Pacific Northwest NATIONAL LABORATORY

ES ENVIRONMENTAL

# Coordinating and Disseminating Research on Environmental Effects of MRE

September 28, 2023

U.S. DEPARTMENT OF ENERGY BATTELLE

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

# Objectives of Today's Webinar

1. Updates on OES-Environmental
2. Insight into two key stressors from the research community

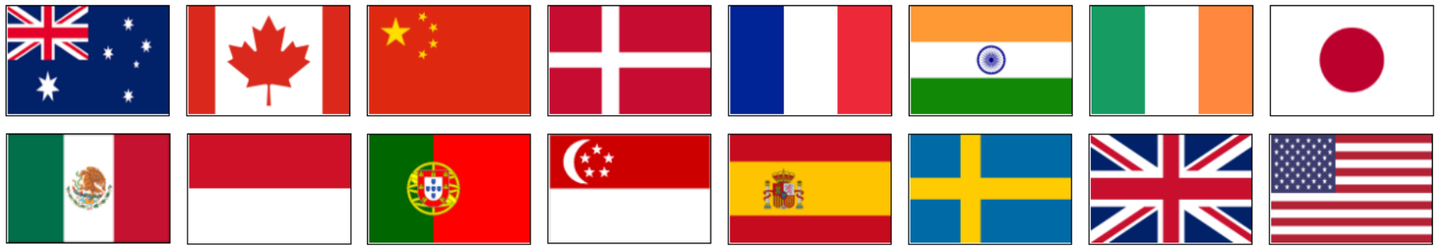
# Agenda

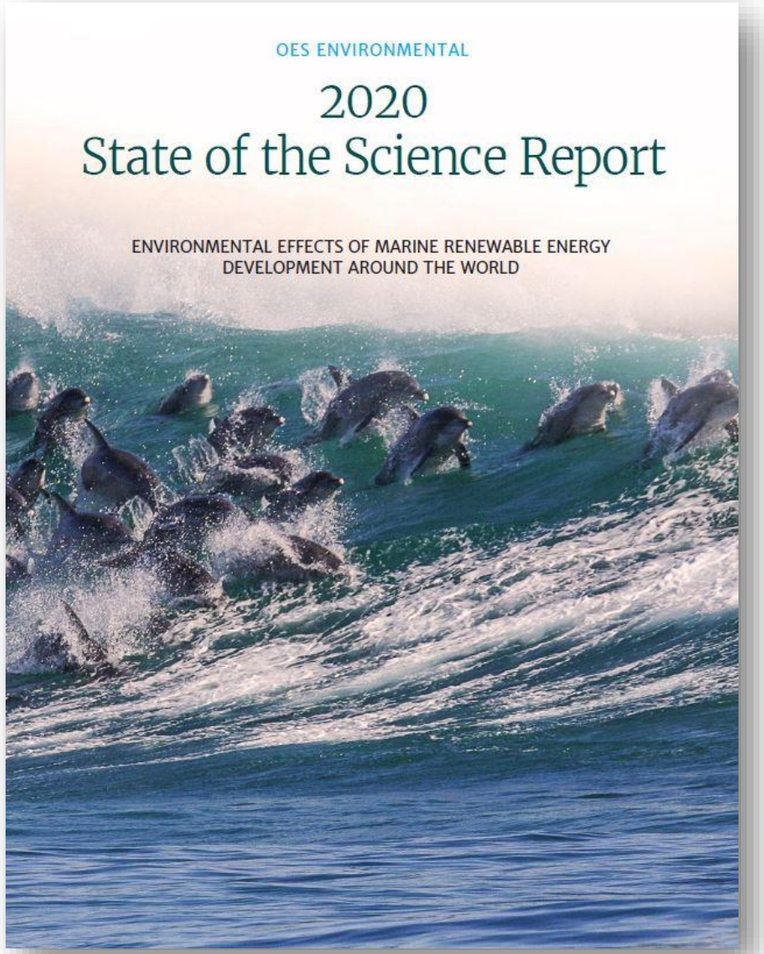
- OES-Environmental overview
  - *Tethys*
  - MRE Educational Resources
  - 2024 State of the Science Report
  - Advancing MRE
- Research on key stressor-receptor interactions
  - Underwater noise – Joe Haxel, PNNL
  - Collision risk – Doug Gillespie, SMRU

# OES-Environmental

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

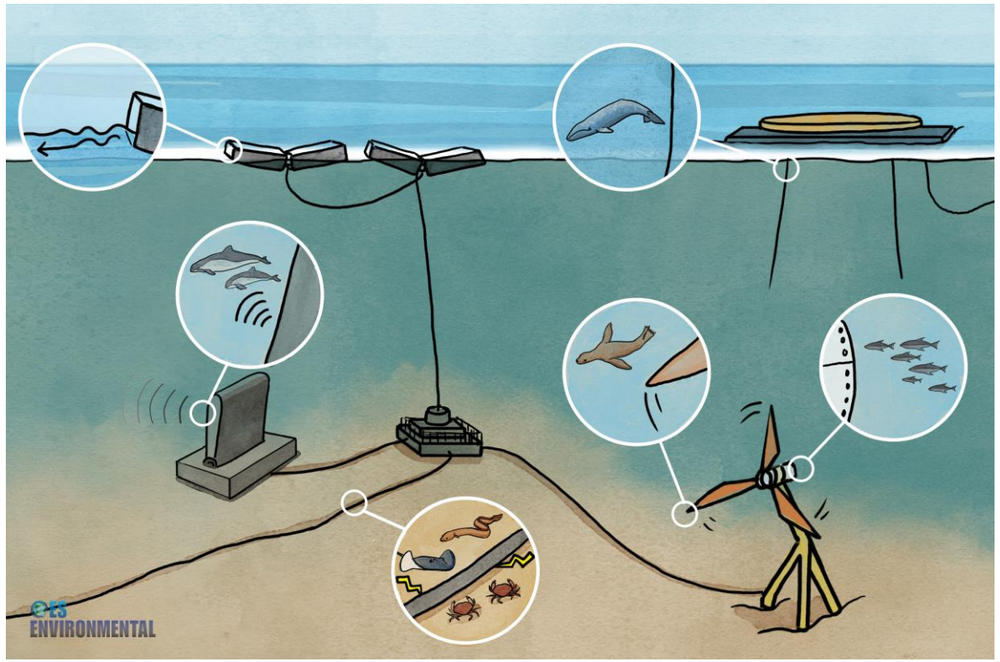
- Established by the IEA-Ocean Energy Systems in 2010
- Examines environmental effects of marine renewable energy (MRE) development to advance the industry in a responsible manner
- Led by the US DOE Water Power Technologies Office and implemented by Pacific Northwest National Laboratory
- 16 member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





