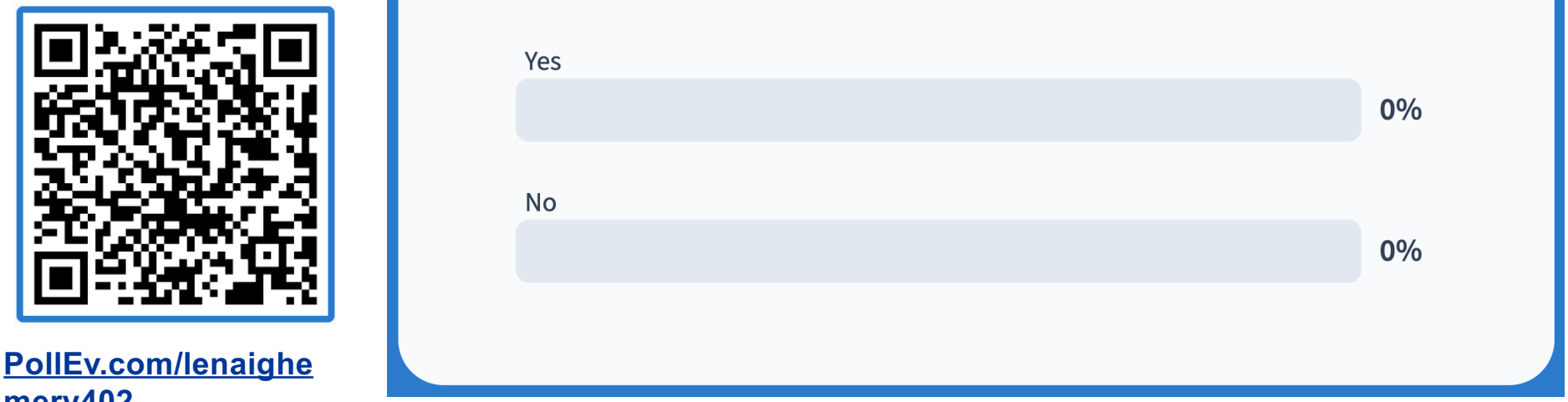

Is marine energy relevant for powering ocean observations buoys at sea?

