Environmental Monitoring for Marine Energy – Instrumentation for Devices and Arrays

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Workshop Agenda

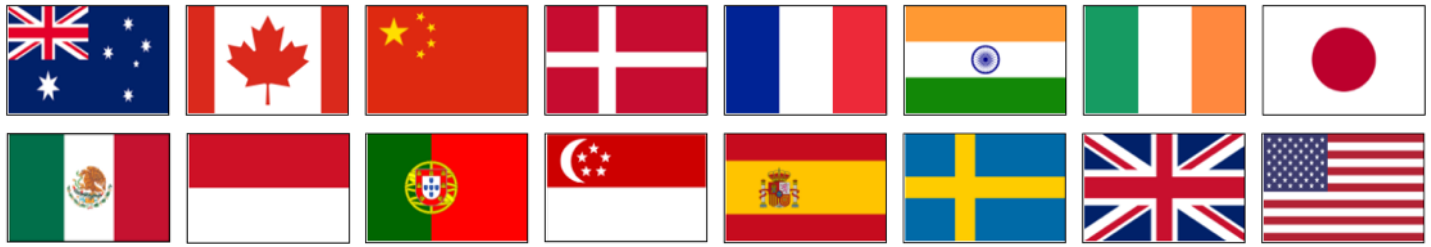
Start Time	Agenda Topic
16:00	Introductions, Purpose of the Workshop
16:10	Monitoring Plans Collision Risk Instruments + Platforms Acoustic Instruments Scenarios
16:35	Breakout Discussions
17:15	Report Out
17:25	Next Steps
17:30	Adjourn

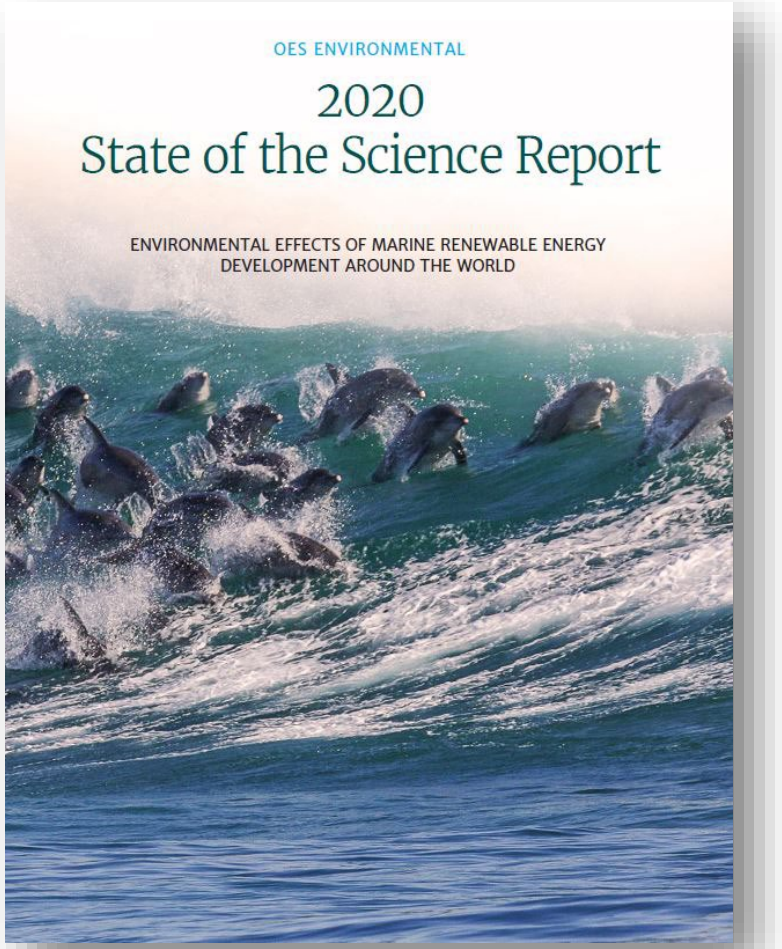
Questions we will address today:

- How do we collect data at the scale of one device (or small array)?
- How can the data from the initial deployment be interpreted for the next (larger) phase?
- How will these data be collected as we scale up to the next phase?
- How do we avoid a DRIP (data rich/information poor) issue and collect meaningful data?
- What should guidance on the proper use of monitoring systems include/look like?
- What should guidance on the development and management of an effective monitoring/management plan include/look like?

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

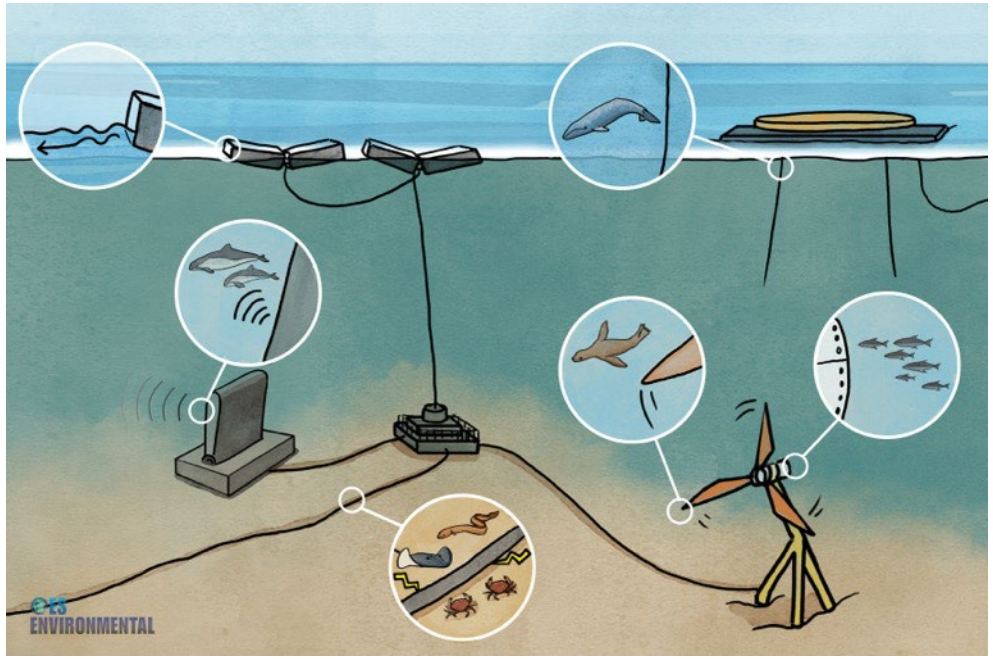




https://tethys.pnnl.gov/about-oes-environmental

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
- Underwater noise
- Electromagnetic fields
- Habitat changes
- Entanglement
- Changes in oceanographic systems
- Displacement

https://tethys.pnnl.gov/publications/state-of-the-science-2020

Examples of Environmental Monitoring and Mitigation around Marine Energy Projects

Verdant, New York (USA)

Developer: Verdant Power LLC

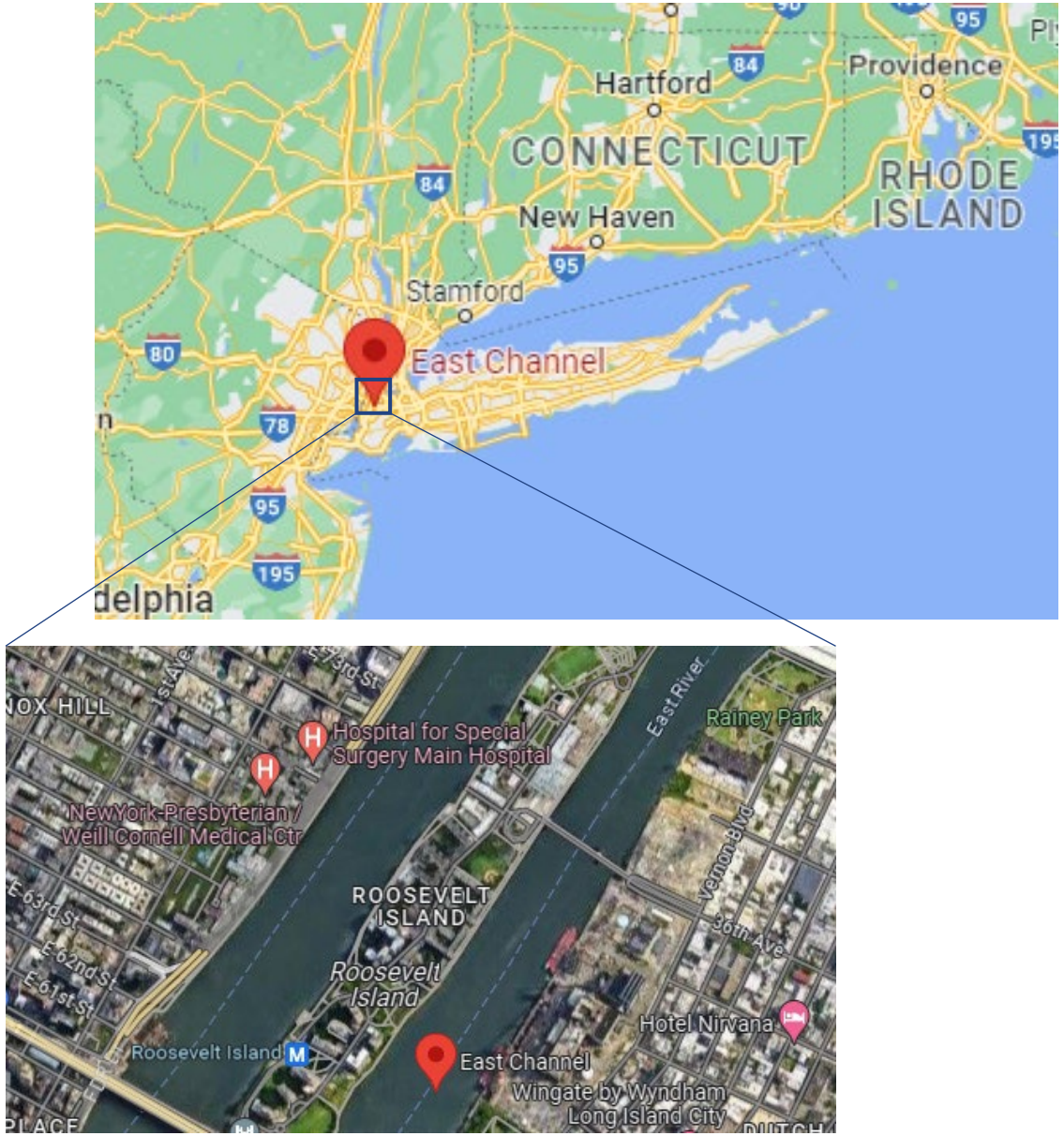
Regulators:

- 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 (USA)

	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

- The risk of collision for fish was retired based on monitoring, which showed little evidence of potential harm to fish species
- The project met all set-out goals and was decommissioned in 2021 after becoming the U.S.'s first commercially-licensed tidal power project
- Mitigation and monitoring were publicly funded by U.S. DOE

CalWave, California (USA)

Developer: CalWave

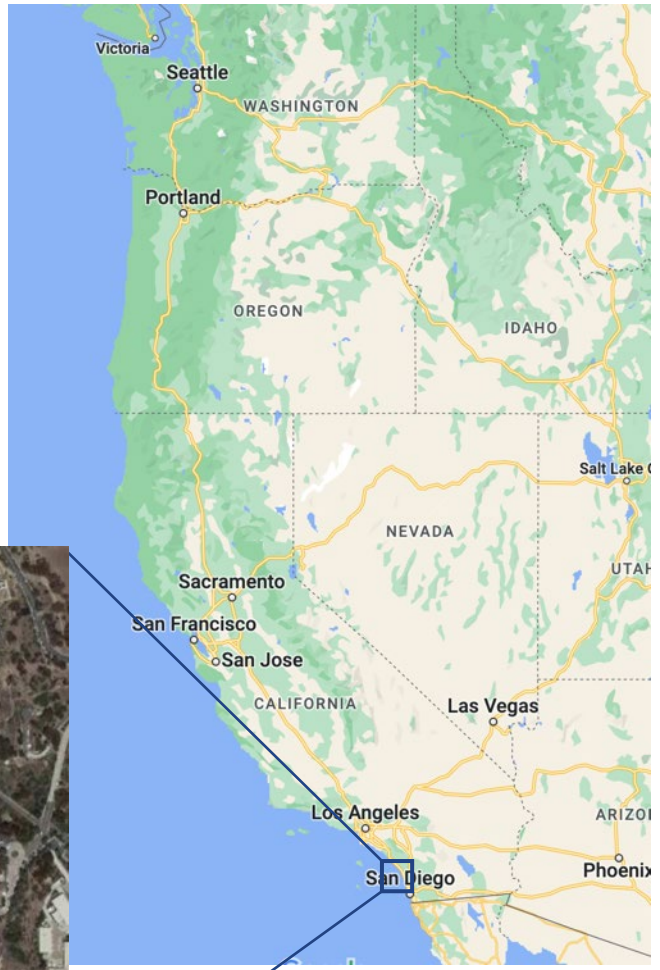
Regulators:

- 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 (USA)

	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Underwater Noise	Machinery located inside pressure hull	Drifting (days) and fixed (months) hydrophones Appropriately trained MMOs on board vessels; 500m distance from whales and 100m distance from marine mammals & sea turtles	Any unanticipated impact on protected species would have required reporting

- 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
- 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
- Mitigation and monitoring publicly funded by U.S. DOE and privately through cost share

MeyGen, Pentland Firth (UK)

Developer: Atlantis Resources

Regulator: Marine Scotland, Scottish Ministers, Crown Estate

Location: Inner Sound, Pentland Firth, Scotland

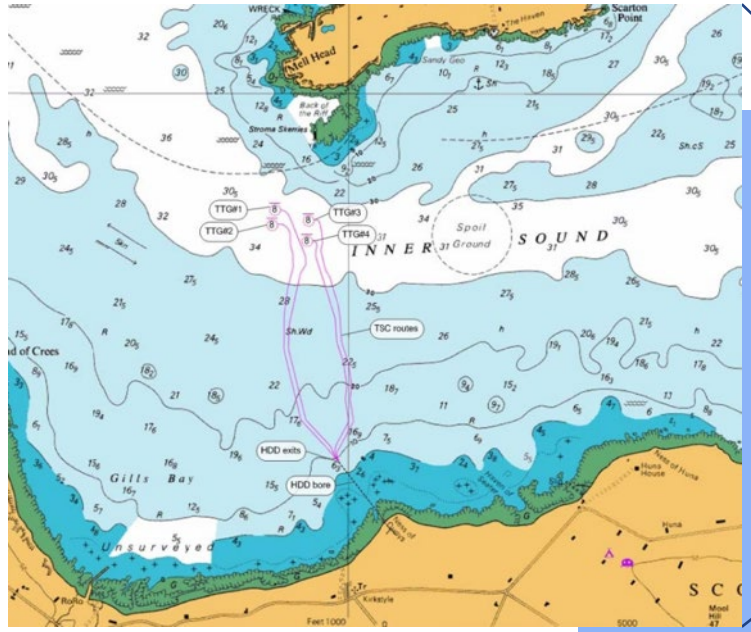
Generating capacity:

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

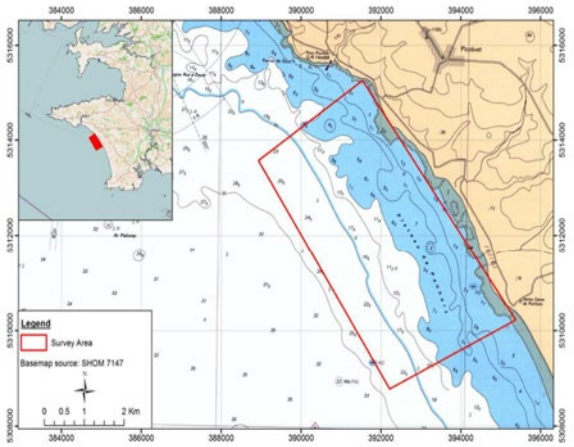


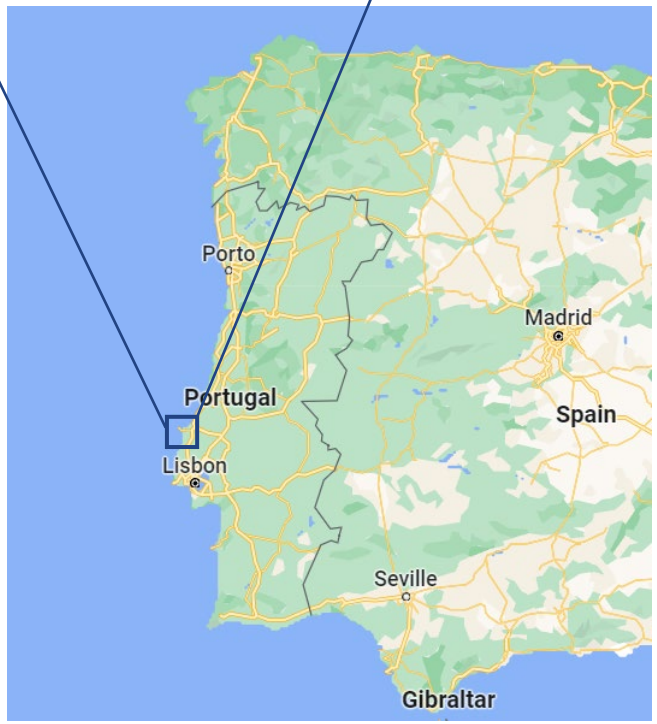
Meygen, Pentland Firth (UK)

	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 Passive acoustic monitoring for animal presence	EMMP

- Evidence of avoidance behaviour by harbour porpoise (SMRU, St. Andrews Univ)
- Project steering group determined environmental monitoring
- Demonstrated the ‘survey, deploy and monitor’ approach
- Need for data collected to inform future arrays
- Combination of private and public funding

WaveRoller (Portugal)





Developer: AW-Energy

Regulator: Comissão de Coordenação e Desenvolvimento Regional (CCDR) de Lisboa e Vale do Tejo

Location: Peniche, Portugal

Generating capacity: rated for 500kW – 1000kW

Consent status: Consent granted and license continued

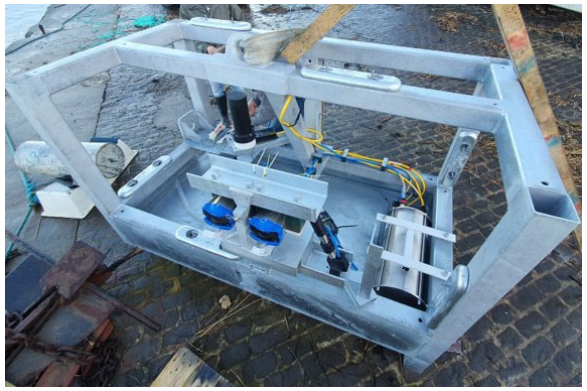
WaveRoller (Portugal)

