

Workshop on Environmental Monitoring and Mitigation around Deployed Marine Energy Devices

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Workshop Agenda

Start Time	Agenda Topic
10:15	Introductions, purpose of the workshop
10:30	Examples of environmental monitoring and mitigation around projects
11:10	Best practices in monitoring
11:40	Role of research in supporting monitoring programs
11:50	Next steps
12:00	Adjourn

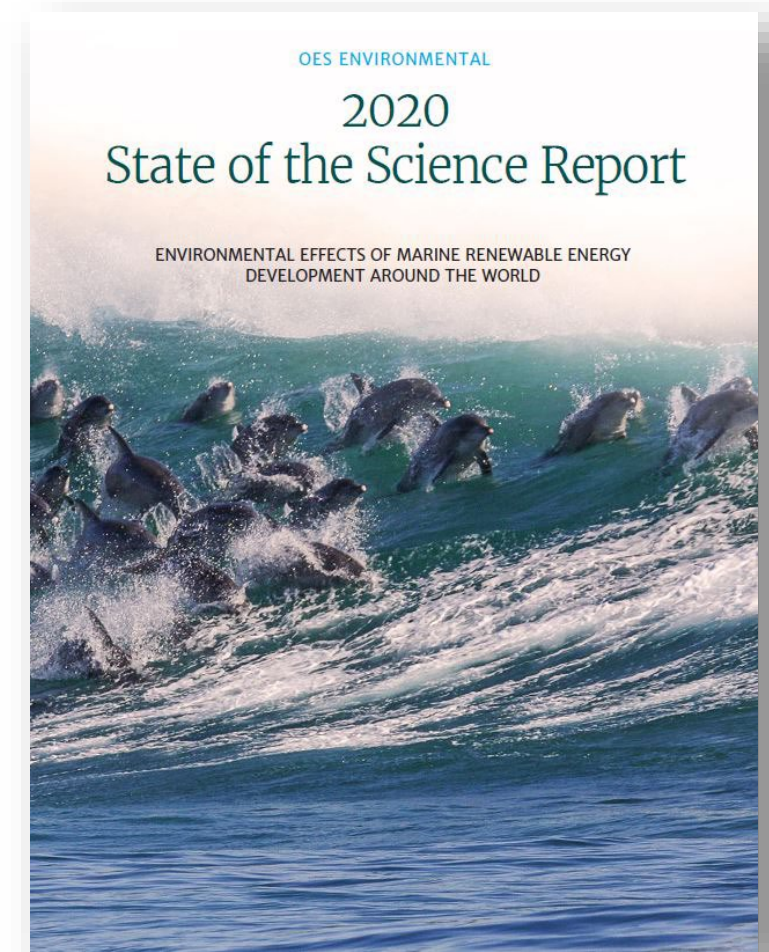
Questions we will address today:

- What and who drives specific monitoring data collection and analysis needs around a deployed device?
- What information can help focus these monitoring efforts?
- Are there other types of information that might be needed?
- How can we deliver this information for the good of the sector?
- How does these data prepare us for the leap to arrays?

OES-Environmental

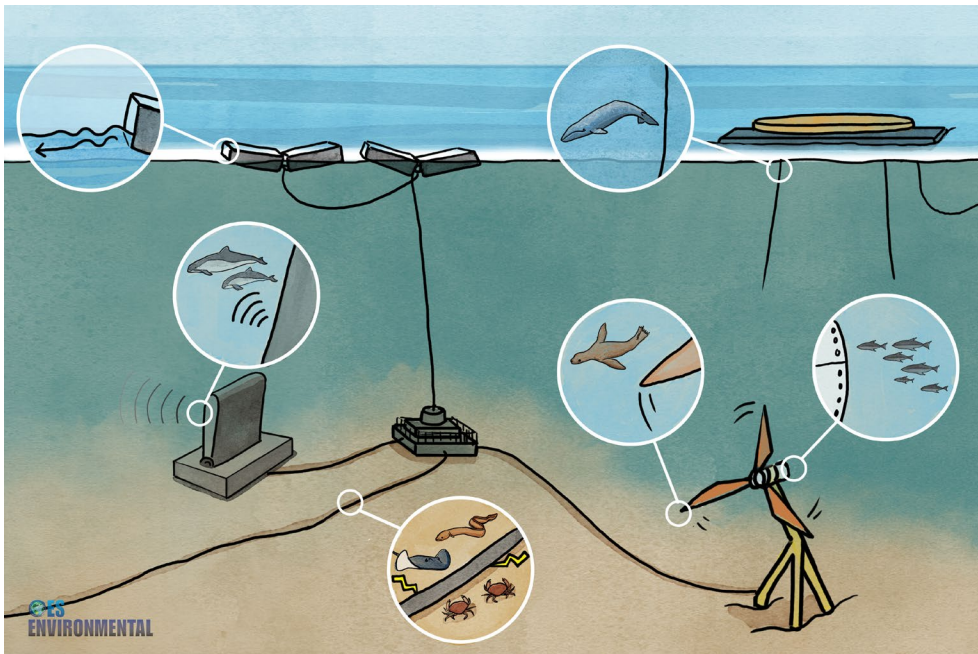


- Established by the IEA-Ocean Energy Systems in 2010
- Examines environmental effects of marine energy development to advance the industry in a responsible manner
- Led by the U.S. Department of Energy (DOE) Water Power Technologies Office and implemented by Pacific Northwest National Laboratory
- 16 member countries for Phase 4



Marine Energy & Environmental Effects

- Energy harnessed from waves and tides, and other moving water, gradients
- Early stages of development, deployment, and commercialization
- Environmental concerns continue to slow consenting/permitting worldwide



Key stressor-receptor interactions:



Collision risk



Entanglement



Underwater noise



Changes in oceanographic systems



Electromagnetic fields



Displacement



Habitat changes

Examples of Environmental Monitoring and Mitigation around Marine Energy Projects

- ORPC Maine, US
- ORPC Alaska, US
- Verdant, US
- CalWave, US
- PacWave, US
- SMEC, Canada
- Voith, Scotland
- Meygen, Scotland
- Morlais, Wales