Go to Poll Everywhere

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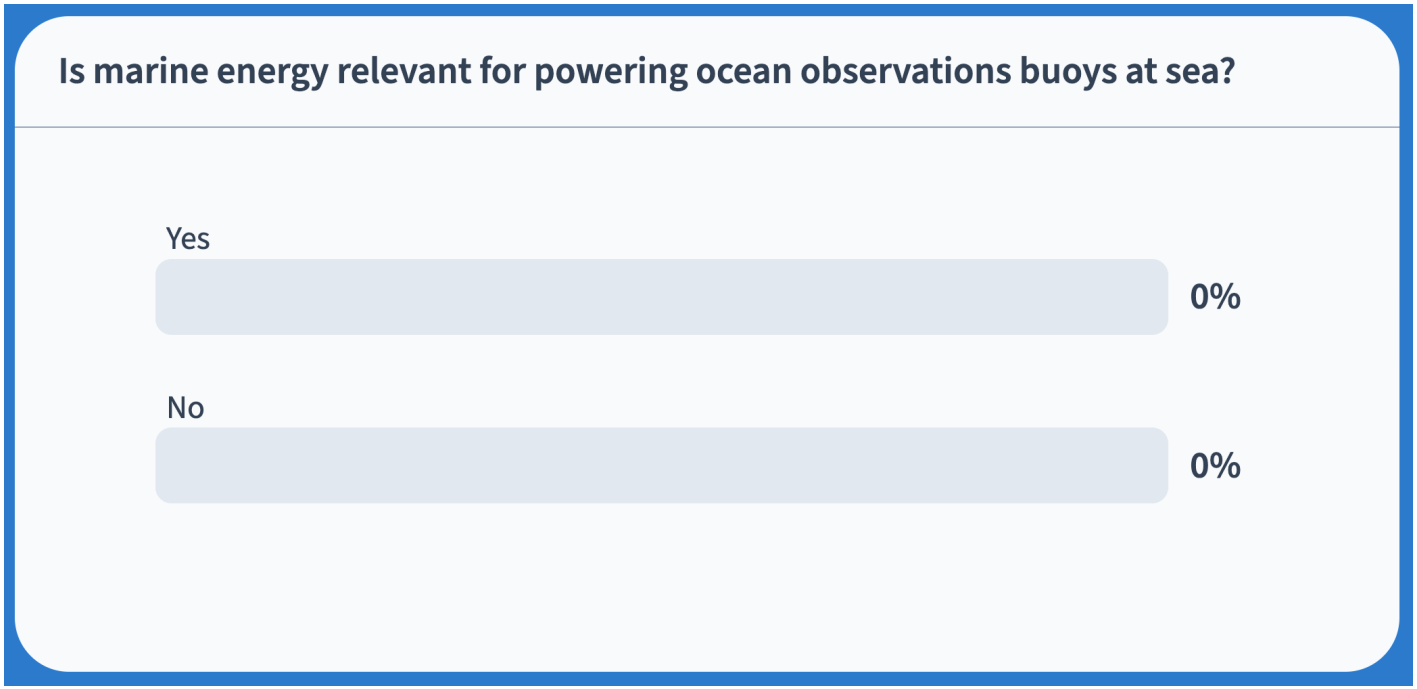
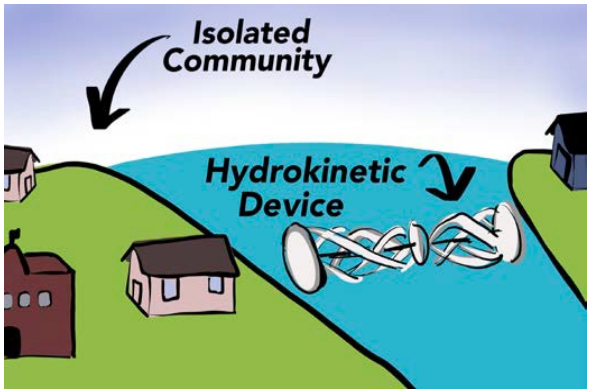
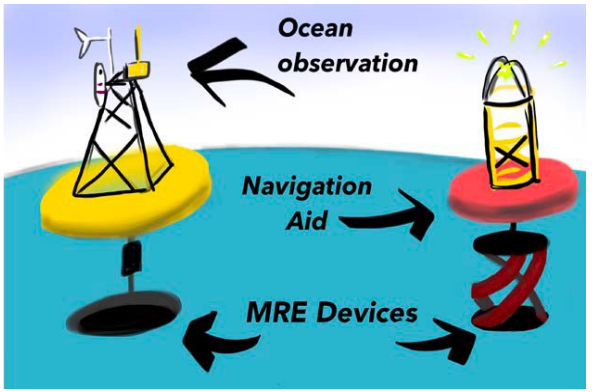
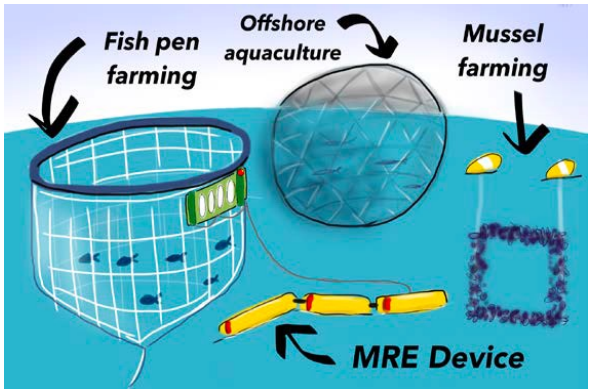
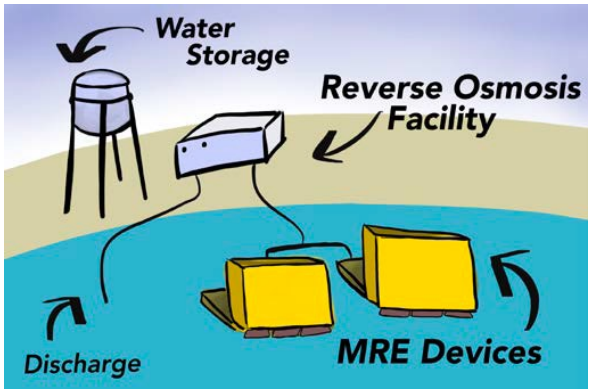