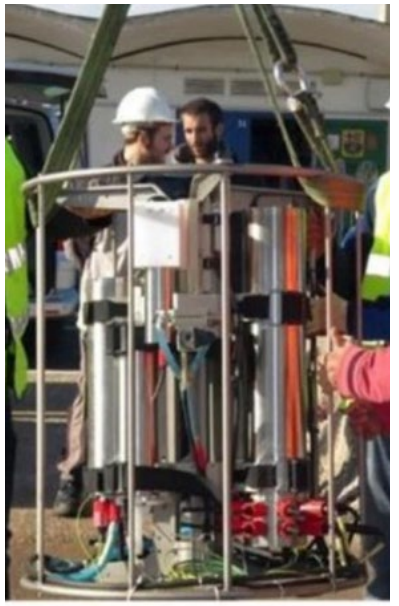
	Mitigation Measures	Monitoring Requirements	Reporting Requirements
Underwater Noise	N/A	Operational noise monitoring for marine mammals	N/A – consent focused on environmental impacts in installation

- Operational monitoring confirmed no impact on marine mammals, used existing noise exposure criteria for behavior and injury
- Device installed at lower depths than used by cetacean species – results in less likely impacts despite noise detectability
- Acoustic monitoring was funded by the developer, AW-Energy and supported by the SURGE project funded by the European Commission

Instruments and Platforms for Collision Risk

- FlowBec – UK
- AMP – US
- Fast EMS – Canada
- HiCUP – UK
- IMP – UK
- EMSO – Spain





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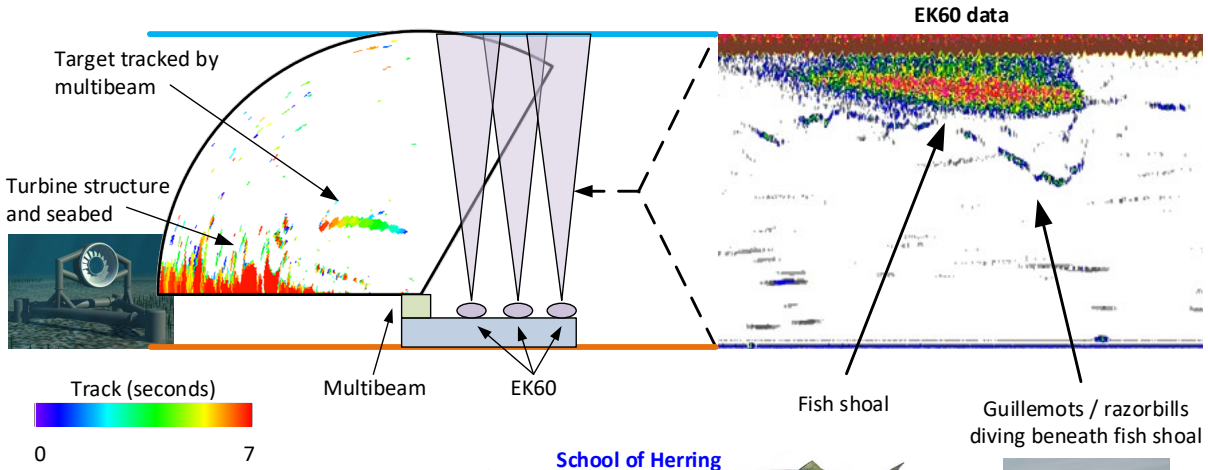
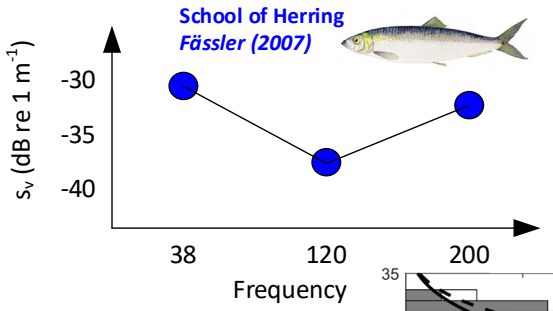
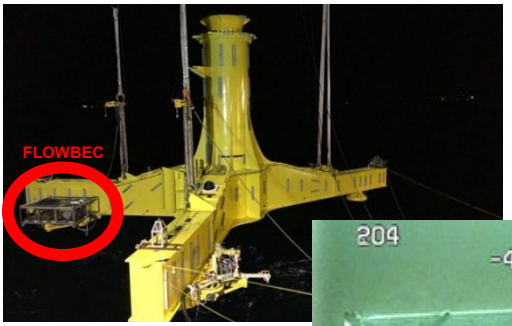
FLOWBEC Monitoring Platform

- Sensor fusion for multi-trophic automated detection and tracking
  - Fish/prey, diving seabirds, marine mammals
- Vertical echosounder (full water column, detection across flow)
- Vertical imaging sonar (animal movement, behaviour)

- Document encounters (collision risk, evasion) but also
  - behaviour (e.g., against flow, foraging, attraction)
  - predictability (biophysical and predator-prey drivers)
  - transferability (mechanisms)







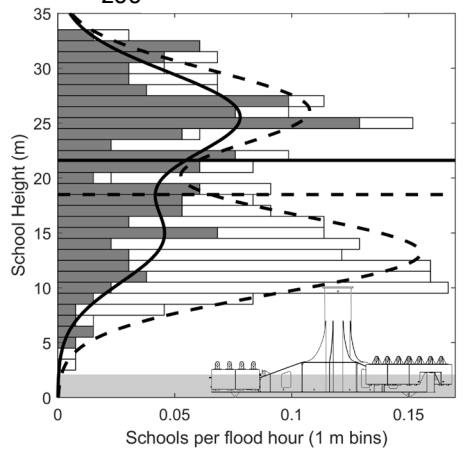
Cabled for MRED nearfield, evasion, encounter, collision risk…

e.g., 21-months at MeyGen

Self-contained (66 kWh batteries, onboard processing)

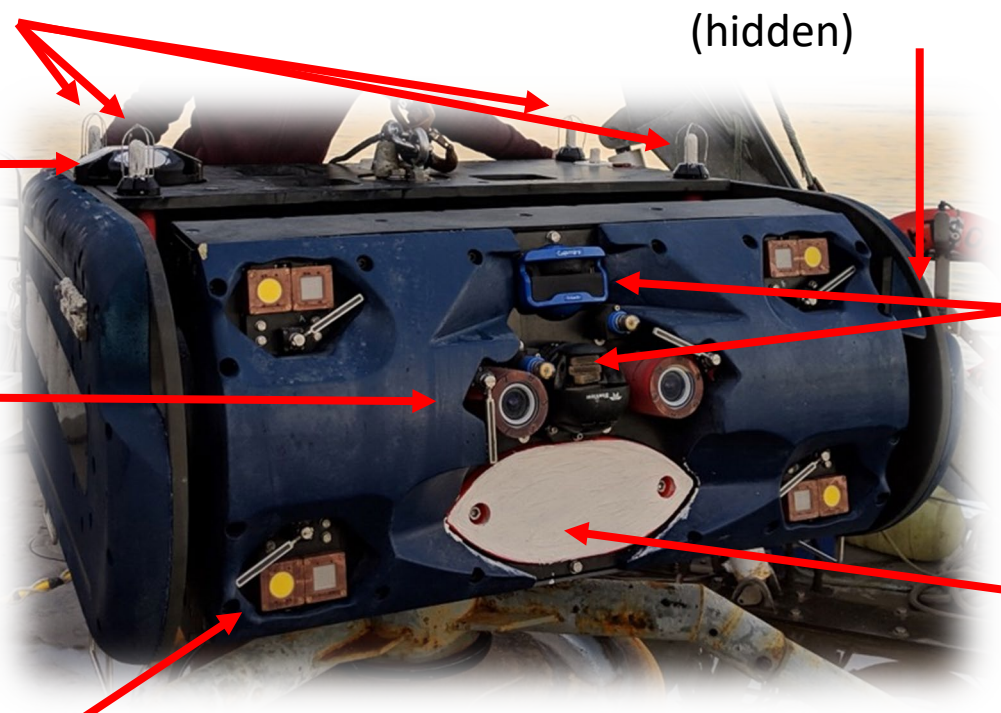
Baseline, floating, array-scale effects, disturbance / displacement, …

Previously EMEC wave/tidal, MeyGen 2015



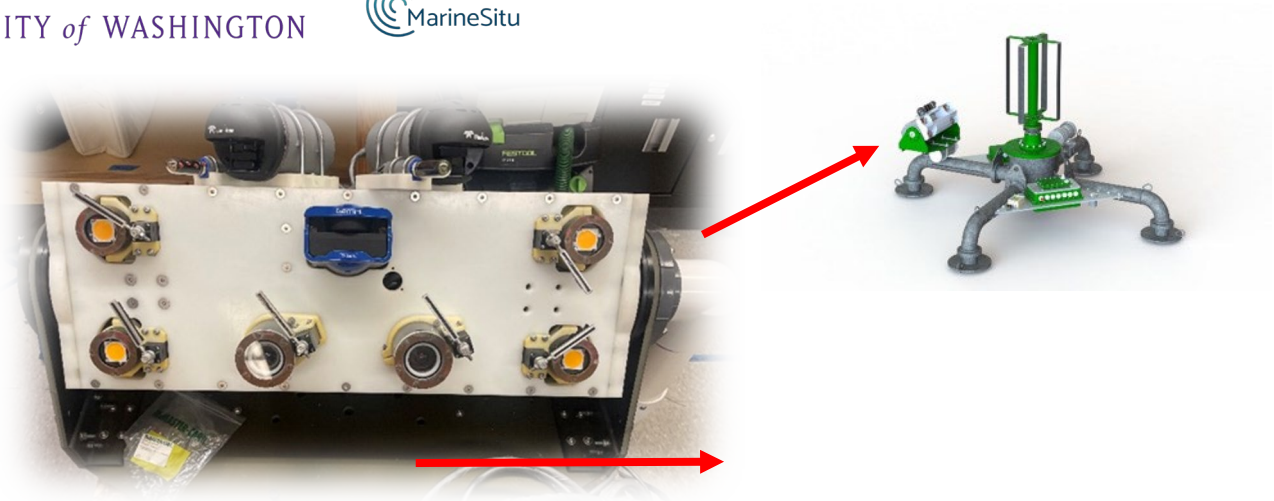
http://doi.org/10.1002/ecs2.4080 Predator-prey biophysical links
http://doi.org/10.1093/icesjms/fsab017 Imaging sonar animal behaviour
http://doi.org/10.1016/j.renene.2019.04.065 Fish changes around turbine
http://doi.org/10.1109/JOE.2016.2637179 Acoustic sensor fusion
http://dx.doi.org/10.1109/JOE.2015.2410851 Platform design