# Marine Renewable Energy (MRE)

- 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

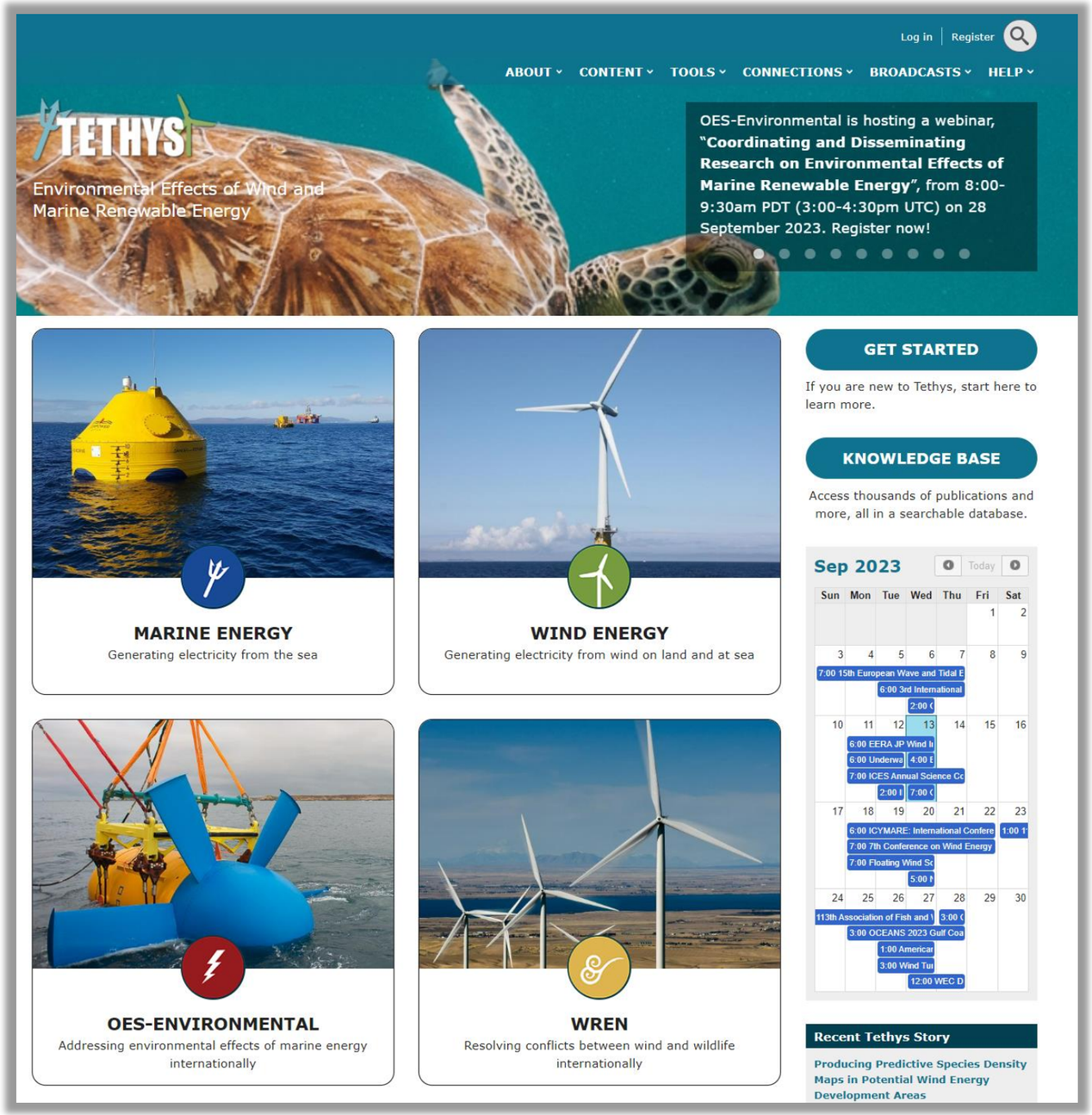



Key stressor-receptor interactions:

- Collision risk
- Mooring line encounter
- Underwater noise
- Changes in oceanographic systems
- Electromagnetic fields
- Displacement
- Habitat changes

https://tethys.pnnl.gov/

- Online Knowledge Base, marine and wind energy
- Hosts over 4,000 marine energy documents
- Additional content, tools, and resources
  - Webinars,
  - OES-Environmental Metadata,
  - Risk retirement resources,
  - MRE Educational Resources,
  - *Tethys* Blasts, etc.



# 2024 State of the Science Report

- New information since 2020
  - Key stressor-receptor interactions, risk retirement, data transferability, etc.
- Human dimensions of MRE – social and economic effects and stakeholder engagement
- Moving beyond single devices, impacts of arrays
  - Scaling up, cumulative effects, ecosystem, and displacement
- New focus areas
  - Tropical and subtropical regions
  - Risk-based frameworks
  - Data and information systems
- Draft in Spring 2024, final in Fall 2024

# MRE Educational Resources

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

- Provide resources for students of all ages to increase understanding of environmental effects of MRE
  - Updated in 2023
- New resources added:
  - MRE videos
    - ✓ Overview of Environmental Effects
    - ✓ Underwater Noise
    - ✓ Electromagnetic Fields
    - ✓ Changes in Habitat
  - Marine Energy Adventure: Collision Risk Game available
    - ✓ Play as fish to navigate collision risk!

# Coordinating and Disseminating Research

- Publicly sharing all available information → TETHYS + PRIMRE
- Sharing best practices for avoiding and minimizing harm → Management Measures Tool
- Systematically using data collected at existing projects → Data Transferability + Risk Retirement
- Making science accessible for regulatory uses → Guidance Documents
- Expanding research foci into emerging areas → Systems Approach
- Share information & results publicly → State of the Science 2024; OES-Environmental Webinars

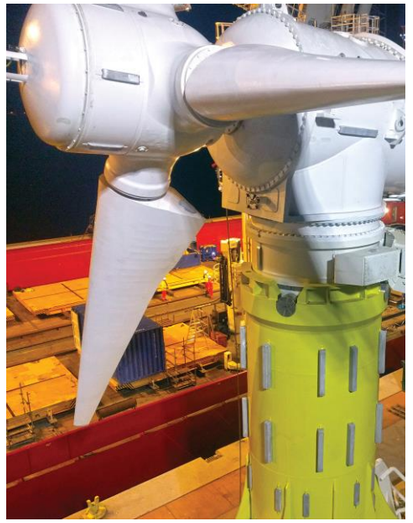
# Increasing Understanding of Key Stressor-Receptor Interactions

- Underwater noise:

  Joe Haxel – Pacific Northwest National Laboratory, Triton Initiative

- Collision risk:

  Doug Gillespie – University of St. Andrews, Sea Mammal Research Unit (SMRU)



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TRITON

# Underwater sounds from marine energy

October 5, 2023

**Joseph Haxel**
Triton Principal Investigator

U.S. DEPARTMENT OF ENERGY BATTELLE

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# Why do we care about underwater sounds from marine energy?

- **The importance of sound** -> Marine mammals, fish, turtles and some invertebrates use either sound pressure or particle motion for critical life functions – foraging, communication, navigation, predator avoidance

- **Uncertainty** -> Concerns around environmental effects from acoustic disturbance stemming from a lack of data = challenges for permitting, time, cost

- **Best practices** -> How can we best measure and evaluate changes in acoustic conditions from marine energy?
  - Cost effective
  - Regulatory compliance
  - Transferability

Hawaiian Is Humpback Whale NMS/ Jason Moore

# Measuring sounds from marine energy

International Electrotechnical Commission (IEC) Technical Specification 62600-40
**Acoustic characterization of marine energy converters**

- Sensor requirements
- Sensor locations
- Sample rates
- Recording period
- Supporting data
- Data analysis and reporting

# Regulatory Framework

- NOAA National Marine Fisheries Service – Marine Mammal Acoustic Technical Guidance
- **2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing**

Hearing Groups | Weighting Functions | PTS | TTS

Shanon Dell - PNNL

© New England Aquarium

# CalWave open-ocean wave energy pilot

- September 2021 – July 2022
- 99% system uptime
- 3 acoustic systems used to monitor underwater noise from the IEC 62600-40