Use cases



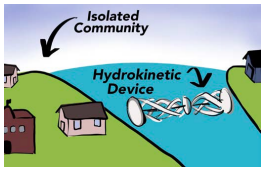






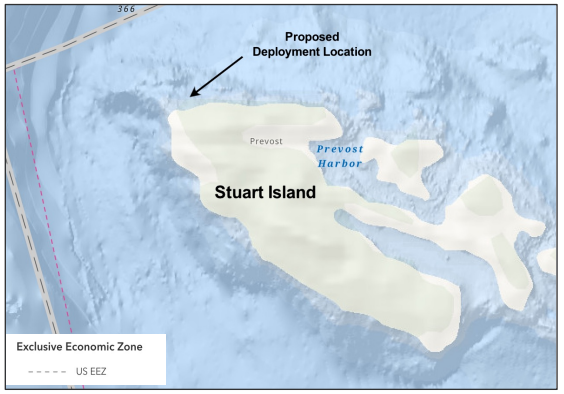
Illustrations by Molly Grear, PNNL

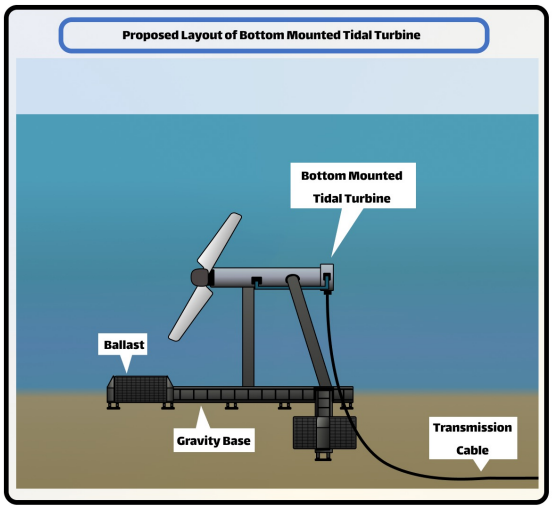
Coastal community & tidal energy



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

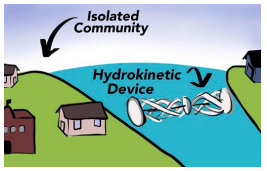




Coastal community & tidal energy

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



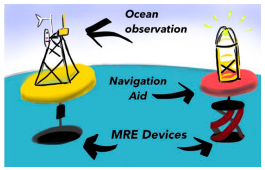
Sunflower sea star

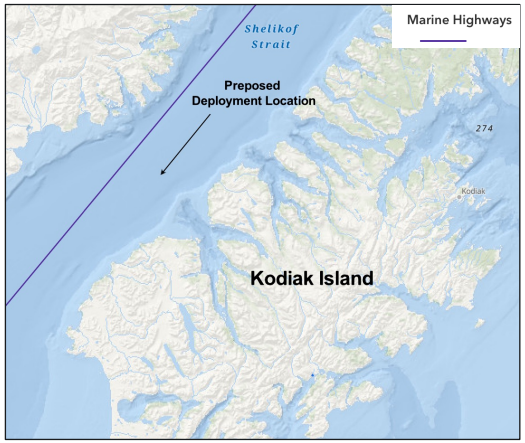
Eelgrass bed

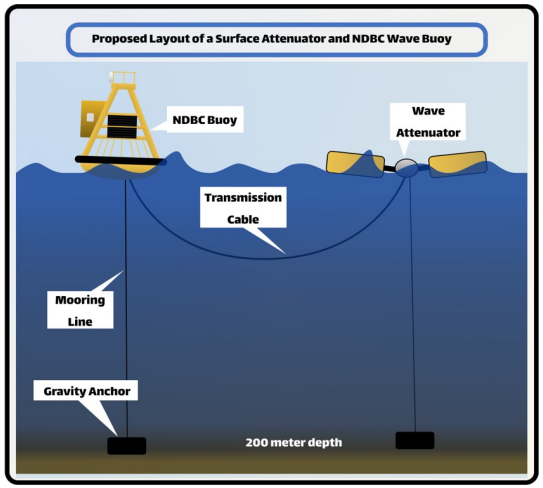
Power at sea & wave energy

The Hypothetical Project

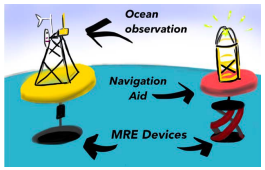
- Off-grid use – Power NDBC buoy in Shelikof Strait, AK
- Existing power sources –
  - 120 W solar PV panels with battery banks
  - Some buoys also equipped with wind turbines
- Power needs –
  - 5 W continuous (limited solar energy availability)
  - Additional power would increase number of sensors 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