Adaptable Monitoring Package (AMP)



Biofouling mitigation: Mechanical wipers and UV lights

See Polagye et al. (2020): "Adaptable Monitoring Package Development and Deployment: Lessons Learned for Integrated Instrumentation at Marine Energy Sites"



Turbine Lander (Oct. ‘23)

Post ~6 mo. in Sequim Bay

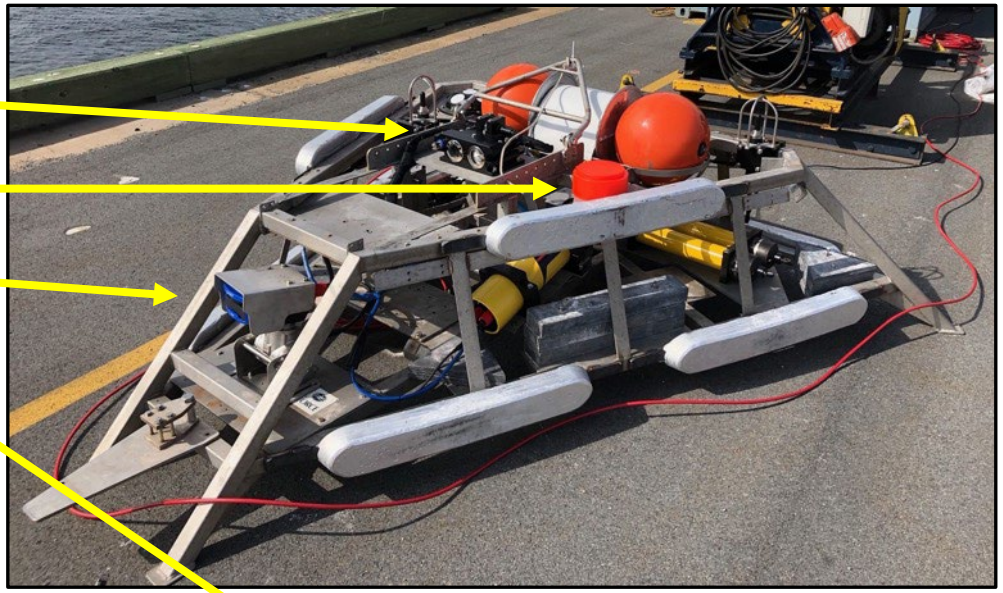
Oscilla Triton-C (currently installed & awaiting deployment)

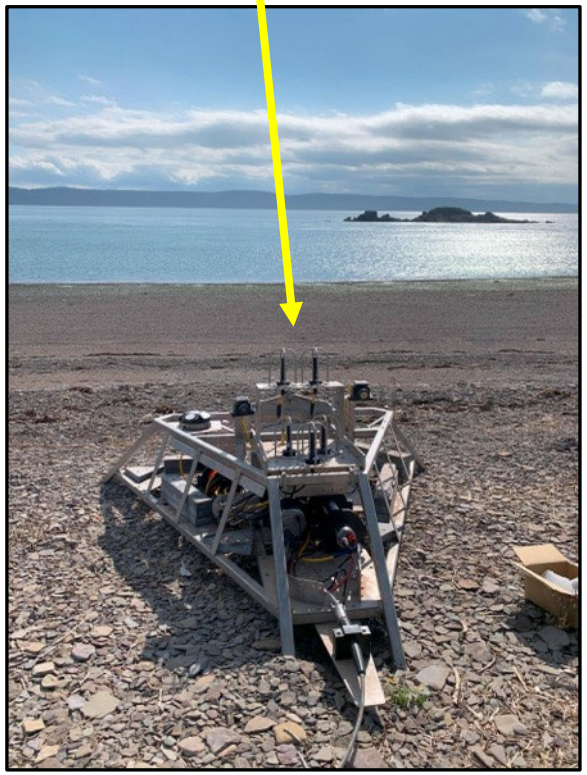
Fred.Olson Lifesaver (WETS)

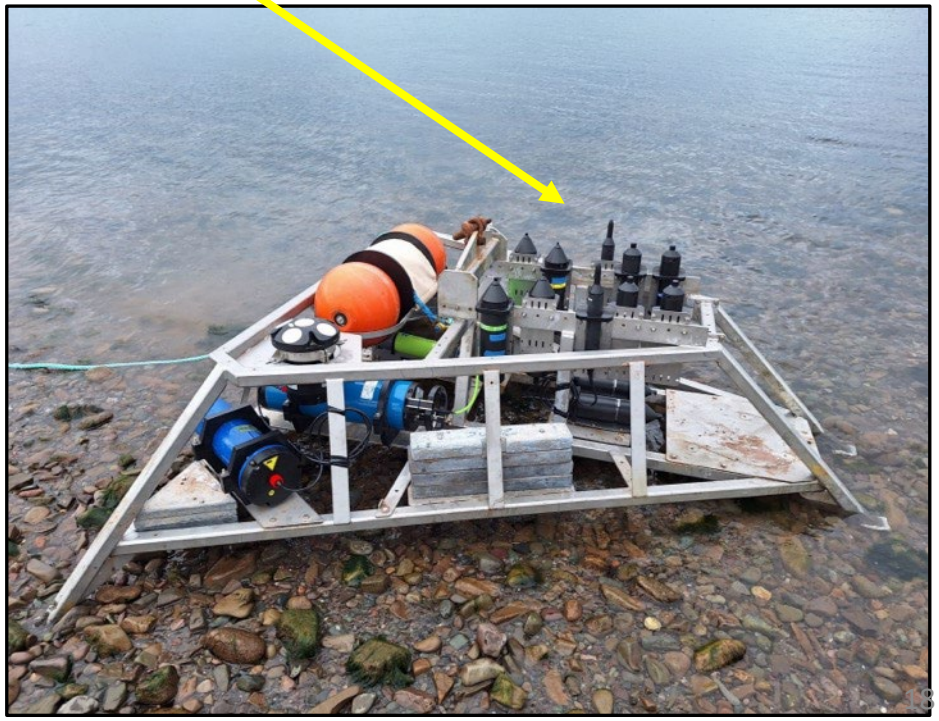
force | Fundy Ocean Research Centre for Energy

FUNDY ADVANCED SENSOR TECHNOLOGY (FAST)

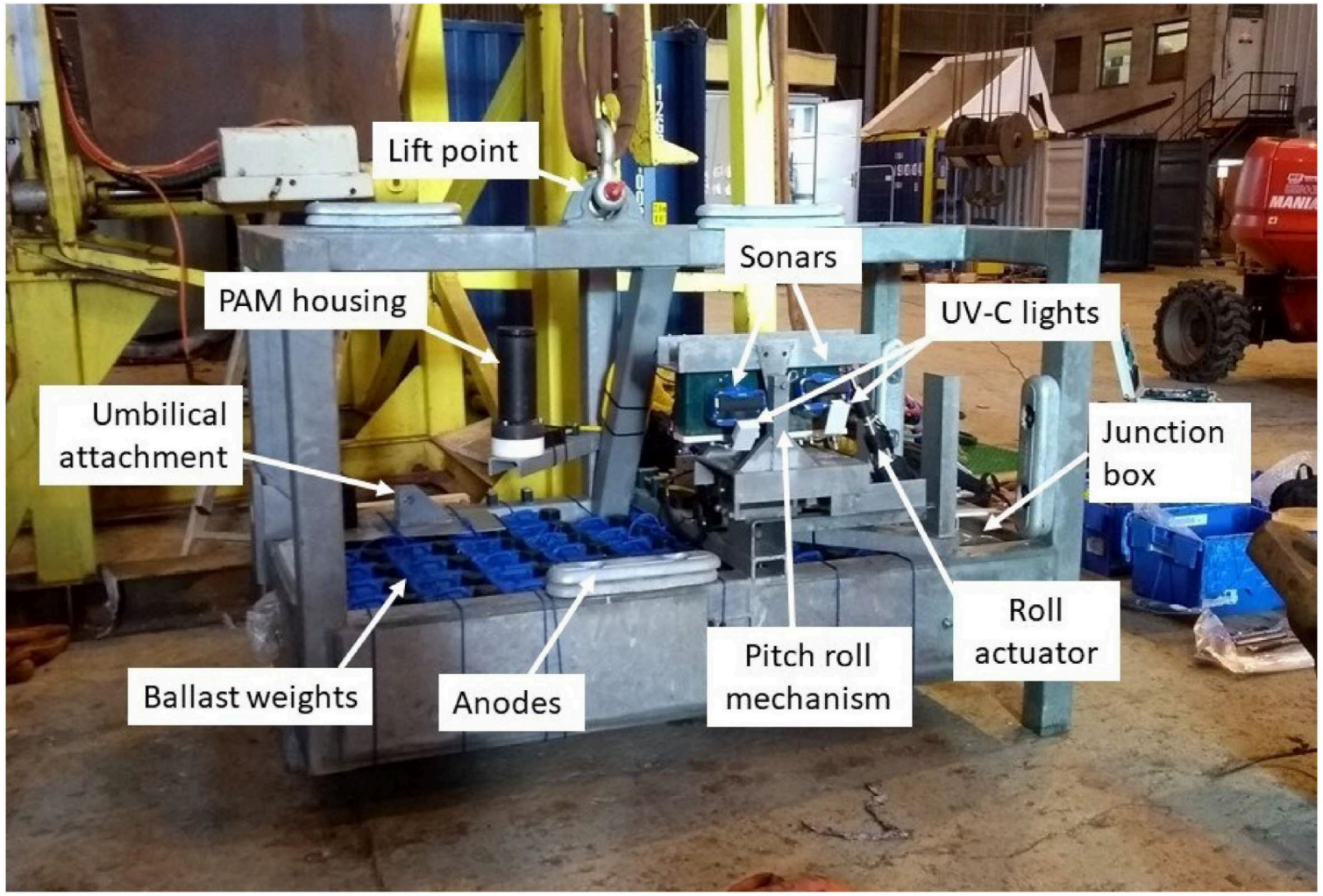
- Highly versatile - custom instrument payloads
- Option for autonomous or cabled deployments