CalWave's X1™ WEC deployed off La Jolla, CA

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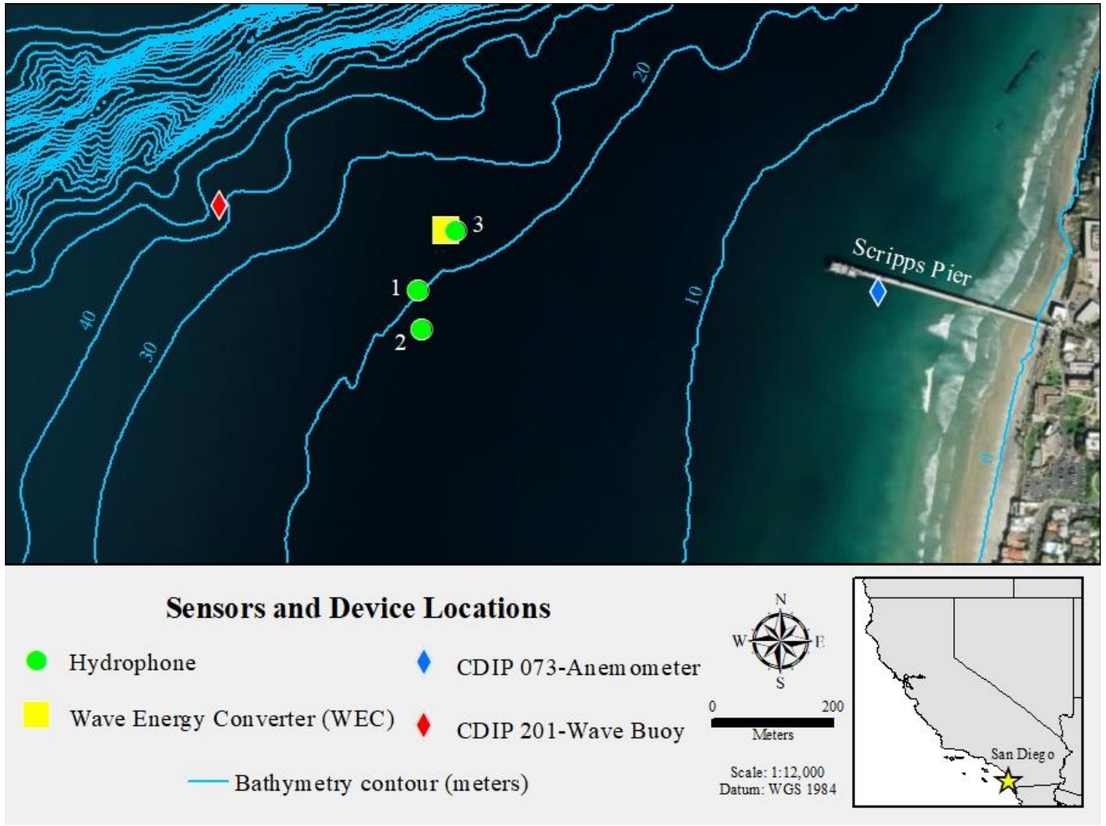
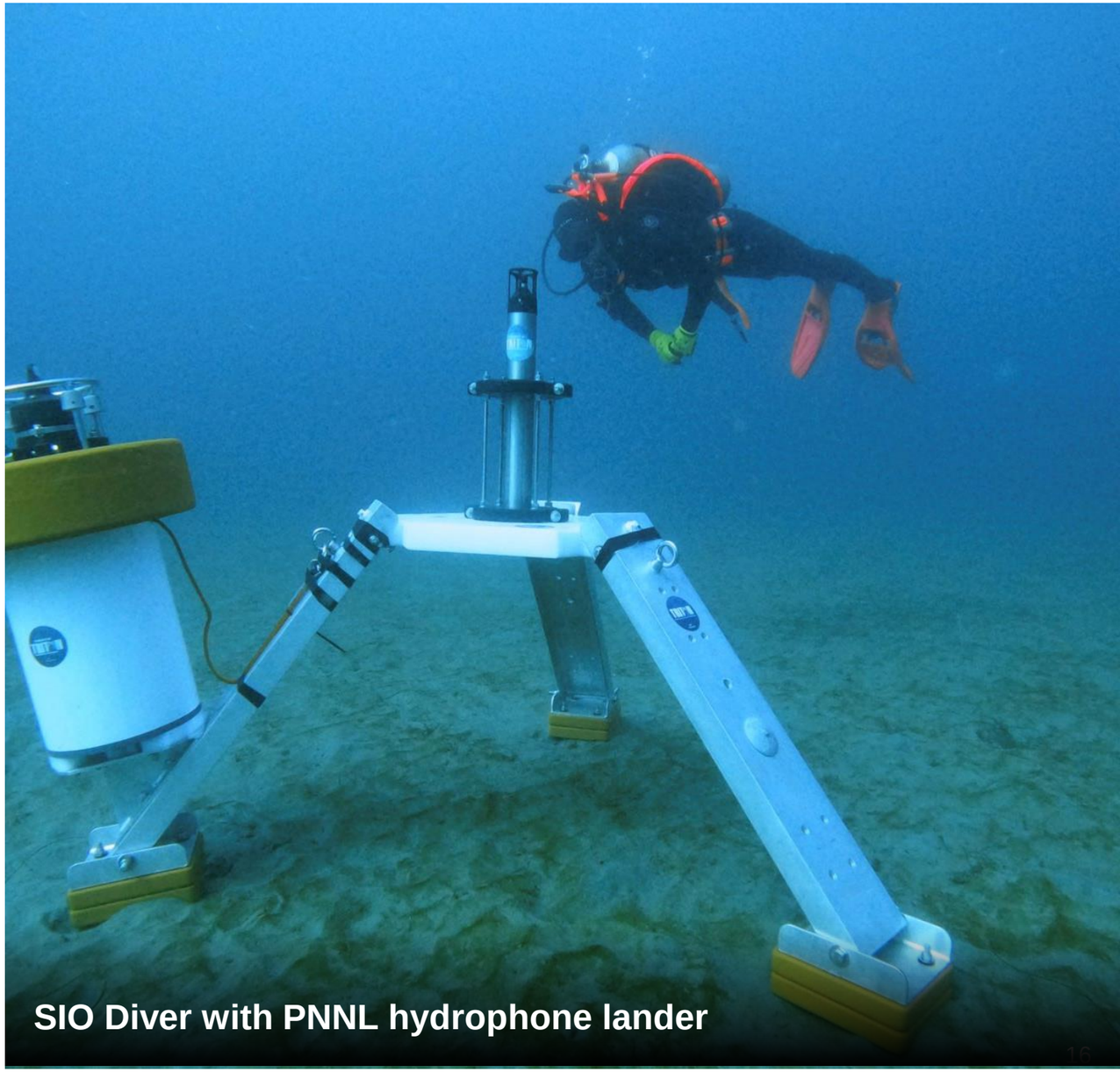
TRITON