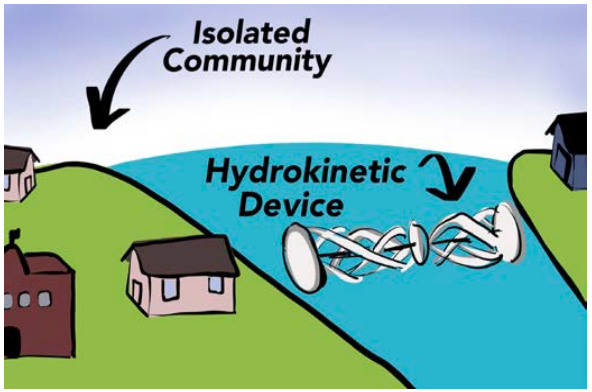
North Pacific right whale

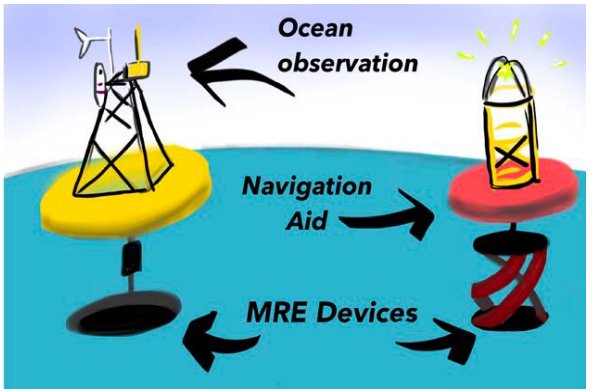
Questions for breakout group discussions

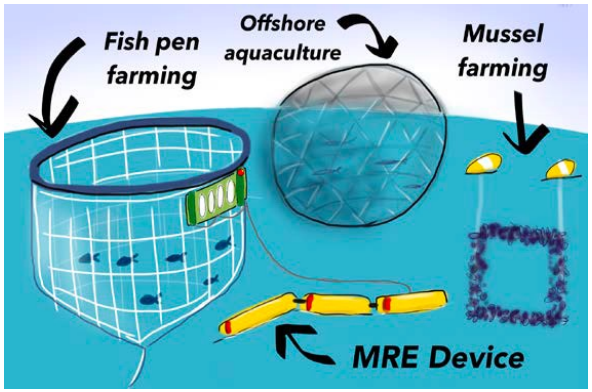
Questions we will address today:

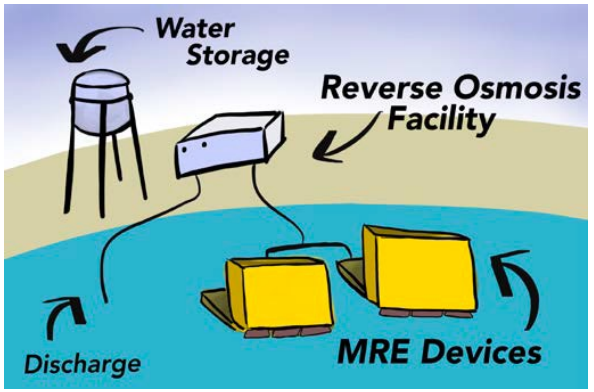
1. What environmental effects would be of greatest concern?
2. How would the environmental effects of small off-grid applications compare to those of utility-scale applications with (multiple) large devices?
3. Would off-grid applications be easier to implement than utility-scale projects? Why?
4. How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