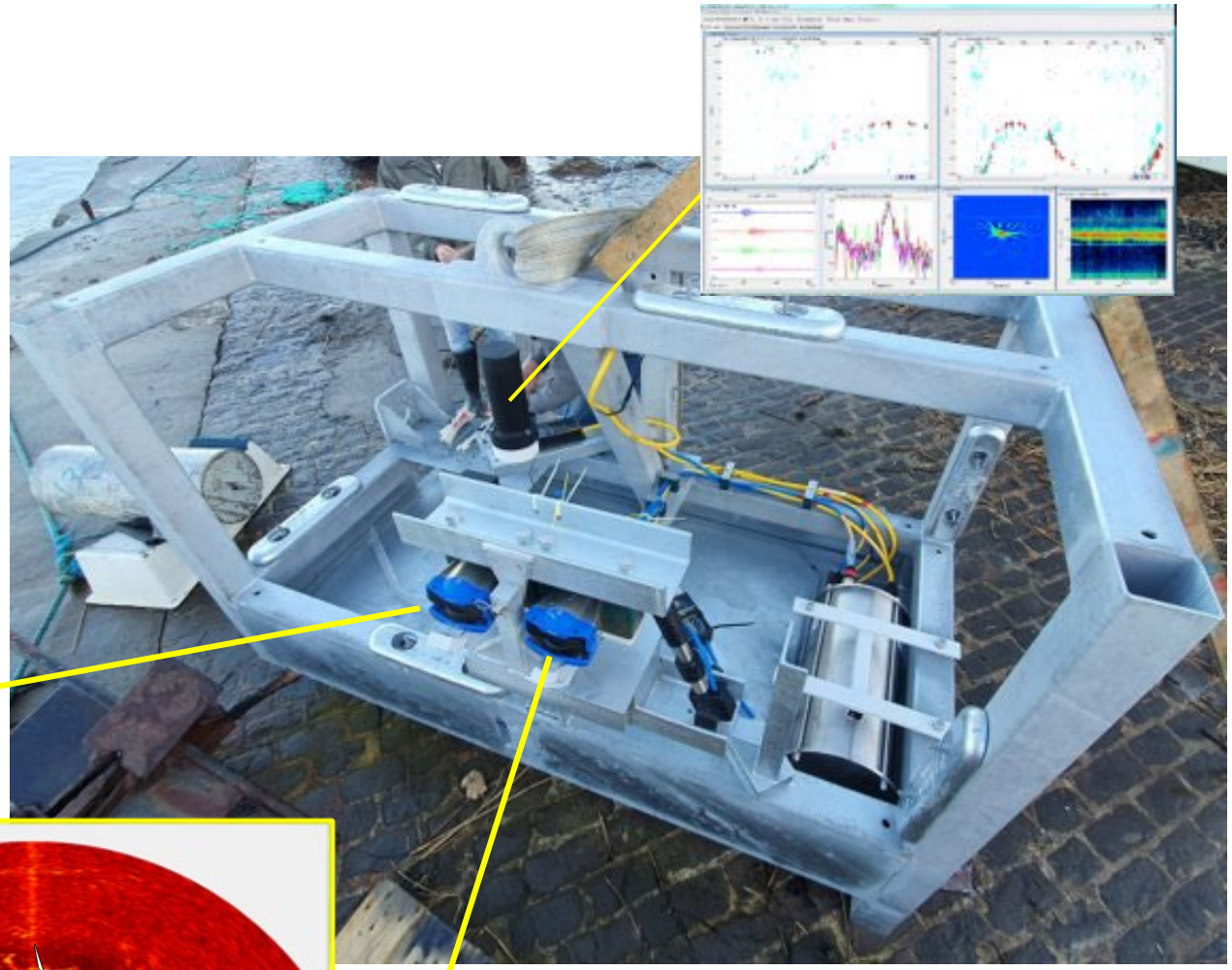




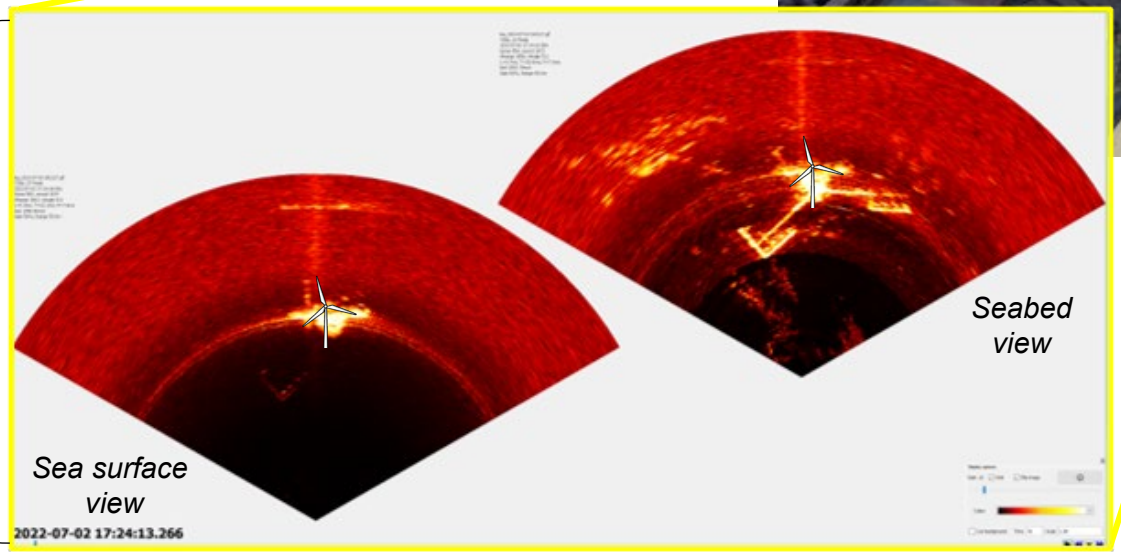
Marine Mammal HiCUP – **Hi**gh **C**urrent **U**nderwater **P**latform



Marine Mammal HiCUP – **Hi**gh **C**urrent **U**nderwater **P**latform



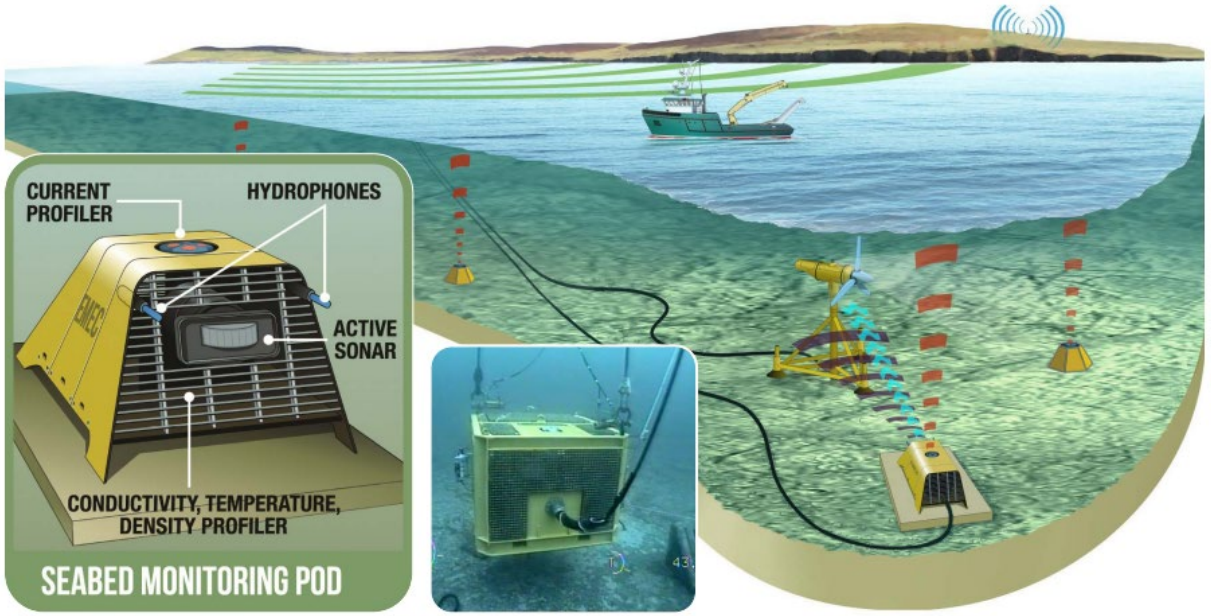
Multibeam imaging sonars



EMEC Integrated Monitoring Pod (IMP)