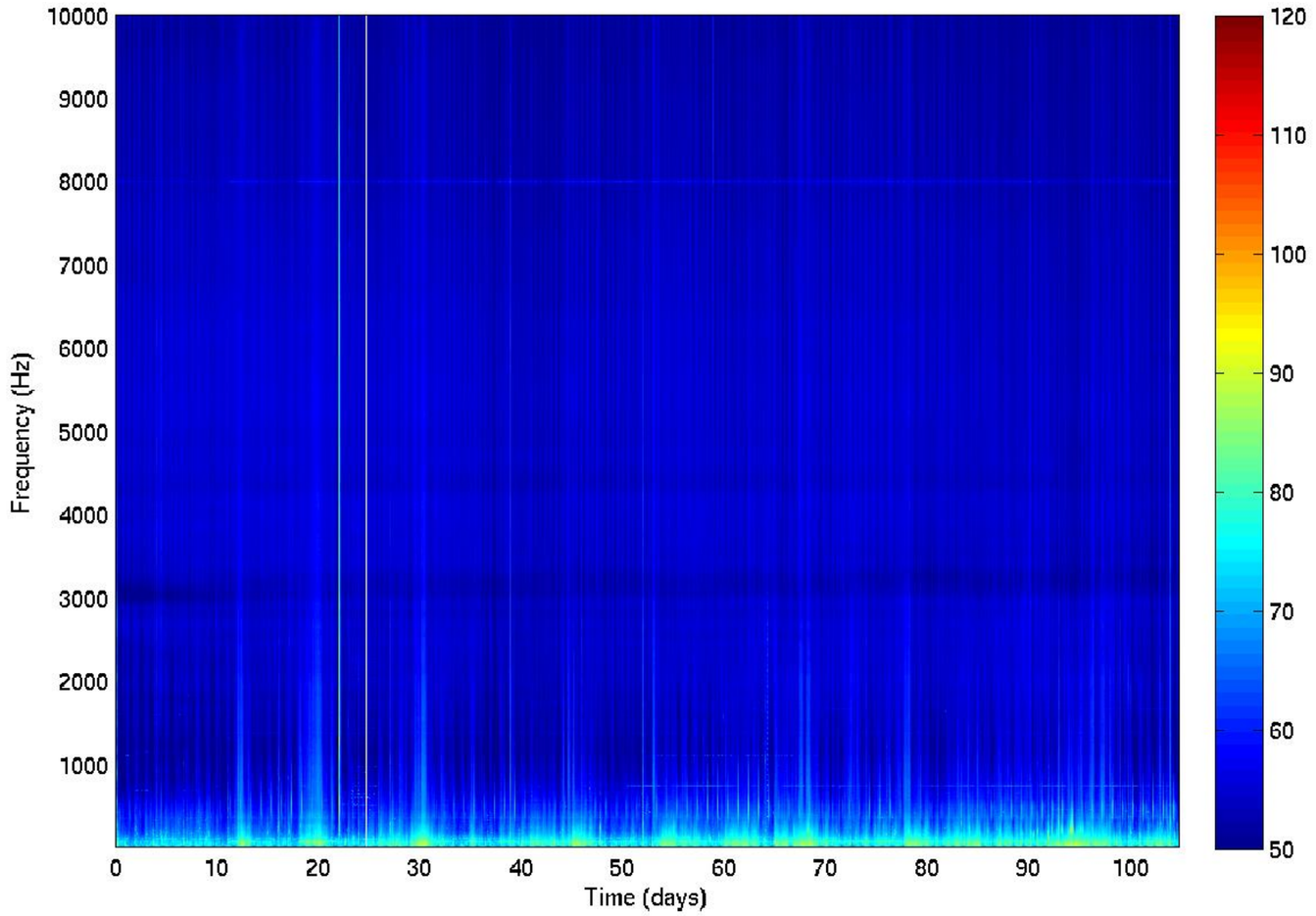


SIO Diver with PNNL hydrophone lander

# Long-term spectral average (LTSA)

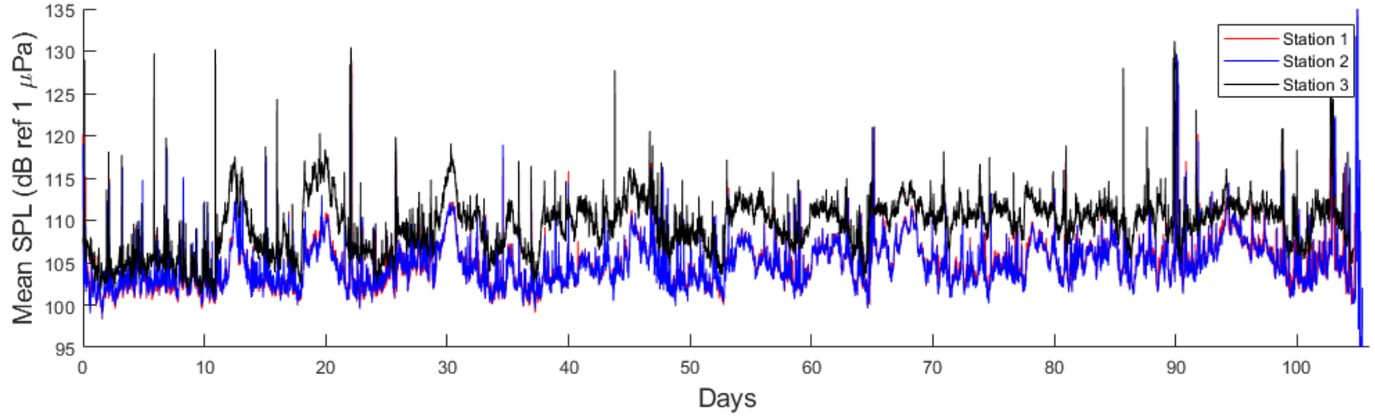
- Low frequency increases in sound levels associated with rising waves/ wind
- Long-term increase in low frequency energy

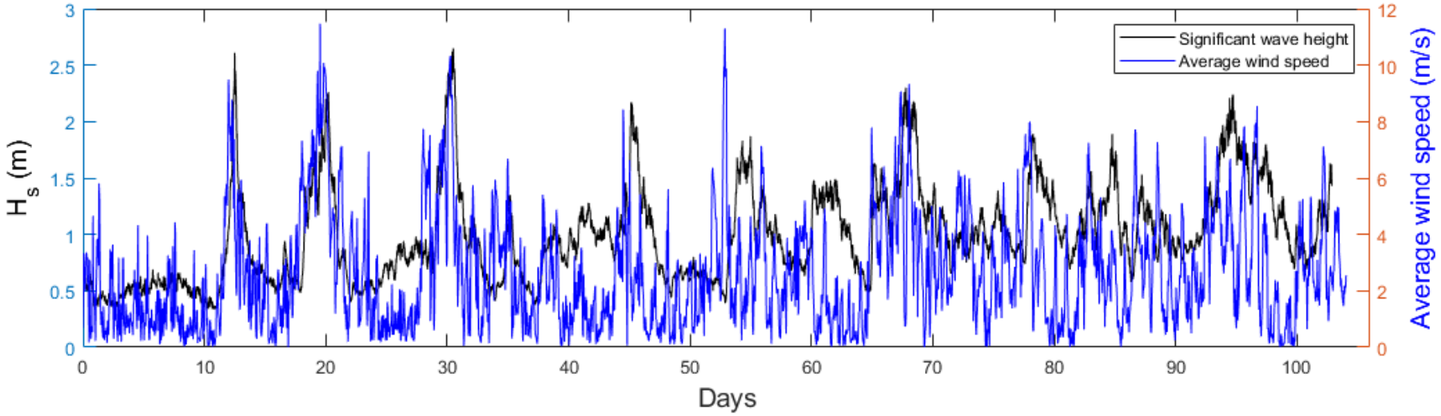



Mean PSD, station 1

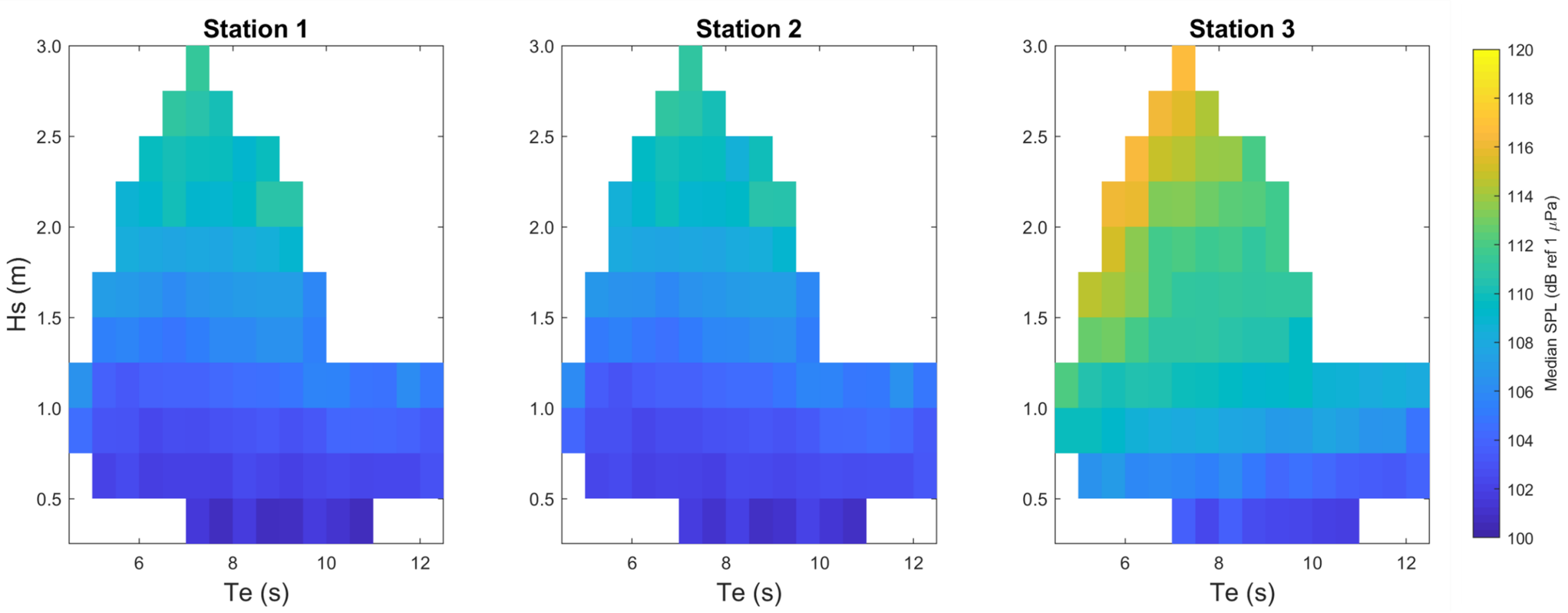
# Sound Pressure Levels (SPL)

- Station 3 consistently the highest sound levels
- SPL varies with wave heights, less with wind speeds
- Long-term increase in wave heights matches rising sound level trend