<https://tethys.pnnl.gov/events/environmental-monitoring-around-deployed-marine-energy-devices>

ORPC Cobscook Bay, Maine

Developer: Ocean Renewable Power Company (ORPC)

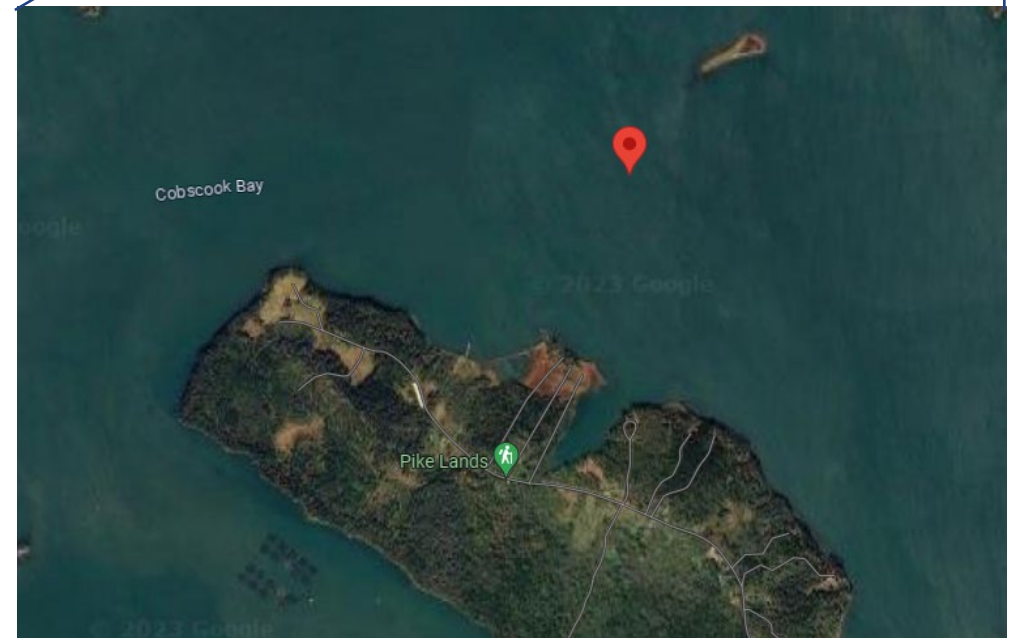
Regulators:

- Federal Energy Regulatory Commission (FERC)
- U.S. Fish and Wildlife Service (FWS)
- NOAA National Marine Fisheries Service (NMFS)
- NOAA Office of Protected Resources
- U.S. Coast Guard (USCG)
- U.S. Army Corps of Engineer (USACE)
- Maine Department of Environmental Protection
- Maine Department of Marine Resources

Location: Cobscook Bay, Maine

Generating capacity: Up to 750 kW

Permitting status: Permitted and reporting completed



ORPC Cobscook Bay, Maine

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Collision Risk	Marine mammal observation (MMO) during operation and maintenance	Visual observations and downward looking hydroacoustic surveys in and around project area	Evidence of marine mammal strike with vessels would need to be reported
Underwater Noise	Measurement of tidal device noise generated compared to ambient noise	In-air acoustic monitoring, hydroacoustic monitoring and drifting noise measurement	Any observation of impact on marine mammal and fish behavior would have to be reported
Benthic Impacts	Anti-fouling paint, buried seabed cable	Video recordings, benthic sampling and biofouling assessments	Disturbance to seabed causing adverse effects would need to be reported
Other Notables	Dedicated trained marine mammal observers, ADCP deployment	Trained observers aboard vessels, assessment of hydrodynamic changes	Any indication of displacement or altered hydrodynamics causing negative impacts on marine organisms would need to be reported

ORPC Cobscook Bay, Maine

Observations:

- **Mitigation and monitoring measures: what worked well, what didn't go to plan?**
 - Acoustic monitoring was delayed initially due to operational status and weather constraints
 - Benthic sampling was challenging at times due to constraints from strong tidal currents
- **Agreed mitigation and monitoring measures: key challenges and lessons learned**
 - Despite a few challenges such as electronic glitches, delayed monitoring start dates, and acoustic interference, monitoring went well, and adaptive management was employed throughout project duration
- **How mitigation and monitoring activities were funded: private, public, both?**
 - Public (U.S. DOE funding)



ORPC Igiugig, Alaska

Developer: Ocean Renewable Power Company (ORPC)