Report out









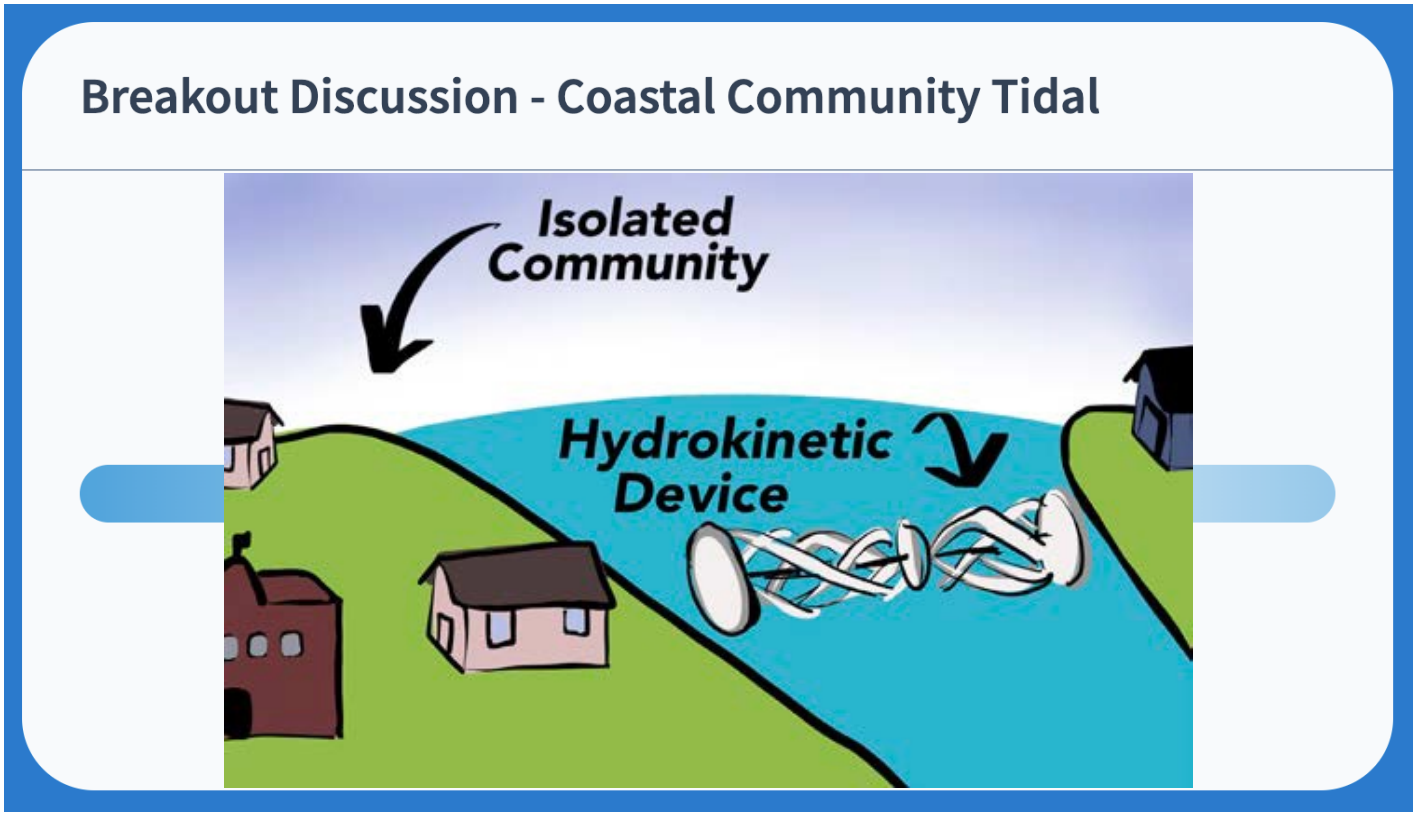
Illustrations by Molly Grear, PNNL

What stood out from your group?