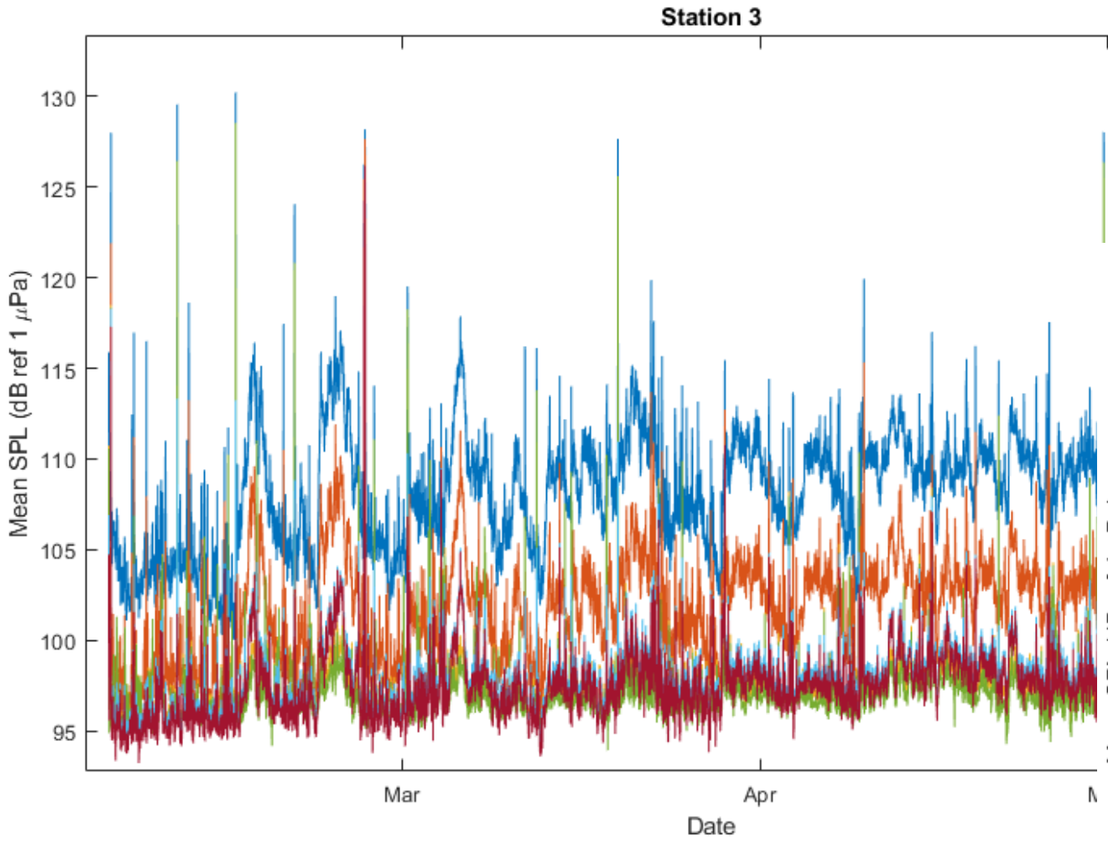



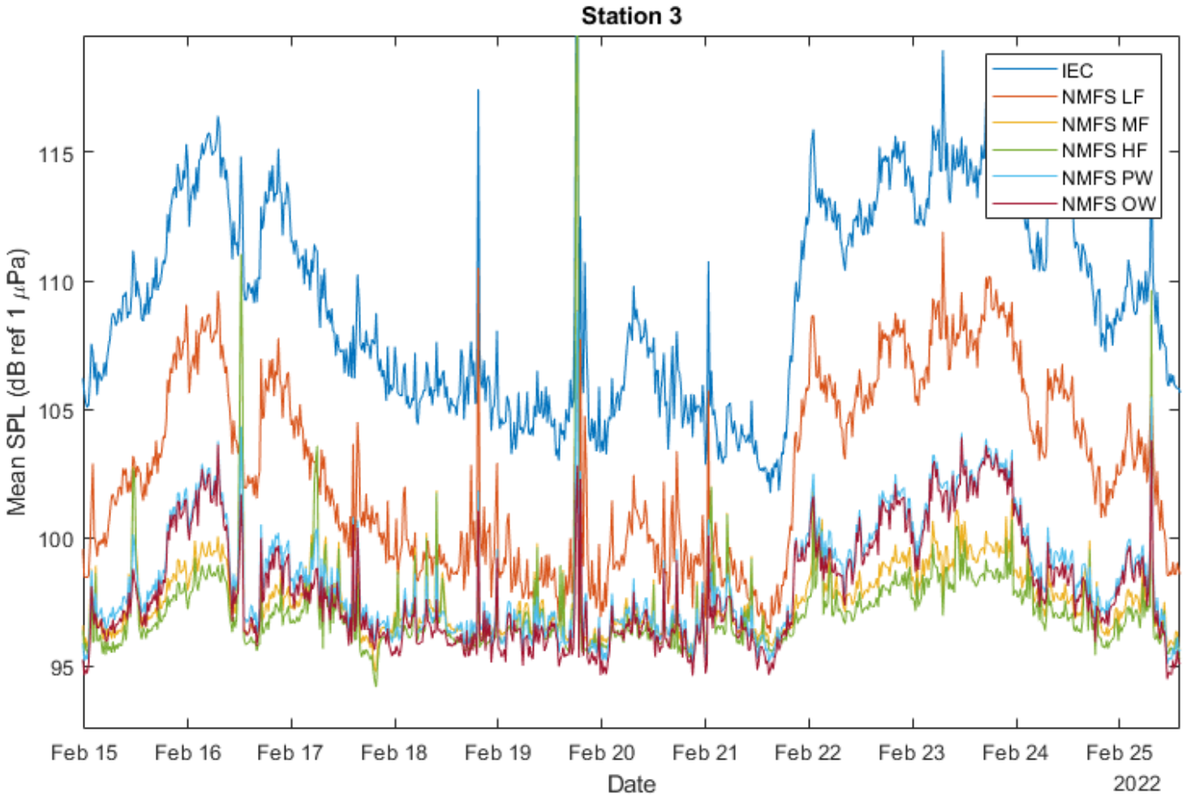
# Sound Pressure Levels with waves and winds




What about mapping SPL's with device power generation time series?

# IEC 62600-40 → NMFS hearing groups

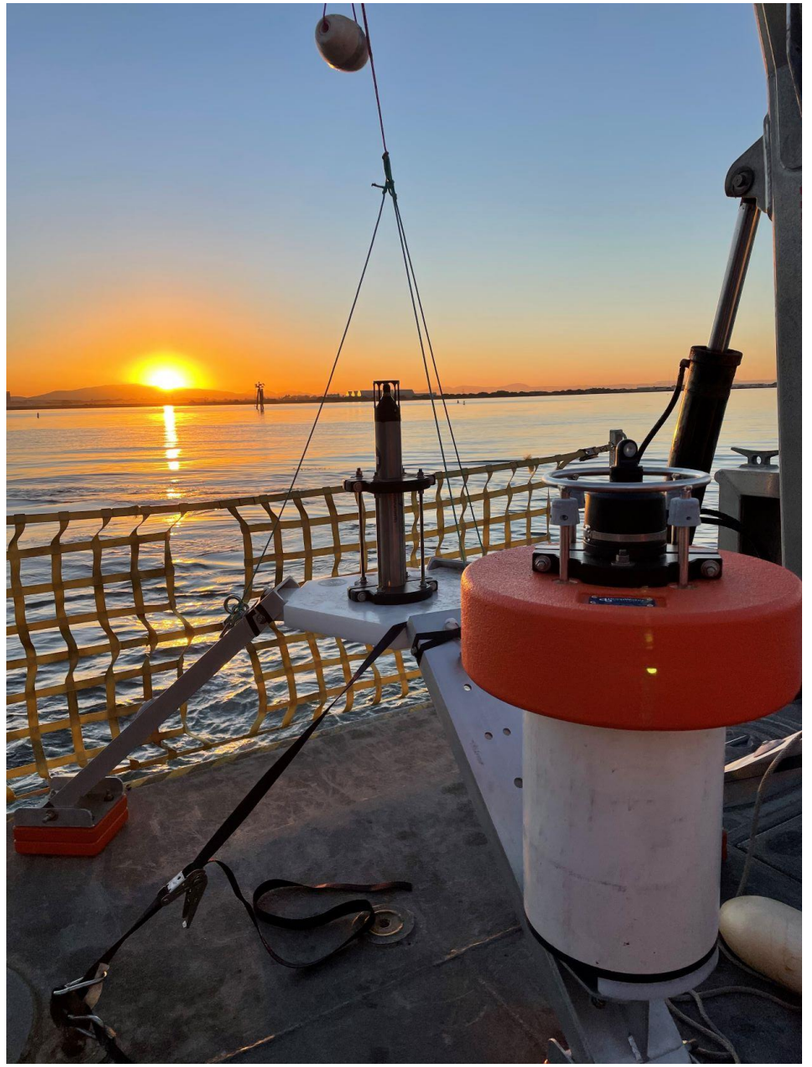


# “Aligning acoustic characterization standards for marine energy converters with regulatory threshold criteria: insights from a wave energy converter off the California coast”

J. Haxel, X. Zang, J. McVey, G. Staines, and E. Cotter

*in draft, coming in 2024



# Thank you

For more information, visit:
pnnl.gov/projects/triton/underwater-noise

Joe Haxel

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University of St Andrews

SCOTTISH OCEANS INSTITUTE

# Monitoring Collision Risk
## (how we do it in Scotland)

**Douglas Gillespie**, Gordon Hastie, Carol Sparling, Jessica Montabaranom, Katie Rapson, Jamie Macaulay, Emma Longden

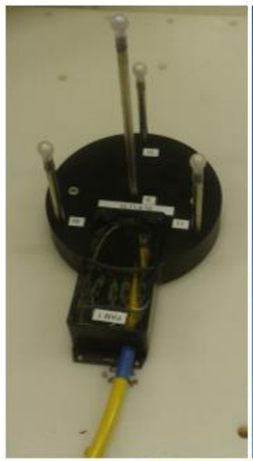
Sea Mammal Research Unit

University of St Andrews

Sea Mammal Research Unit

# The Meygen turbine site

- Four large (25 x 19m) gravity foundations
- 2017 – 2019: 451 days PAM Monitoring using a 12 hydrophone array mounted on the foundation.