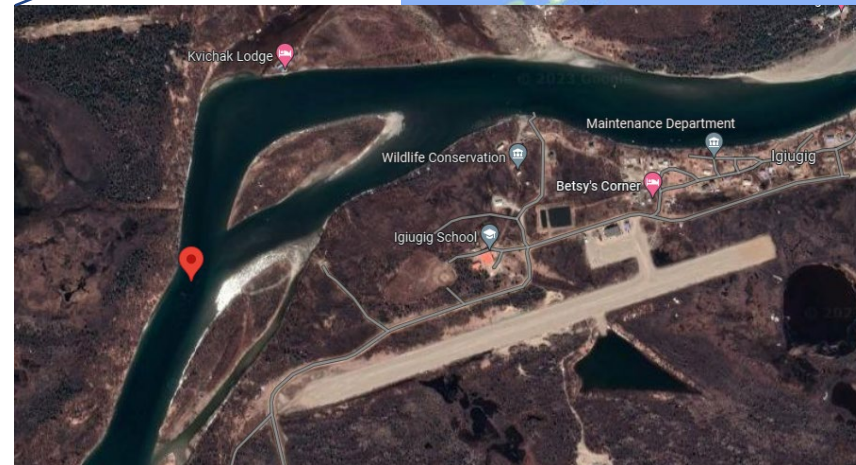
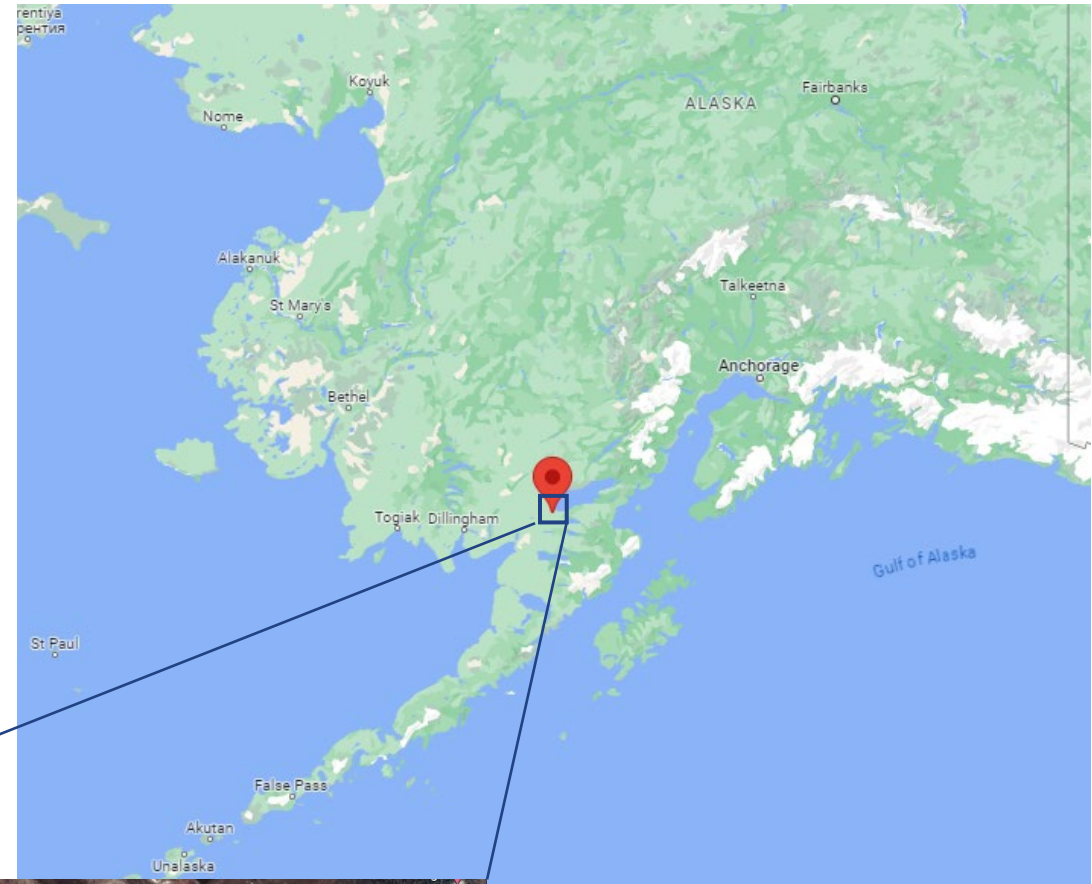
Regulators:

- FERC
- Igiugig Village Council
- Alaska Department of Fish and Game
- Alaska Department of Community and Economic Department

Location: Kvichak River, Igiugig, Alaska

Generating capacity: Up to 50 kW

Permit status: Permitted and reporting completed



ORPC Igiugig, Alaska

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Collision Risk	Reducing turbine speed or making it nonoperational during high fish passage periods	Underwater video monitoring for fish collision and fish behavior	Fish collision events and altered behavior would need to be reported, particularly those of sockeye salmon
Underwater Noise	N/A	N/A	N/A
Benthic Impacts	N/A	N/A	N/A
Other Notables	Consideration of turbine site selection, encapsulated generator for leak prevention	Flow conditions and inflow velocities measured	Any negative impacts due to changes in hydrodynamics would be reported

ORPC Igiugig, Alaska

Observations:

- **Mitigation and monitoring measures: what worked well, what didn't go to plan?**
 - Confirming fish collision events as strikes or near misses was challenging to differentiate
 - Fish could have been attracted to the lights used for night monitoring, affecting actual fish attraction/avoidance results
- **Agreed mitigation and monitoring measures: key challenges and lessons learned**
 - Monitoring went well and RivGen was found to have little negative impact on fish
 - Implemented a fish monitoring plan, adaptive management plan, project and public safety plan, and a navigation safety plan
- **How mitigation and monitoring activities were funded: private, public, both?**
 - Public (U.S. DOE funding)



Verdant, New York

Developer: Verdant Power LLC

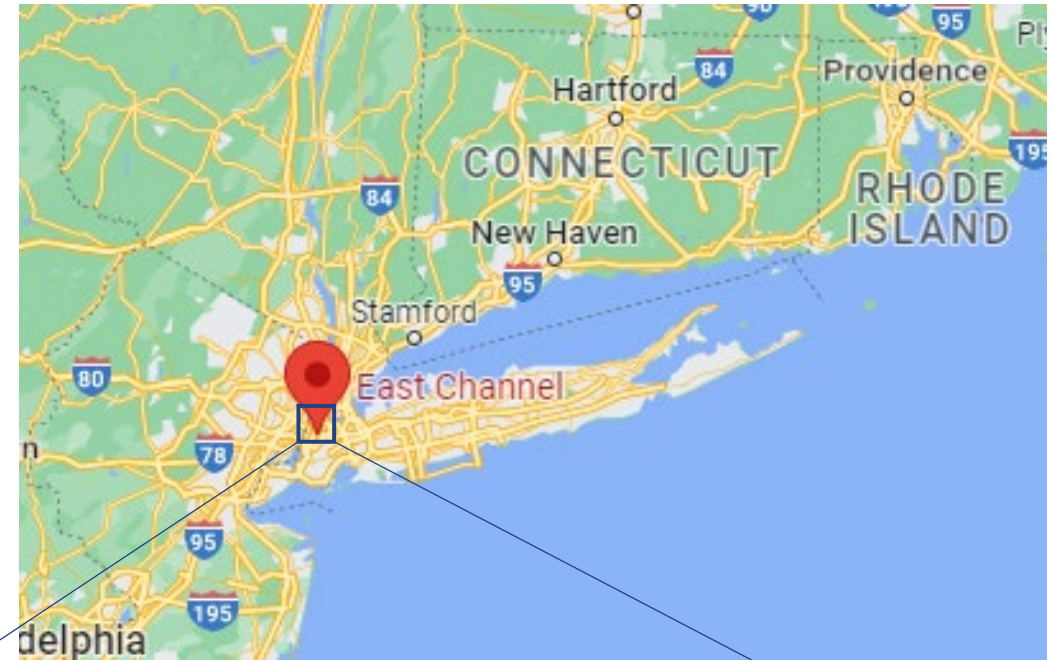
Regulators:

- FERC
- USACE
- NMFS
- New York State Energy Research and Development Authority
- New York State Department of Environmental Conservation
- Con Edison

Location: New York, New York

Generating capacity: 175 kW

Consent status: Permitted, reporting completed, project ended



Verdant, New York

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Collision Risk	Seasonal Dual-Frequency Identification Sonar (DIDSON) deployed	Fish movement studies using acoustic telemetry, Analysis of post-deployment multibeam hydroacoustic data,	Images taken of any fish interactions with the system
Underwater Noise	N/A	Underwater sound monitoring of turbines, observations	Observations of protected species must be recorded
Benthic Impacts	Electromechanical parts are low-voltage and in a sealed box	No post-deployment studies based on results of pre-deployment studies	N/A
Other Notables	Anti-fouling paint on turbines	Seasonal fixed hydroacoustic instruments deployed to show habitat change	Report detection of tagged (rare, threatened, endangered) species

Verdant, New York

Observations:

- **Mitigation and monitoring measures: what worked well, what didn't go to plan?**
 - The risk of collision for fish was retired based on monitoring, which showed little evidence of potential harm to fish species
- **Agreed mitigation and monitoring measures: key challenges and lessons learned**
 - The project met all set-out goals and was decommissioned in 2021 after becoming the U.S.'s first commercially-licensed tidal power project
- **How mitigation and monitoring activities were funded: private, public, both?**
 - Public (U.S. DOE funding, NY State Energy Research and Development Authority funding)



CalWave, California

Developer: CalWave

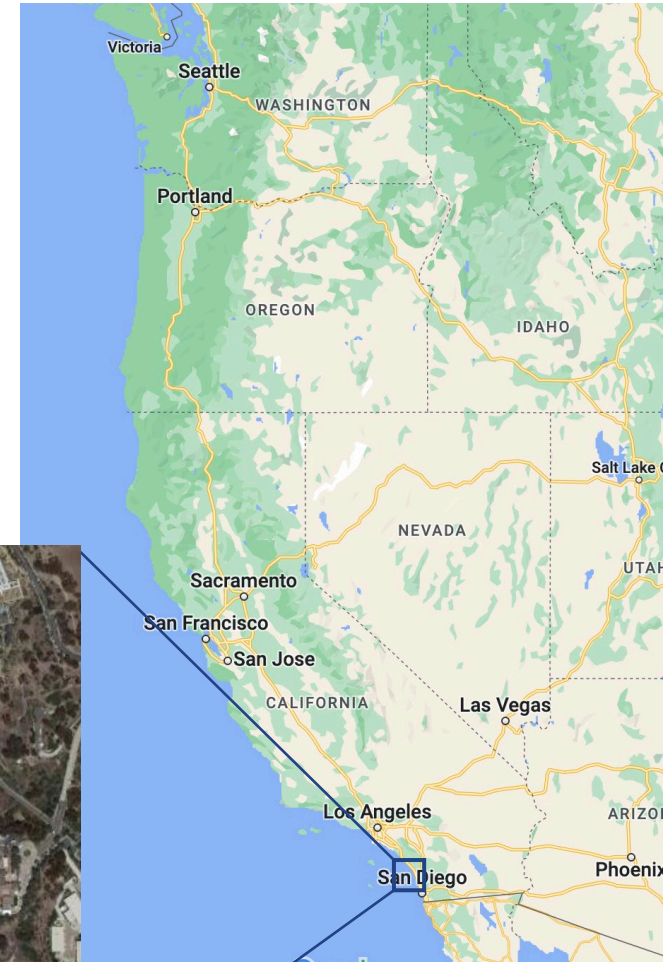
Regulators:

- NMFS
- USACE
- USCG Private Aids to Navigation (PATON)
- California Department of Fish and Wildlife
- California Water Boards

Location: La Jolla, California

Generating capacity: 15 kW

Permit status: Permitted, reporting completed, project ended



CalWave, California

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Animal Encounters	Device motion relative to surrounding wave environment	External onboard camera continuously observing moving components	Any unanticipated impact on ESA-listed species would have required reporting
Underwater Noise	Machinery located inside pressure hull	Drifting (days) and fixed (months) hydrophones	Any unanticipated impact on protected species would have required reporting
Benthic Impacts	Consideration in anchoring selection	360-degree video camera (days) observing anchors	Observations of any unanticipated changes from baseline
Other Notables	Taut mooring lines (minimizing entanglement risk) Vessel operations at test site deemed higher risk to marine life than deployed WEC itself	On-device video camera (all duration) Appropriately trained MMOs on board vessels; 500m distance from whales and 100m distance from marine mammals & sea turtles	Marine mammal observations and any unanticipated changes from baseline study Reporting of any suspected entanglement to NMFS would have been required

CalWave, California

Observations:

- **Mitigation and monitoring measures: what worked well what didn't go to plan?**
 - All monitoring efforts worked well, despite gradual degradation of image quality of the onboard external camera between months 8 and 10 of deployment due to biofouling
- **Agreed mitigation and monitoring measures: key challenges and lessons learned**
 - Due to the motion of the WEC being aligned with wave action, marine life appeared to move in unison with the WEC. No impacts were observed
 - Moving parts were largely self-cleaning as long as they were exercised periodically
- **How mitigation and monitoring activities were funded: private, public, both?**
 - Public (U.S. DOE funding) + Private (cost share)