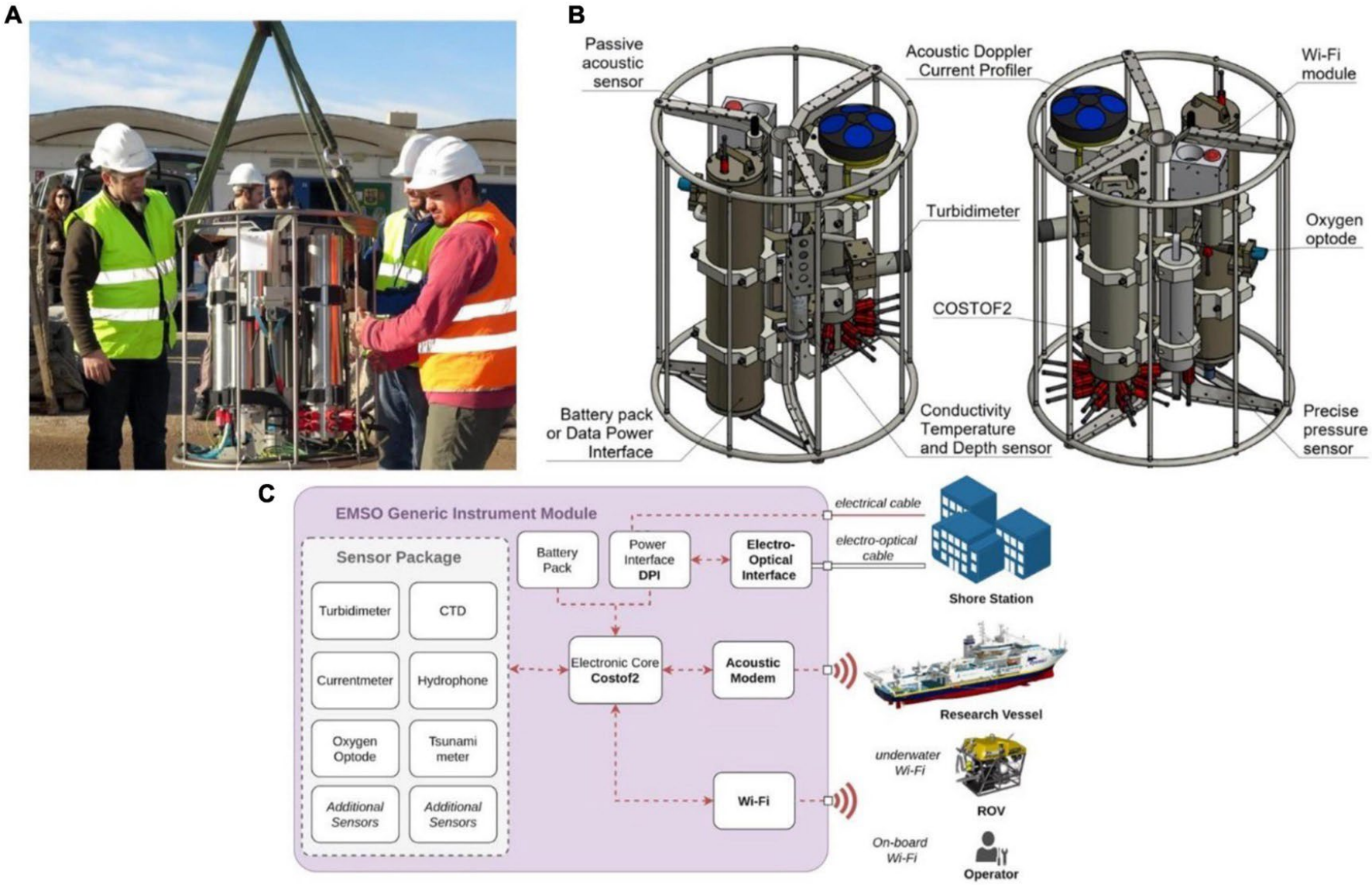
EMEC
THE EUROPEAN MARINE ENERGY CENTRE LTD

- In 2015 EMEC designed and built and deployed a sub-sea monitoring system at the Fall of Warness tidal energy test site in Orkney, Scotland.
- During its deployment, the Integrated Monitoring Pod collected measurements using CTD sensors, hydrophones, active sonar and an ADCP.



- The pod was recovered later the same year after 6 months of successfully transmitting real-time data feeds from the seabed.
- The data was intended to support device design, enable more accurate device performance and support operations and maintenance planning.

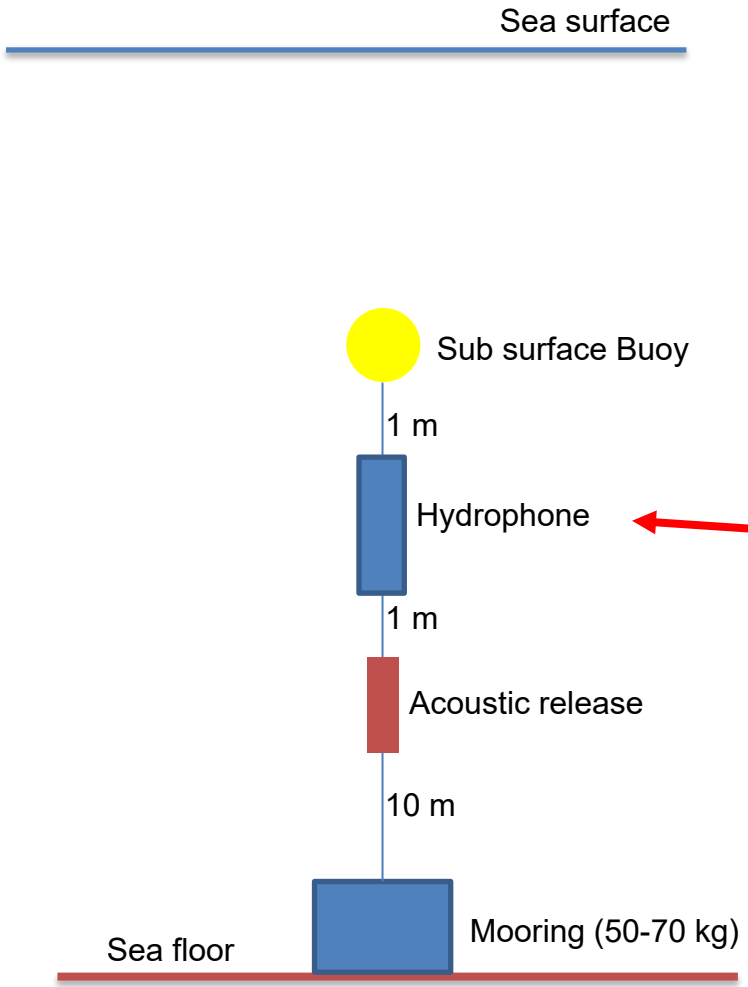
European Multidisciplinary Seafloor and Water Column Observatory (EMSO)



Instruments for Underwater Noise

Acoustics:

- SafeWave – Spain
- CorPower – Sweden
- DAISYs – US
- CRABB – US
- NoiseSpotter – US



SoundTrap ST300 HF
(Ocean InstrumentsNZ)

Feature	SoundTrap ST300 HF
Sample rate	576, 288, 192, 96, 72 & 48 kHz
Bit depth	16-Bit SAR
Self-noise	Less than 37 dB re 1 µPa above 2 kHz
Sensitivity	-204 dB re 1µPa
Bandwidth	20 Hz to 150 KHz ± 3dB
Dynamic Range	96 dB
Autonomy	Up to 13 days continuous operation
Memory	256 GB
Calibration	Factory OCR calibration certificate

Acoustic monitoring equipment

- Equipment used in pre-operational acoustic monitoring campaigns in CorPower's HiWave-5 project in Aguçadoura, Portugal.