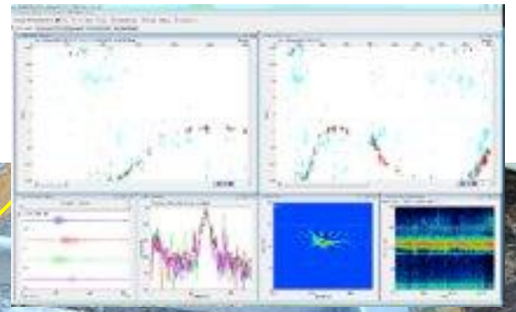


Cetaceans

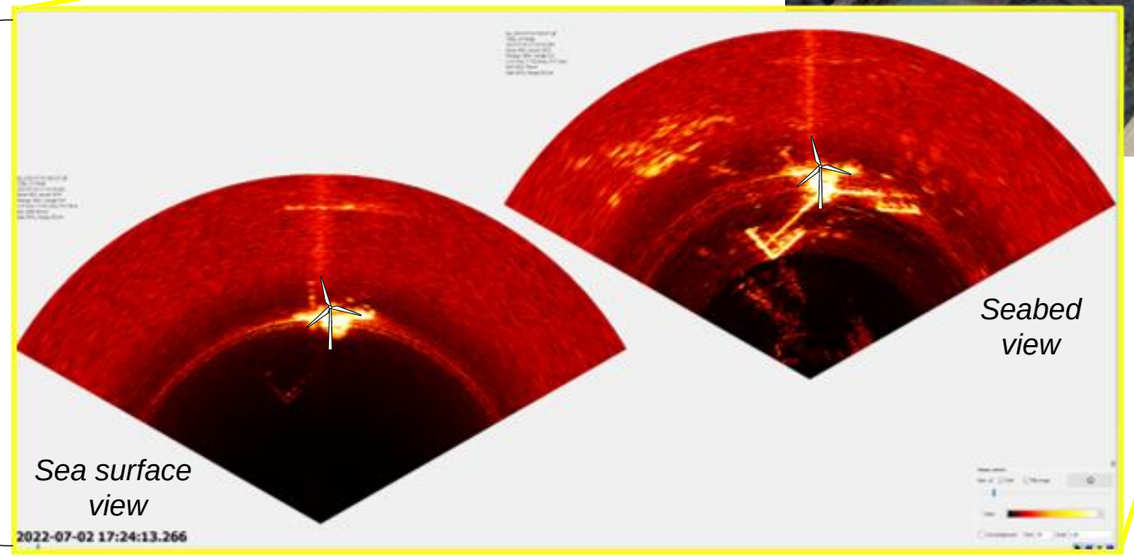
Seals

# 2022 – 2023
# Separate platform monitoring with multibeam active sonar

Passive Acoustics hydrophones



Multibeam imaging sonars




Cetaceans ✓

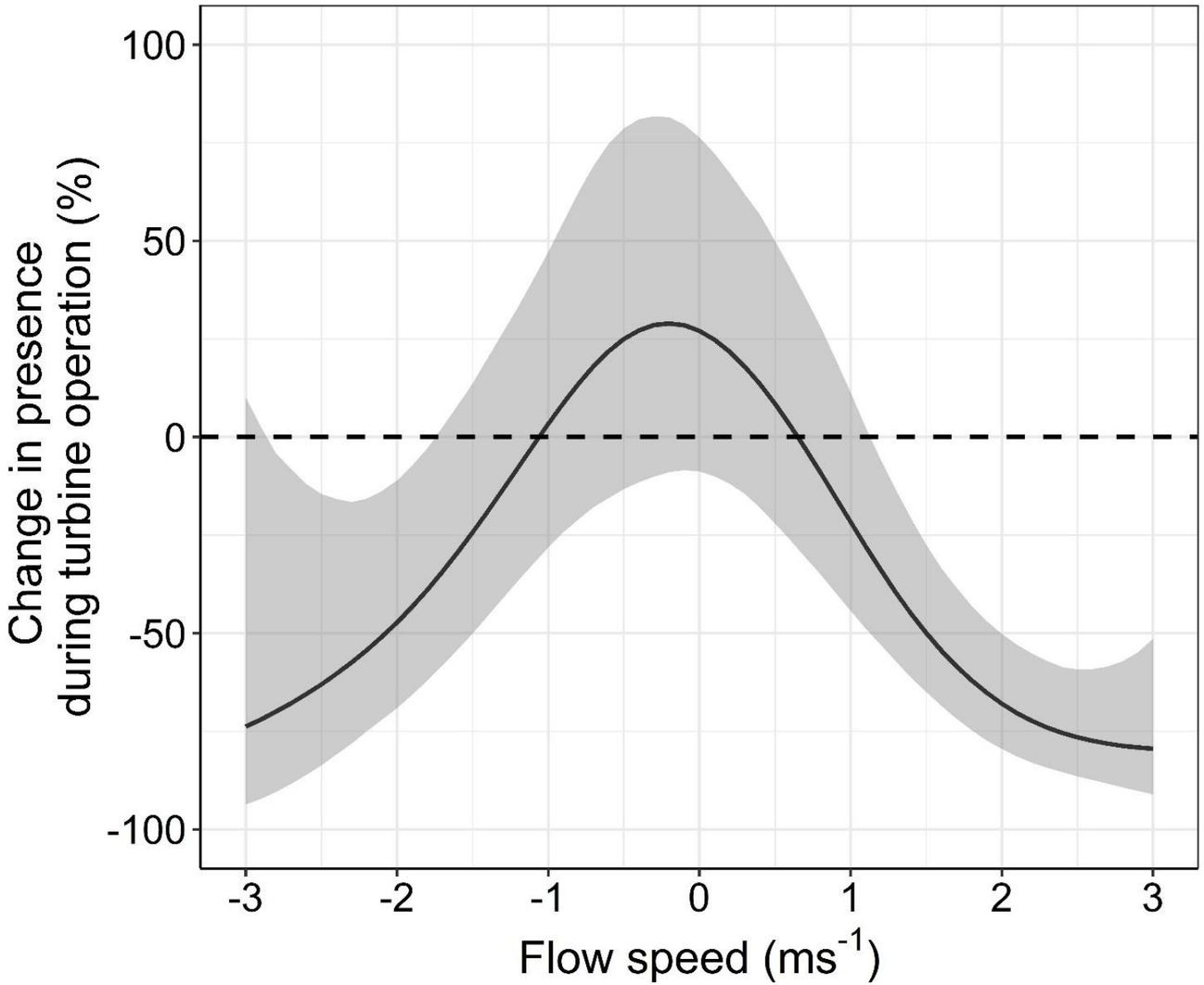
Seals ✓

# Acquisition and Processing


- Power provided from turbine auxiliary supply
- Turbine comms system used to stream raw data to shore
- PC in substation combined real time detection with data archiving to hard drives
- Poor internet, so data recovered monthly by post
- Real time and offline acoustic processing with PAMGuard
- Sonar data collected with manufacturers software
- Sonar data processed offline with new PAMGuard modules
- System allowed for persistent data 24/7 data collection:
  - >450 days of PAM data 2017 to 2019
  - >360 days of Sonar and PAM data 2022 to 2023

# PAM is for Porpoise (2017 – 2019)

- Reduced presence when turbine operating




Significant avoidance during operation of up to 78%

Avoidance was a function of flow speed

Presence around monitored turbine significantly reduced when all 3 of the other turbines in the array were operating