PacWave, Oregon

Developer: Oregon State University

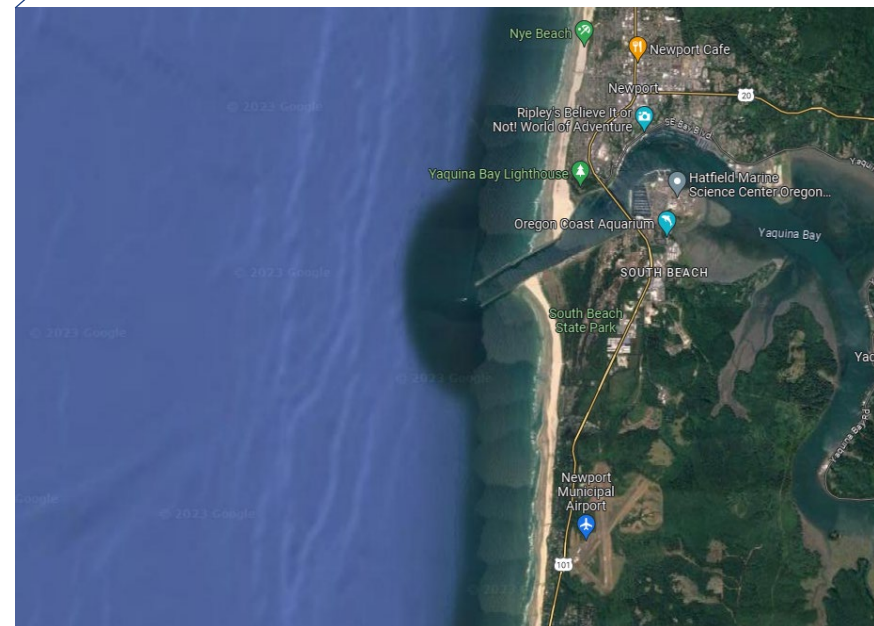
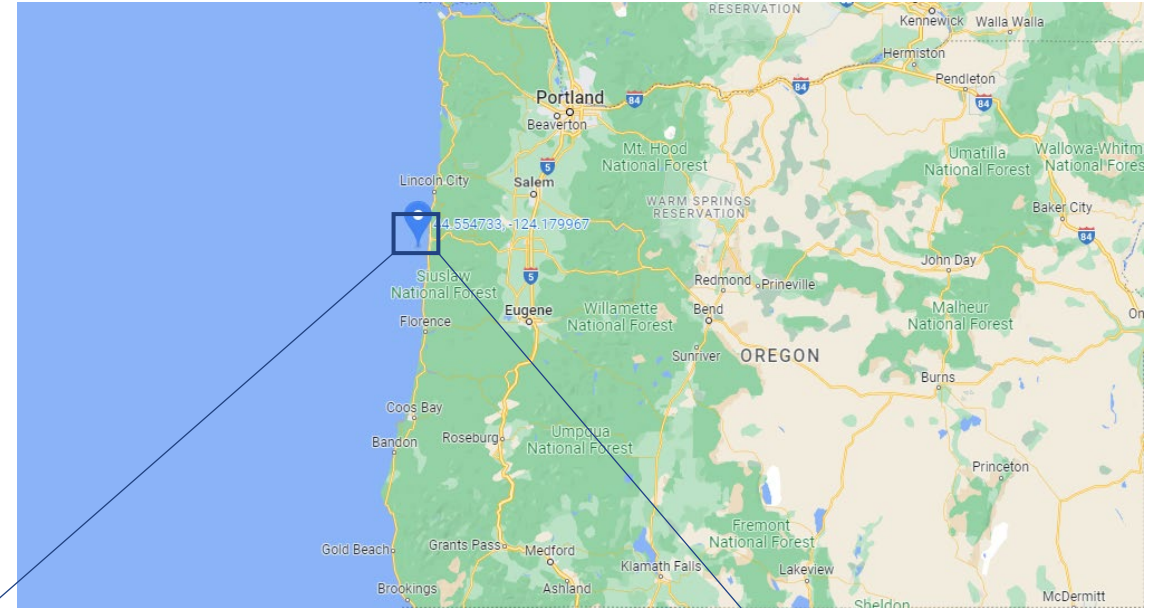
Regulators:

- FERC
- BOEM
- USACE
- USCG
- U.S. Department of Energy (DOE)
- National Park Service
- Oregon Department of Fisheries and Wildlife

Location: Newport, Oregon

Generating capacity: 20 MW (South site); 0.1 MW (North site)