Underwater acoustic monitoring

x3 Hydrophones

OceanInstruments[NZ]

SoundTrap 300

Analysis Software

Audacity ®

Cetacean acoustic monitoring

x2 F-PODs

Chelonia Limited

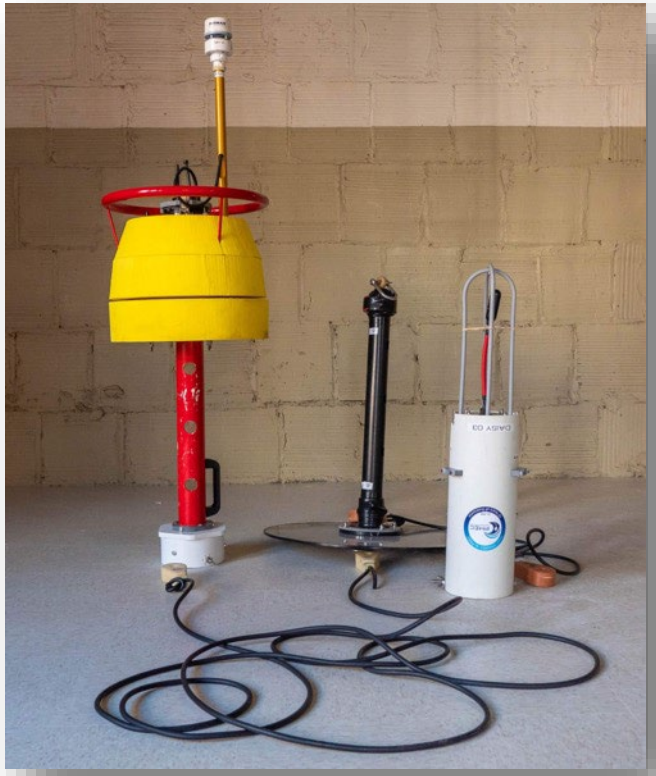
Analysis Software

F-POD.exe (v1.0)

KERNO-F classifier

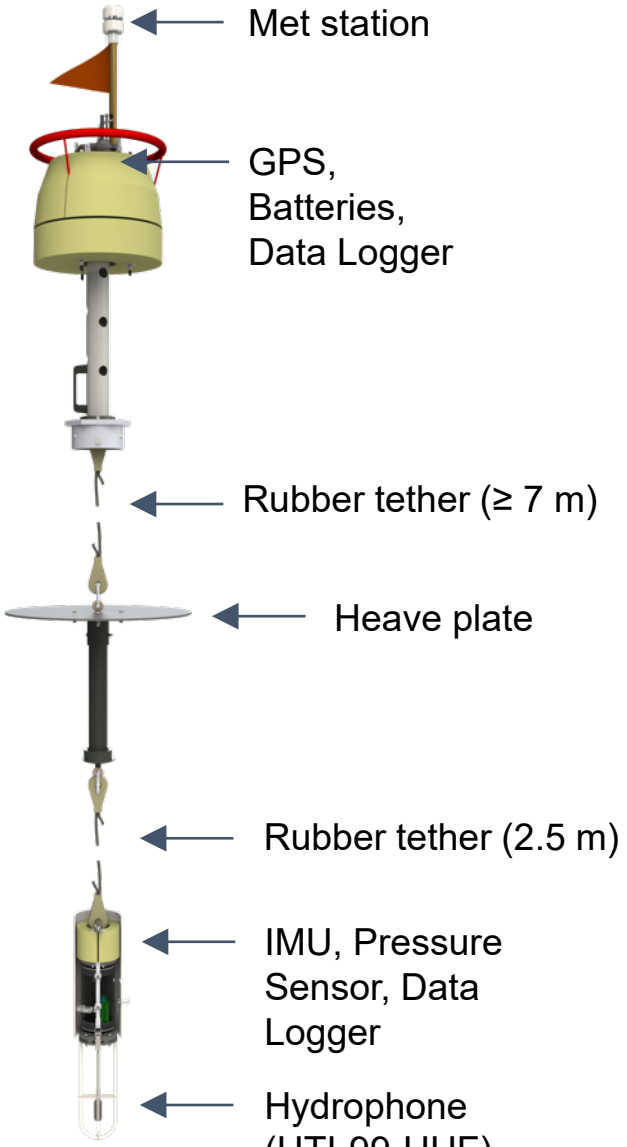
Drifting Acoustic Instrumentation SYstem (DAISY)

UNIVERSITY of WASHINGTON

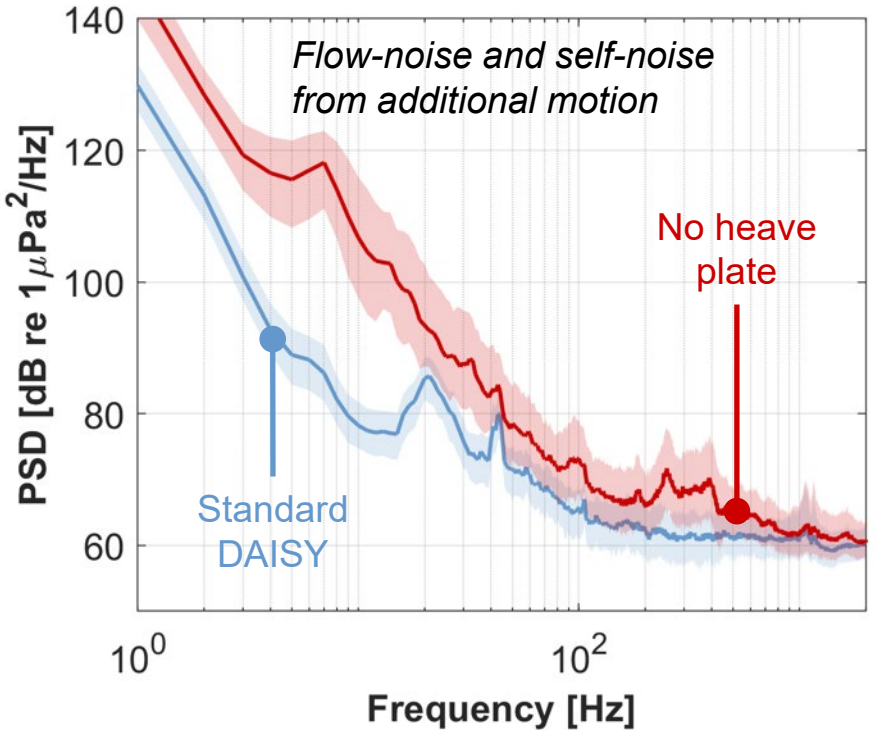


As-built DAISY

Wave measurement configuration



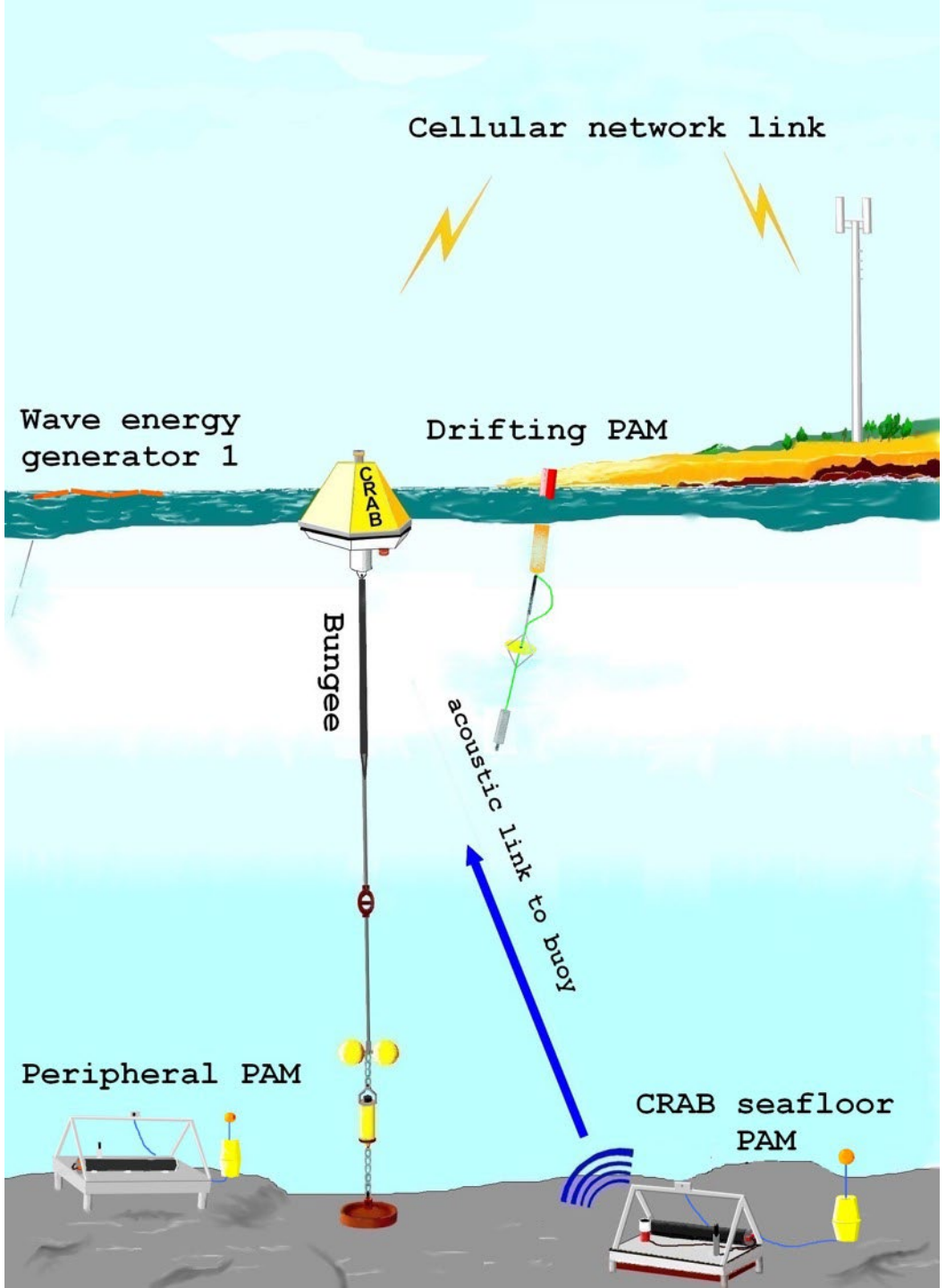
Motion suppression by suspension system plays critical role in measurement accuracy for $f < 1$ kHz