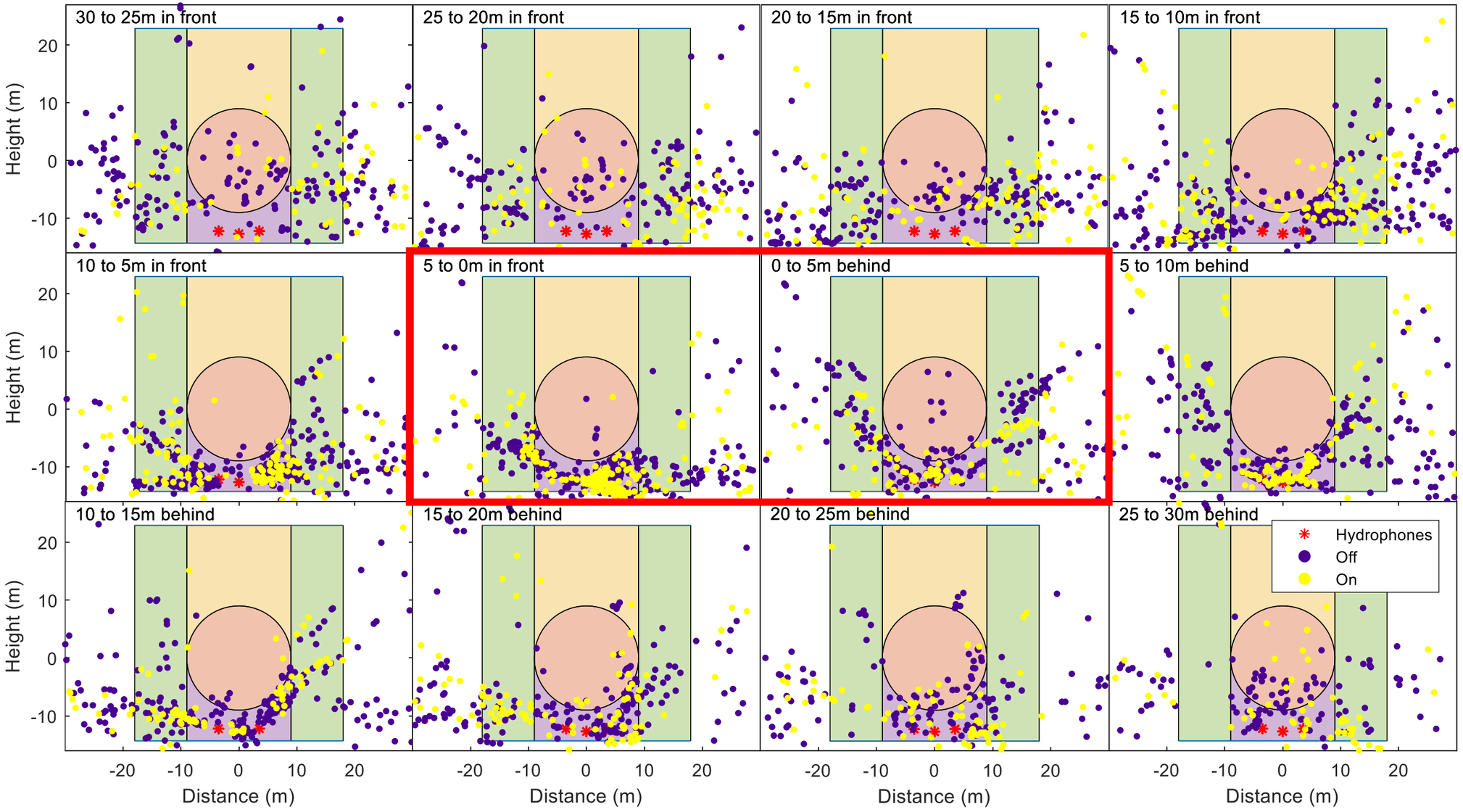
**Avoidance rates should be considered in future collision risk assessments**

University of St Andrews

# Porpoise fine scale evasion of rotor

Viewing straight into the turbine.

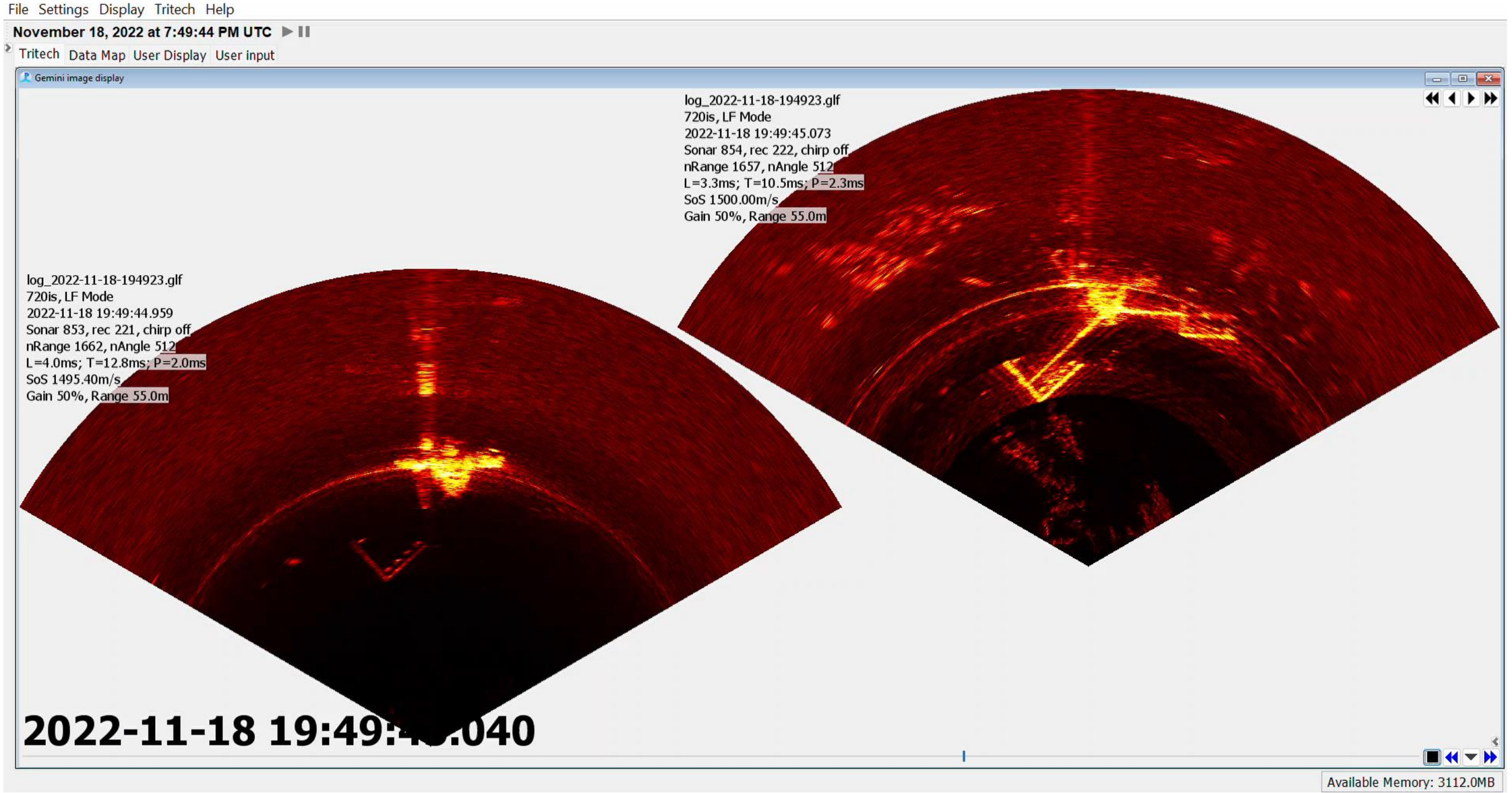
Individual plots show the distribution of points in a 5m slice in front of or behind the turbine.



# Sonar is for Seal (2022 – 2023)

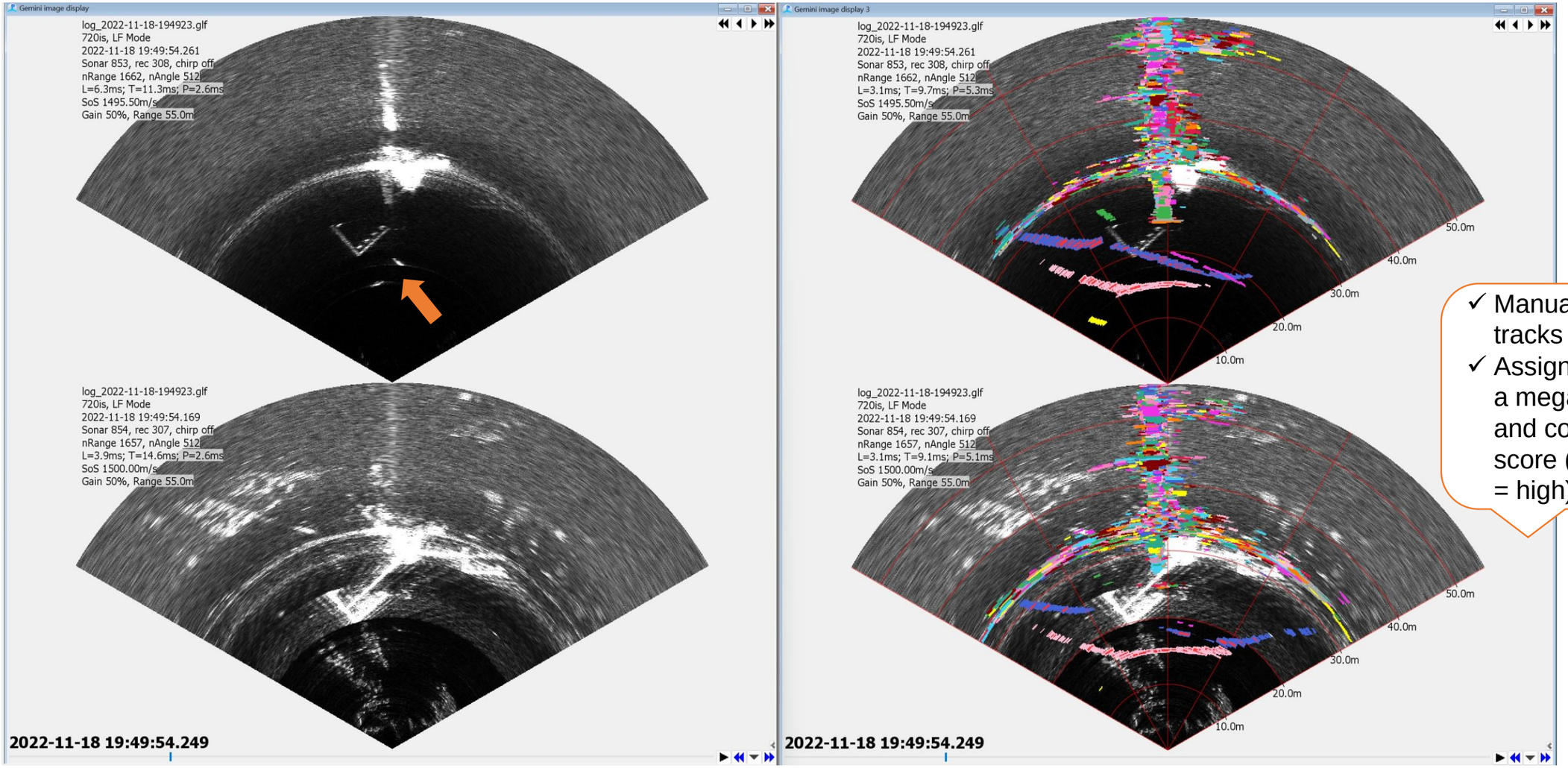
- Tritech Multibeam sonar (720is and 1200ik models)
- Monitors 120° swath out to about 55m with a few cm resolution
- High frequency (720kHz) does not disturb seals
- Unlike PAM, can detect and track silent animals
- Automatic processing not so advanced as it is for PAM
- No effective real time algorithms at start of project, so all data archived (~300GBytes per day)
- Developed our own track detection algorithms as a new PAMGuard module: allows efficient combination of automatic processing and manual validation