Consent status: Permitted



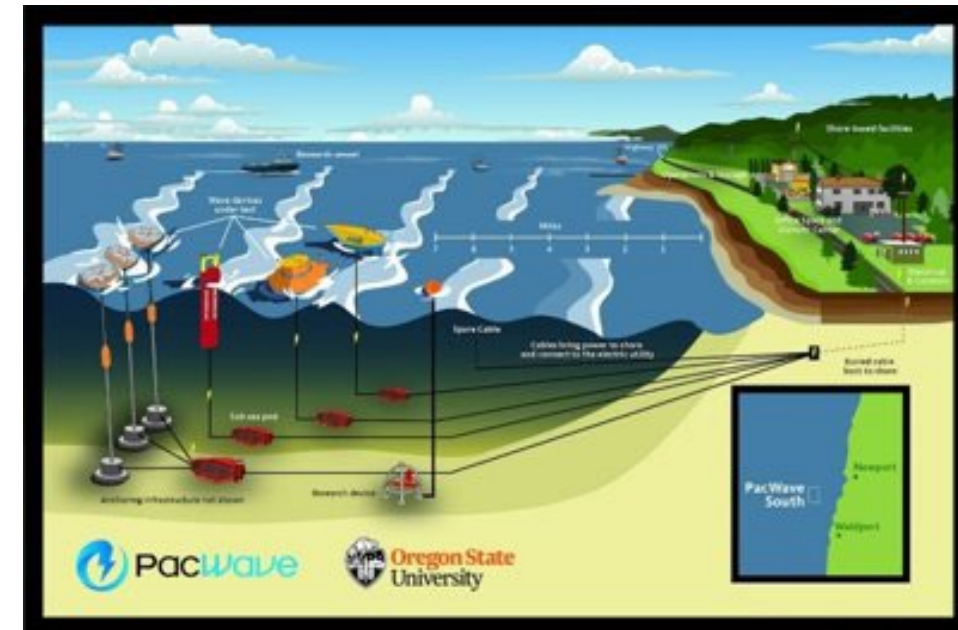
PacWave, Oregon

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Animal Encounters	Navigational markers and lighting (proposed)	Monitor for and remove entangled fishing gear, marine mammal observers	Observations of pinnipeds on project structures and marine mammal sightings
Underwater Noise	Implementation of noise controls (buffers/barriers)	Acoustic monitoring plan using moored autonomous underwater hydrophones and drifting hydrophones	Sound levels greater than 150 dB reported to NMFS within 48 hours
Benthic Impacts	N/A	Modeling to estimate anticipated EMF output and field measurements	EMF levels above 3 mT equal to or greater than 10 meters from the source reported to NMFS within 48 hours
Other Notables	Design and maintain cables and moorings in configurations that minimize entrapment or entanglement	Band transect surveys, box core samples, ROV with Tritech Gemini multibeam imaging sonar, trawling	N/A

PacWave, Oregon

Observations:

- **Mitigation and monitoring measures: what worked well, what didn't go to plan?**
 - South site (cabled to shore) still under construction, North site (not cabled) operational
 - Baseline monitoring completed at both sites; no device installed yet so no post-installation monitoring
- **Agreed mitigation and monitoring measures: key challenges and lessons learned**
 - Environmental concerns originally focused on devices and systems before shifting to specific stressor-receptor interactions
- **How mitigation and monitoring activities were funded; private, public, both?**
 - Public (U.S. DOE funding)



Grand Passage, Sustainable Marine Energy (Canada) Ltd.

Developer: Sustainable Marine

Regulator:

- Fisheries and Oceans Canada (DFO)

Location: Grand Passage, Nova Scotia

Generating capacity: 0.42 MW

Consent status: Permitted, reporting completed, project ended

FORCE application withdrawn in 2023

Sustainable Marine projects and facilities in Nova Scotia



Grand Passage, Sustainable Marine Energy (Canada) Ltd.

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Collision Risk	Daylight only operation, shutdown if 'Schedule 1 Species at Risk' is seen within 100 m	Collection and analysis of underwater video data and acoustic data, voluntary half-hourly marine animal observation	Quarterly underwater video and hydrophone data analysis and reporting issued to DFO
Underwater Noise	N/A	Collection and analysis of acoustic data	Quarterly hydrophone data analysis and reporting issued to DFO
Benthic Impacts	N/A	N/A	N/A
Other Notables	N/A	N/A	N/A

Grand Passage, Sustainable Marine Energy (Canada) Ltd.

Observations:

- **Mitigation and monitoring measures: what worked well what didn't go to plan?**
 - Underwater cameras functioned as expected; water clarity is variable
 - Hydrophone allowed assessment of device noise and detection of vocalizing mammals
- **Agreed mitigation and monitoring measures: key challenges and lessons learned**
 - Proponent proposed plan; some back-and-forth; decision-making somewhat opaque
- **How mitigation and monitoring activities were funded: private, public, both?**
 - Private initially; some activities part of research funded by Canadian government



Voith Hydro, Orkney

Developer: Voith Hydro

Regulator: Marine Scotland

Location: EMEC tidal test area, Fall of Warness, Orkney

Generating capacity: 1 MW

Consent status: Consenting completed in 2013 and reporting complete

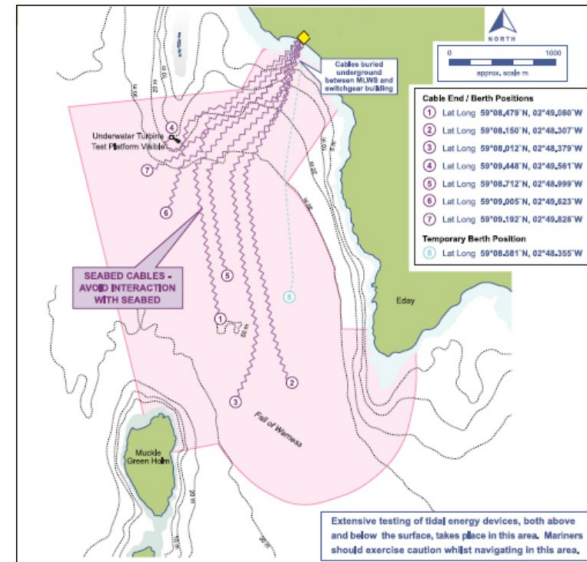
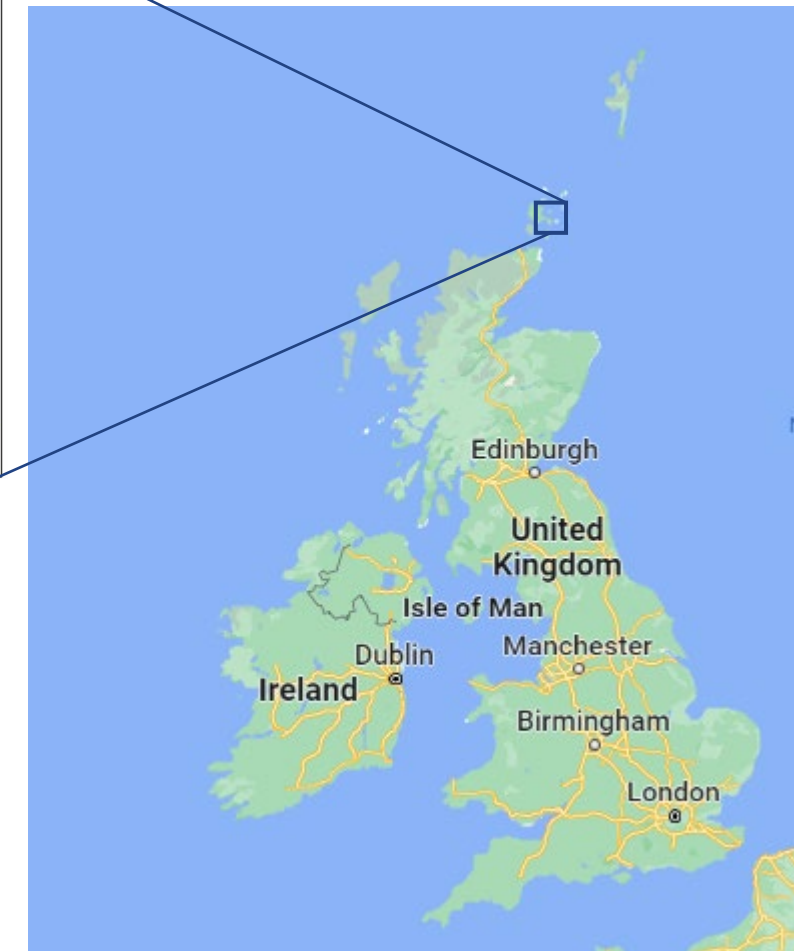