Coastal community & tidal energy use case

Go to Poll Everywhere

PollEv.com/lenaighemery402

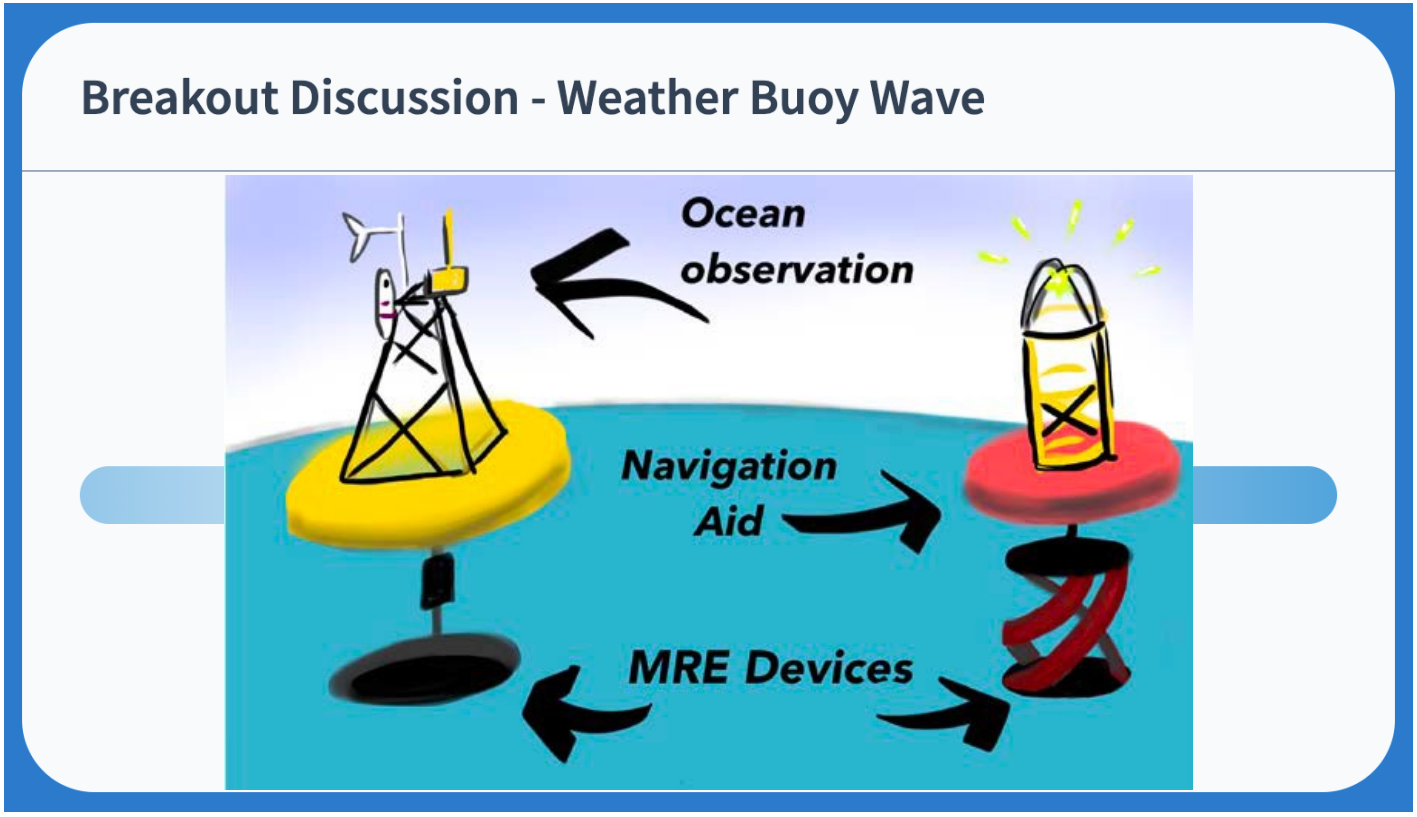


What stood out from your group?