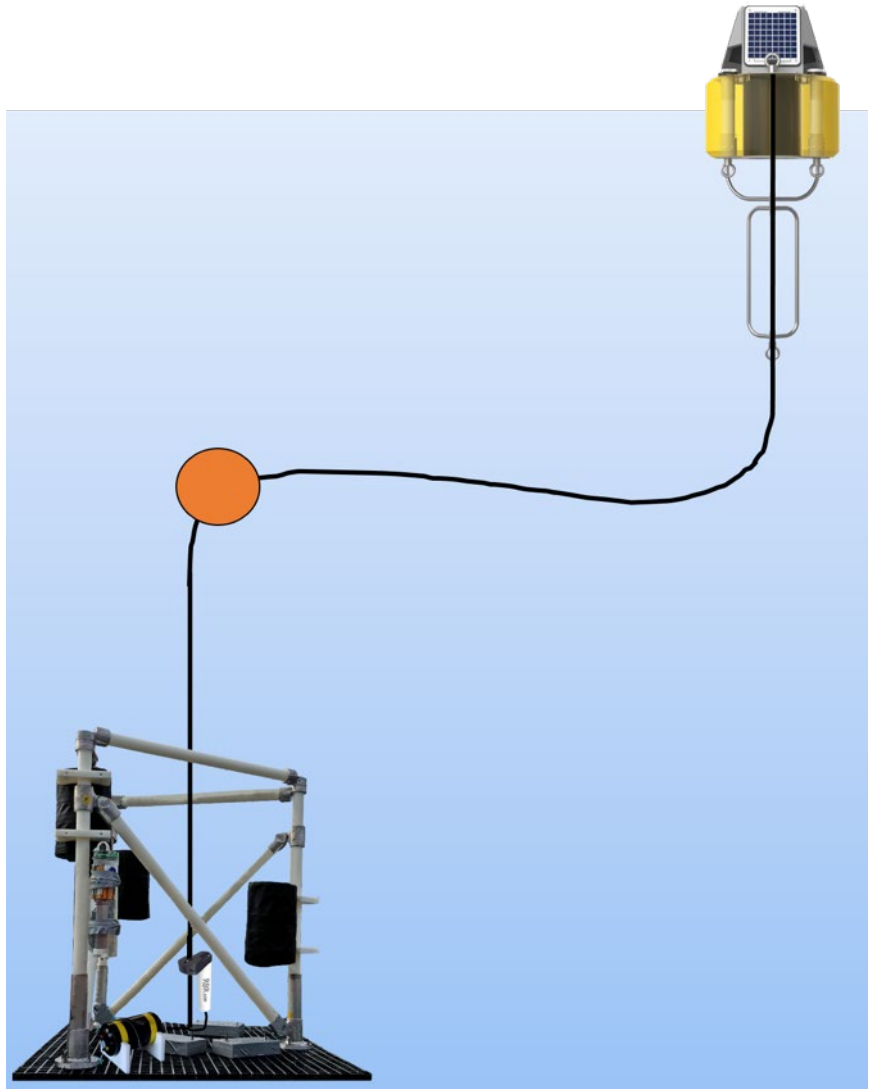
H_s = 1.8 m, T_e = 6.2 s

CRAB acoustic monitoring for PacWave

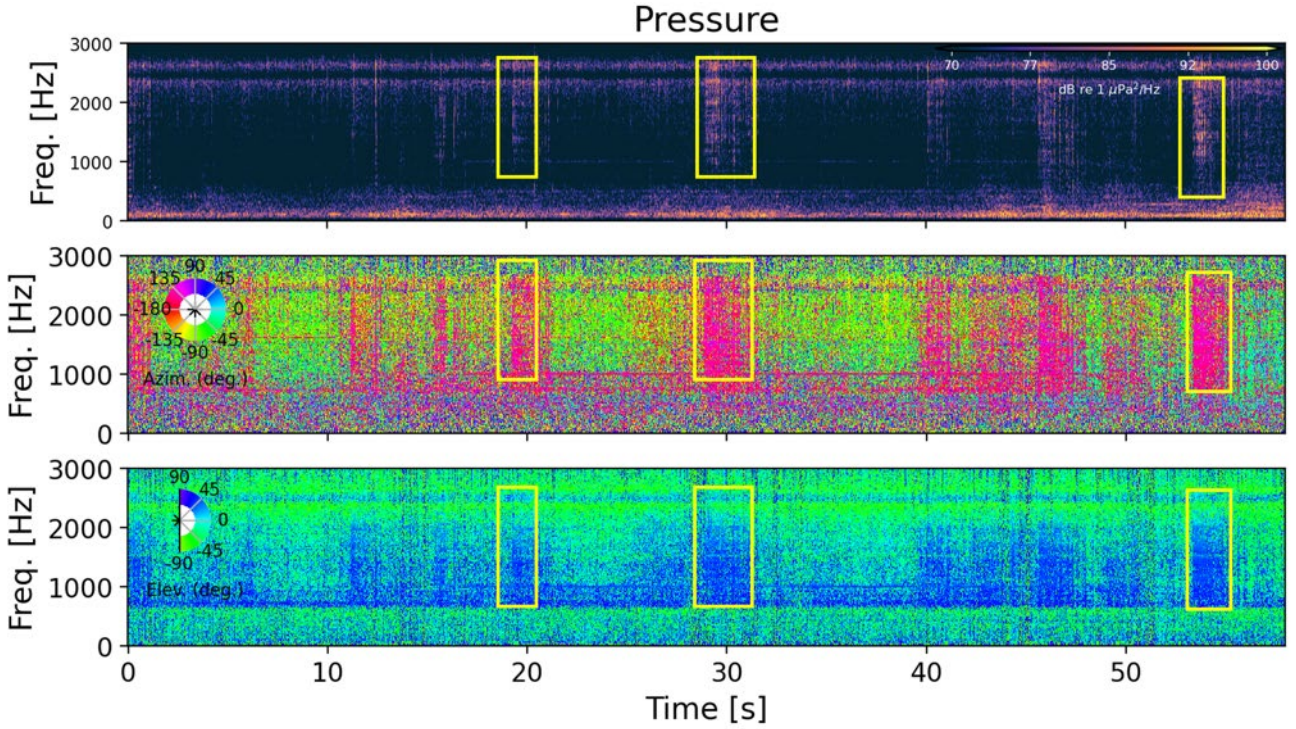
U.S. open ocean wave test site, Pacific Ocean



Directional Acoustic Sensing using NoiseSpotter®



- Each sensor measures acoustic pressure and 3D particle motion, 50 Hz-3 kHz
- Sensor spacing:
  - Vertical: 35 cm, 50 cm, 70 cm above seabed.
  - Horizontal: 1 m separation
- Sensors enclosed in flow noise-removal shields



Directional characterization of CalWave WEC sound

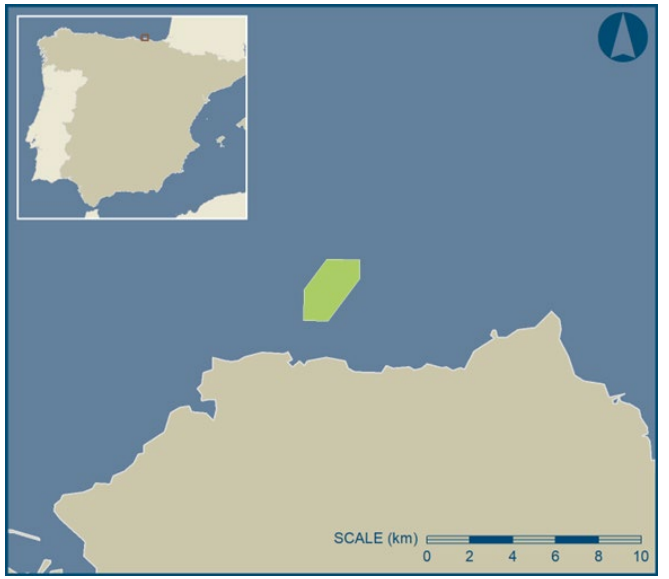
integral

Scenario #1: Collision Risk Monitoring for a Tidal Device

Device	Project Site	Size of Project	Key Environmental Risks	Species at Risk
• Floating tidal (~2 MW) • Dynamic mooring system, • 2 large rotors on each side • 3 blades each	Raz Blanchard • English Channel, near Alderney • 40 m deep • Tidal current up to 4 m/sec • H_s up to 2.25 m	1, then 4, then 30 devices	• Collision risk • EMF • Underwater noise • Habitat changes	• Dolphins, harbour porpoise, pilot whales • Harbour and grey seals • Diving seabirds • Commercially important fish • Lobster

Scenario #2: Acoustic Monitoring for a Wave Device

Device	Project Site	Size of Project	Key Environmental Risks	Species at Risk
• 500 kW wave point absorber • Dynamic mooring system, • Rock anchors	BiMEP • 1.7 km off Mutriku, Spain • 50-90 m deep • Wave power density 21 -26 kW/m • Also suitable for wind	1, then 4, then 30 devices	• Underwater noise & vibration • Light • EMF • Entanglement • Habitat changes	• Dolphins, pilot whales • Diving seabirds • Benthic communities



Breakout Group Discussion

- How do we collect data at the scale of one device (or small array)?
- How can the data from the initial deployment be interpreted for the next (larger) phase?
- How will these data be collected as we scale up to the next phase?

BONUS QUESTIONS:

- How do we avoid a DRIP (data rich/information poor) issue and collect meaningful data?
- What should guidance on the proper use of monitoring systems include/look like?
- What should guidance on the development and management of an effective monitoring/management plan include/look like?

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
- Welsh Government Information Notes
  - https://gov.wales/marine-renewable-energy-environmental-information-notes
- Critical Evidence Needs
  - https://gov.wales/marine-renewable-energy-environmental-information-notes
- Forward Look
  - http://www.orjip.org.uk/sites/default/files/ORJIP%20Ocean%20Energy%20Forward%20Look%203%20FINAL.pdf

Next Steps

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

Thank you!

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Please fill out our short survey!

https://www.surveymonkey.com/r/EWTEC2023