Figure 2: EMEC Fall of Warness tidal test site infrastructure



Voith Hydro, Orkney (UK)

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Collision Risk	Turbine soft starts during commissioning, minimize turbine standstill	Underwater video monitoring to investigate near field behavior	Soft start 'log' (6 months)
Underwater Noise	Drilling soft start, MMO during drilling (mitigation zone)	Acoustic monitoring during: <ul style="list-style-type: none"> - Drilling - Vessel thrusters - Above deck activities 	MMO report and acoustic monitoring report (8 weeks)
Benthic Impacts	Pre-construction ROV survey	Post-construction ROV survey	Pre-construction report (prior to installation), post-installation ROV report and 'as built plan' (28 days)
Other Notables	Vessel management plan agreed to reduce disturbance at seal haul outs	Seal haul out monitoring during installation activities, biofouling time lapse video	Environmental monitoring report (12 months)

Voith Hydro, Orkney (UK)

Observations:

- **Mitigation and monitoring measures: what worked well what didn't go to plan?**
 - Retired acoustic monitoring of vessel and drilling operations, 'soft starts'
 - Cameras worked but fouled quickly
- **Agreed mitigation and monitoring measures: key challenges and lessons learned**
 - Used permits at EMEC, iterative process with regulators
 - Strong policy support for tidal energy development at the time
 - Clear distinction made between monitoring and supplementary research
- **How mitigation and monitoring activities were funded: private, public, both**
 - All activities funded by developer



MeyGen, Pentland Firth

Developer: Atlantis Resources

Regulator: Marine Scotland, Scottish Ministers, Crown Estate

Location: Inner Sound, Pentland Firth, Scotland

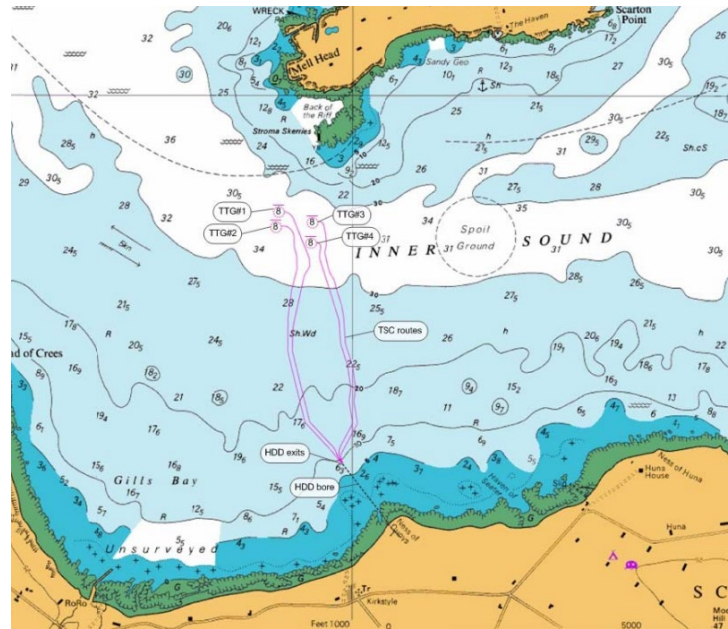
Generating capacity:

Phase 1 – 6 MW installed to date

Phase 2 – additional 80 MW

Phase 3 – total 398 MW

Consent status: Consent granted for up to 86 MW generating capacity, conditional on staged deployment



Meygen, Pentland Firth (UK)

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Collision Risk	N/A	Survey Deploy Monitor strategy, marine mammal monitoring program, seal tagging, shoreline monitoring, active acoustics	Environmental Mitigation and Monitoring Plan (EMMP)
Underwater Noise	N/A	Operational noise monitoring, noise modelling	EMMP
Benthic Impacts	Minimize footprint of foundation piles, minimize cable voltage to reduce EMF, increase length of drilled cables	Habitat monitoring, dispersion of drill cuttings during HDD, visual survey	EMMP
Other Notables	N/A	Passive acoustic monitoring, boat-based surveys, ERI survey, multi-beam echo sounder, side scan sonar	Project Environment Monitoring Programme

Meygen, Pentland Firth (UK)

Observations:

- **Mitigation and monitoring measures: what worked well what didn't go to plan?**
 - Evidence of avoidance behaviour by harbour porpoise (key papers published)
- **Agreed mitigation and monitoring measures: key challenges and lessons learned**
 - Project steering group determined environmental monitoring
 - Demonstrated the 'survey, deploy and monitor' approach
 - Need for data collected to inform future arrays
- **How mitigation and monitoring activities were funded: private, public, both?**
 - Combination of private and public funding