Power at sea & wave energy use case

Go to Poll Everywhere

PollEv.com/tethyspnnl296

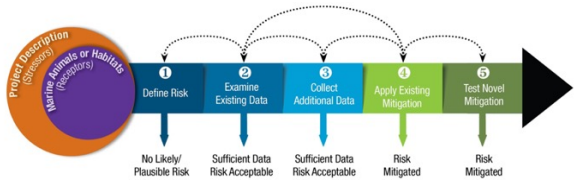


OES-Environmental resources

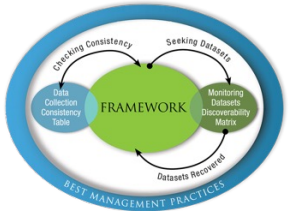
Moving from Science to Permitting

Available data and information

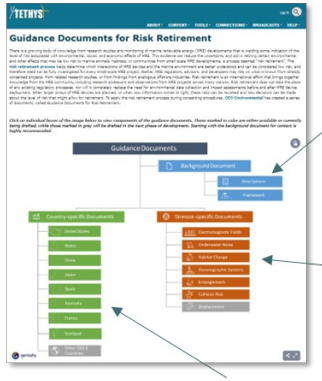
Evidence bases

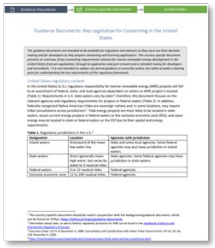


Risk retirement



Data transferability





Guidance documents

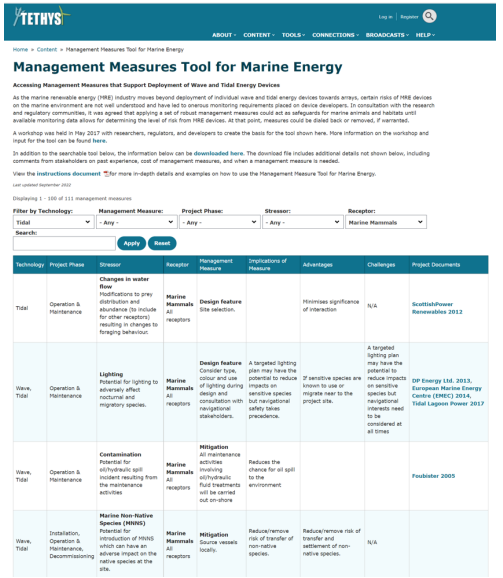
Feedback from marine energy community

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

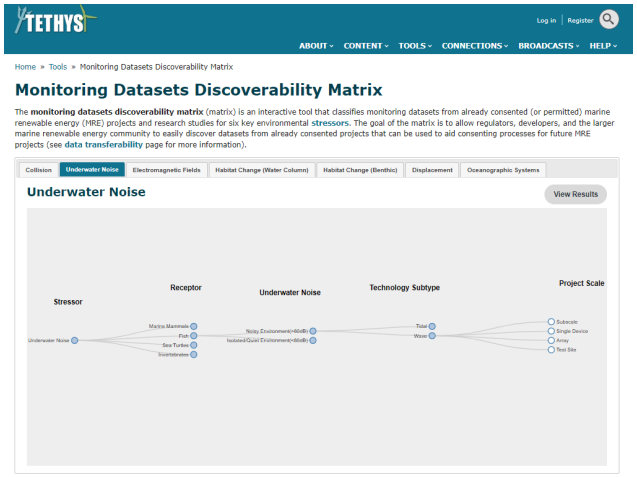
https://tethys.pnnl.gov/management-measures



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



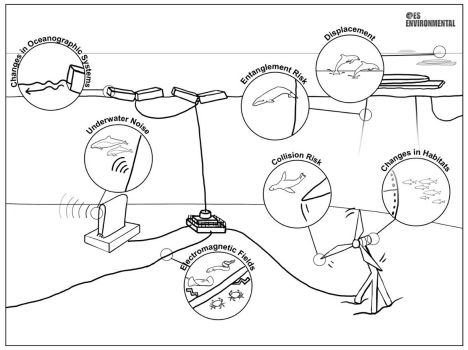
OES-Environmental resources

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

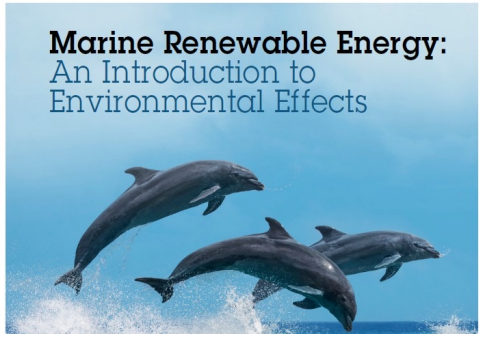


Marine Renewable Energy Coloring Book

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



Marine Renewable Energy 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

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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
lenaig.hemery@pnnl.gov

Please fill out our short survey!

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