# Seal tracks on sonar



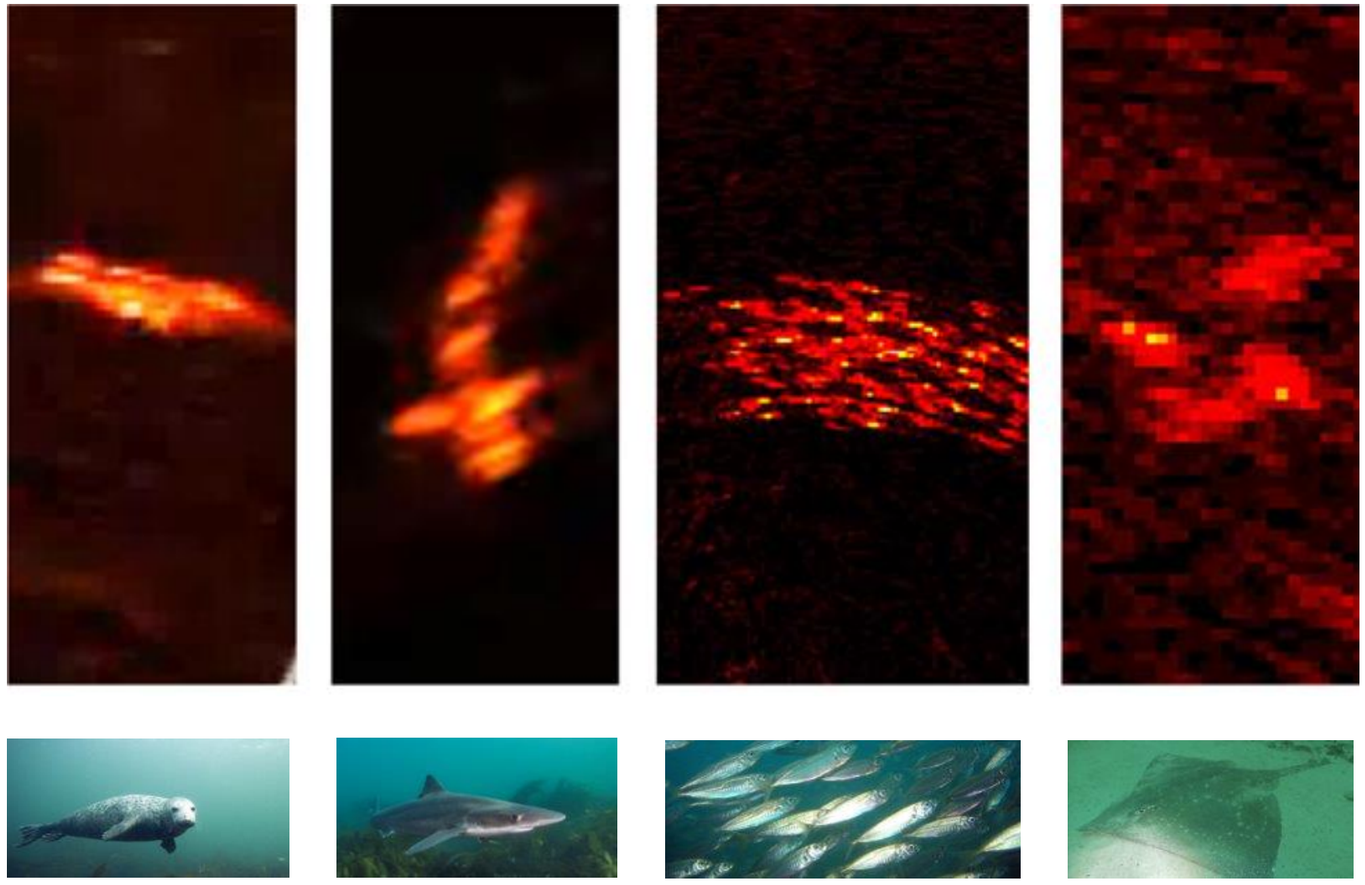
# Bespoke movement detector for tracking seals

## PAMGuard interface




- ✓ Manually review tracks
- ✓ Assign a megafauna ID and confidence score (1 = low – 5 = high)

# Animals on sonar





From the first 266 days …

| Track Type | Human annotated tracks |
|---|---|
| Marine mammals | 359 |
| Fish schools | 4,582 |
| Individual fish | 5,554 |
| Birds | 215 |
| Unidentified | 3,614 |
| Total | 14,324 |

# Current Effort and Future Plans

- Extracting track metrices to parameterise avoidance response of seals
- Better sonar processing algorithms (ML)
- Better sonar ground truth data for species identification
- Real time monitoring (real time feedback on encounter rates)
- Real time mitigation (acoustic deterrents, slow turbine????)
- Array scale monitoring?
  - Fine scale: behaviour between turbines
  - Broad scale: barrier effects, large scale avoidance?

# References & Acknowledgements


**Methods Papers**

Gillespie, D.; Palmer, L.; Macaulay, J.; Sparling, C.; Hastie, G. Passive Acoustic Methods for Tracking the 3D Movements of Small Cetaceans around Marine Structures. PLoS ONE 2020, 15 (5), 16pp, doi:https://doi.org/10.1371/journal.pone.0229058.

Hastie, G.D.; Wu, G.-M.; Moss, S.; Jepp, P.; MacAulay, J.; Lee, A.; Sparling, C.E.; Evers, C.; Gillespie, D. Automated Detection and Tracking of Marine Mammals: A Novel Sonar Tool for Monitoring Effects of Marine Industry. Aquatic Conservation: Marine and Freshwater Ecosystems 2019, 29 (S1), 119–130, doi:https://doi.org/10.1002/aqc.3103.

Gillespie, D.; Oswald, M.; Hastie, G.; Sparling, C. Marine Mammal HiCUP: A High Current Underwater Platform for the Long-Term Monitoring of Fine-Scale Marine Mammal Behavior Around Tidal Turbines. Frontiers in Marine Science 2022, 283.

Gillespie, D., Hastie, G., Montabaranom, J., Longden, E;, Rapson, K., Holoborodko, A., Sparling, C., Automated Detection and Tracking of Marine Mammals in the Vicinity of Tidal Turbines using Multibeam Sonar. J, Marine Science and Engineering. (Submitted).

**Results Papers**

Palmer, L.; Gillespie, D.; MacAulay, J.D.; Sparling, C.E.; Russell, D.J.; Hastie, G.D. Harbour Porpoise (Phocoena Phocoena) Presence Is Reduced during Tidal Turbine Operation. Aquatic Conservation: Marine and Freshwater Ecosystems 2021.

Gillespie, D.; Palmer, L.; Macaulay, J.; Sparling, C.; Hastie, G. Harbour Porpoises Exhibit Localized Evasion of a Tidal Turbine. Aquatic Conservation: Marine and Freshwater Ecosystems 2021, doi:https://doi.org/10.1002/aqc.3660.


Any questions? Get in touch at
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SAE

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Sea Mammal Research Unit

# Q&A + Discussion

Please fill out our 4-minute survey!

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

# Thank you!

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