Anglesey Marine Energy: Morlais

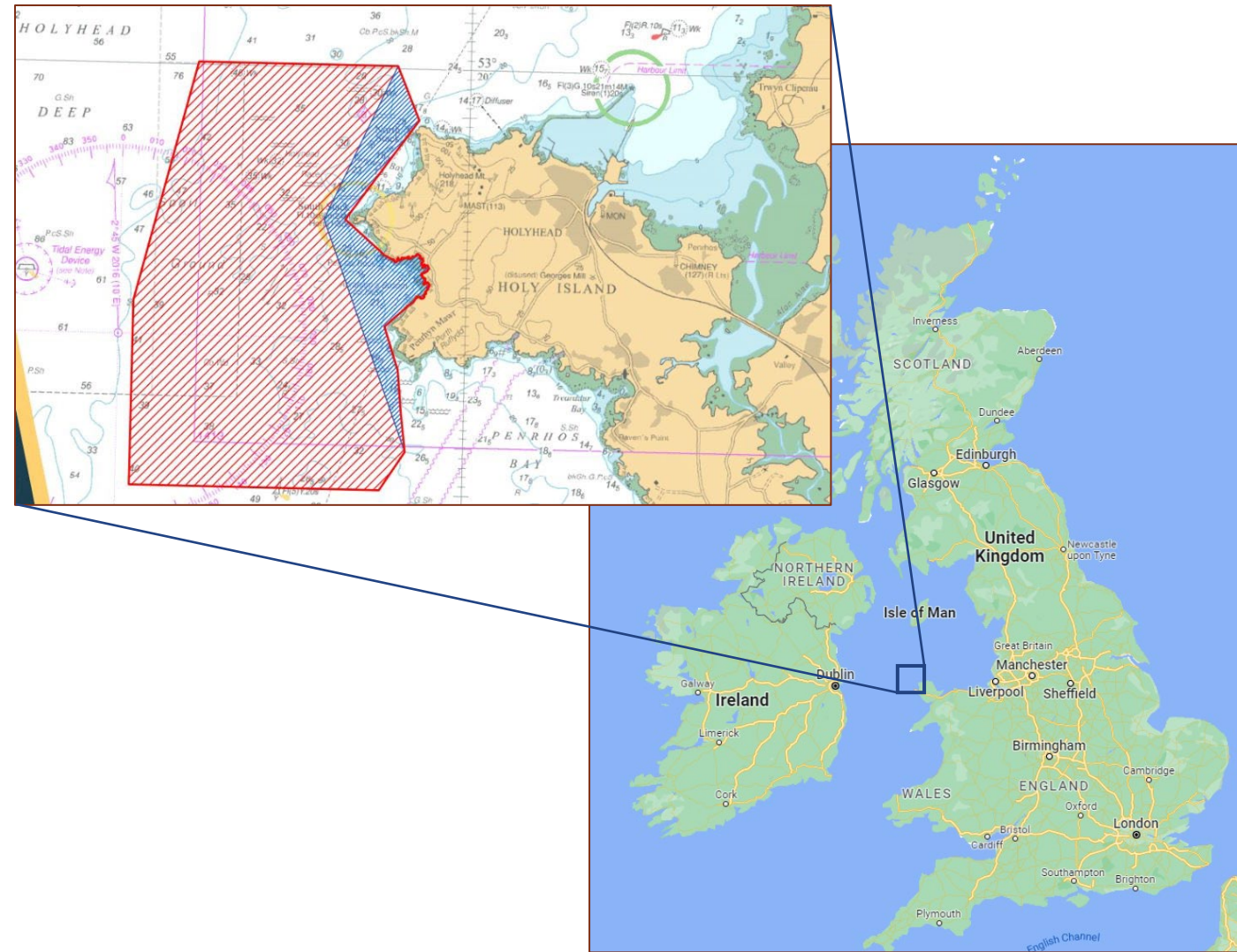
Developer: Menter Môn (not for profit, 3rd sector)

Regulator: Natural Resources Wales

Location: 35 km² area of seabed off the coast of Holy Island, Anglesey (within the West Anglesey Demonstration Zone (WADZ))

Generating capacity: 240 MW

Consent status: consent was awarded in December 2021.



Morlais Demonstration Zone, Anglesey (UK)

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Collision Risk	Acoustic deterrent devices, visual deterrents	PAM, active sonar, surface/underwater cameras, vantage point survey, colony counts	To be completed, EMMP in development
Underwater Noise	Marine mammal mitigation plan	Noise quantification & spatial distribution	To be completed, EMMP in development
Benthic Impacts	Pre-construction surveys/micro siting	N/A	N/A
Other Notables	To be completed in EMMP	To be completed in EMMP	To be completed, EMMP in development

Morlais Demonstration Zone, Anglesey (UK)

Observations:

- **Mitigation and monitoring measures: what worked well what didn't go to plan?**
 - N/A
- **Agreed mitigation and monitoring measures: key challenges and lessons learned**
 - Advisory Group determined priority questions and indicators
 - Baseline data and other technical work programs underway
- **How mitigation and monitoring activities were funded: private, public, both?**
 - Private and public funding for development of site.

Group Discussion

Questions we will address today:

- What and who drives specific monitoring data collection and analysis needs around a deployed device?
- What information can help focus these monitoring efforts?
- Are there other types of information that might be needed?
- How can we deliver this information for the good of the sector?
- How does these data prepare us for the leap to arrays?



Research to Support Permitting, Successful Projects

- Focus on information gaps based on regulator needs
- Focus on interactions with greatest uncertainty
- Consider monitoring for scale of project (single device versus arrays)
- Consider regional requirements if appropriate (such as European Directives)





Notable Processes and Resources

- Risk retirement, data transferability, guidance documents
 - <https://tethys.pnnl.gov/risk-retirement>
 - <https://tethys.pnnl.gov/data-transferability>
 - <https://tethys.pnnl.gov/guidance-documents>
- Management measures (aka mitigation)
 - <https://tethys.pnnl.gov/management-measures>
- Upcoming:
 - Case studies (examples) of applying data transferability to risk retirement
 - Workshop for developers (?)

Next Steps

- Update critical evidence needs for US and in the global context
- Develop a description, commonalities, differences, among permitted projects for 2024 State of Science
- Enhanced collaboration and exchange between monitoring and research teams



Feedback Survey

Please fill out our short survey!



Thank you!

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