venterra

Global Lessons Learned: Marine Acoustics

Agenda

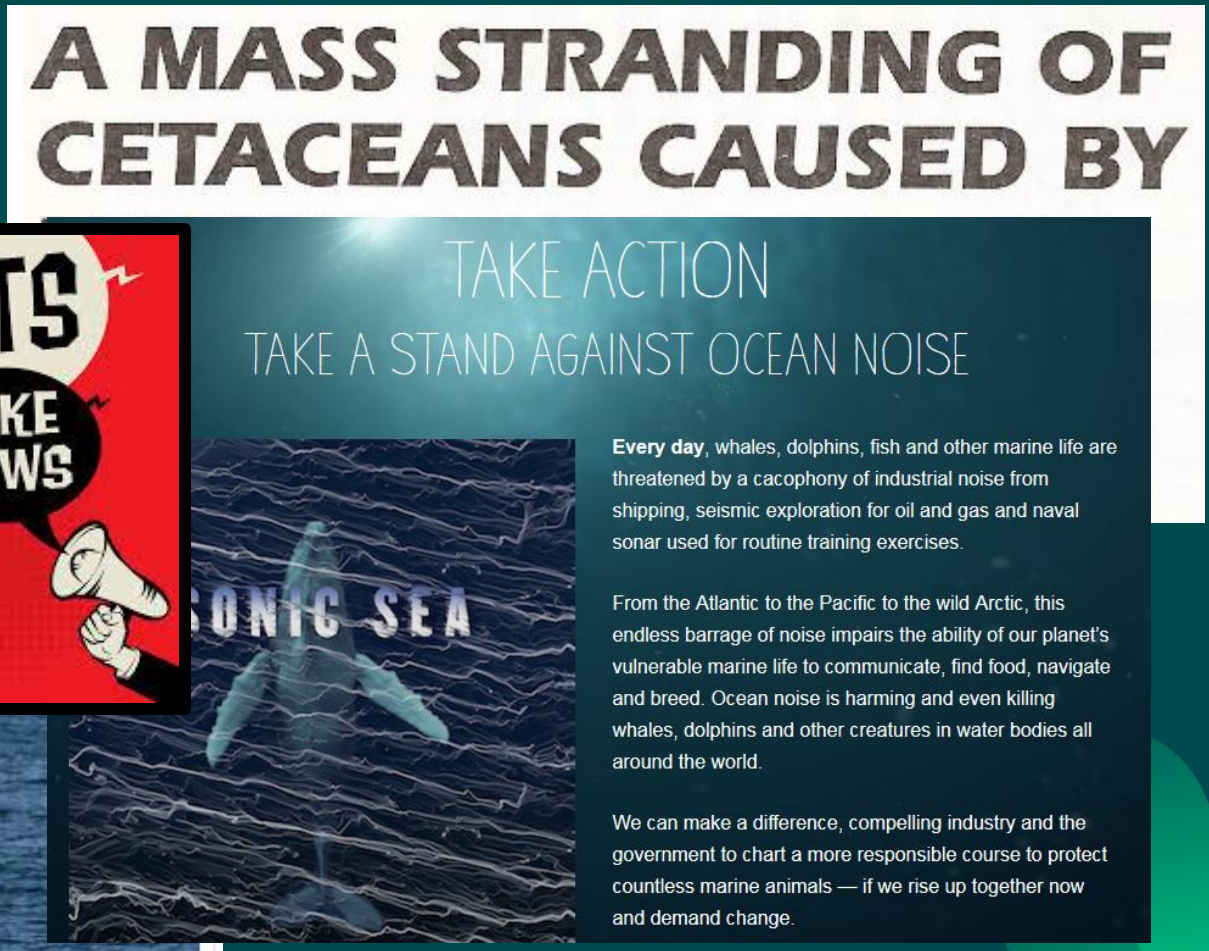
Marine Acoustics: Lessons Learned, Pitfall to Avoid on the Path to Success

We are helping shape the U.S. offshore wind industry, as well as contributing to marine acoustic impact analyses. We share some lessons we have learned to help pave your path to success.

- **Lessons Learned**
  1. Stakeholder Engagement
  2. Baseline Underwater Sound Measurements
  3. Flexible Modeling Structure
- **Pitfall to Avoid**
  1. Underestimating the Complexity of Evaluating Potential Effects

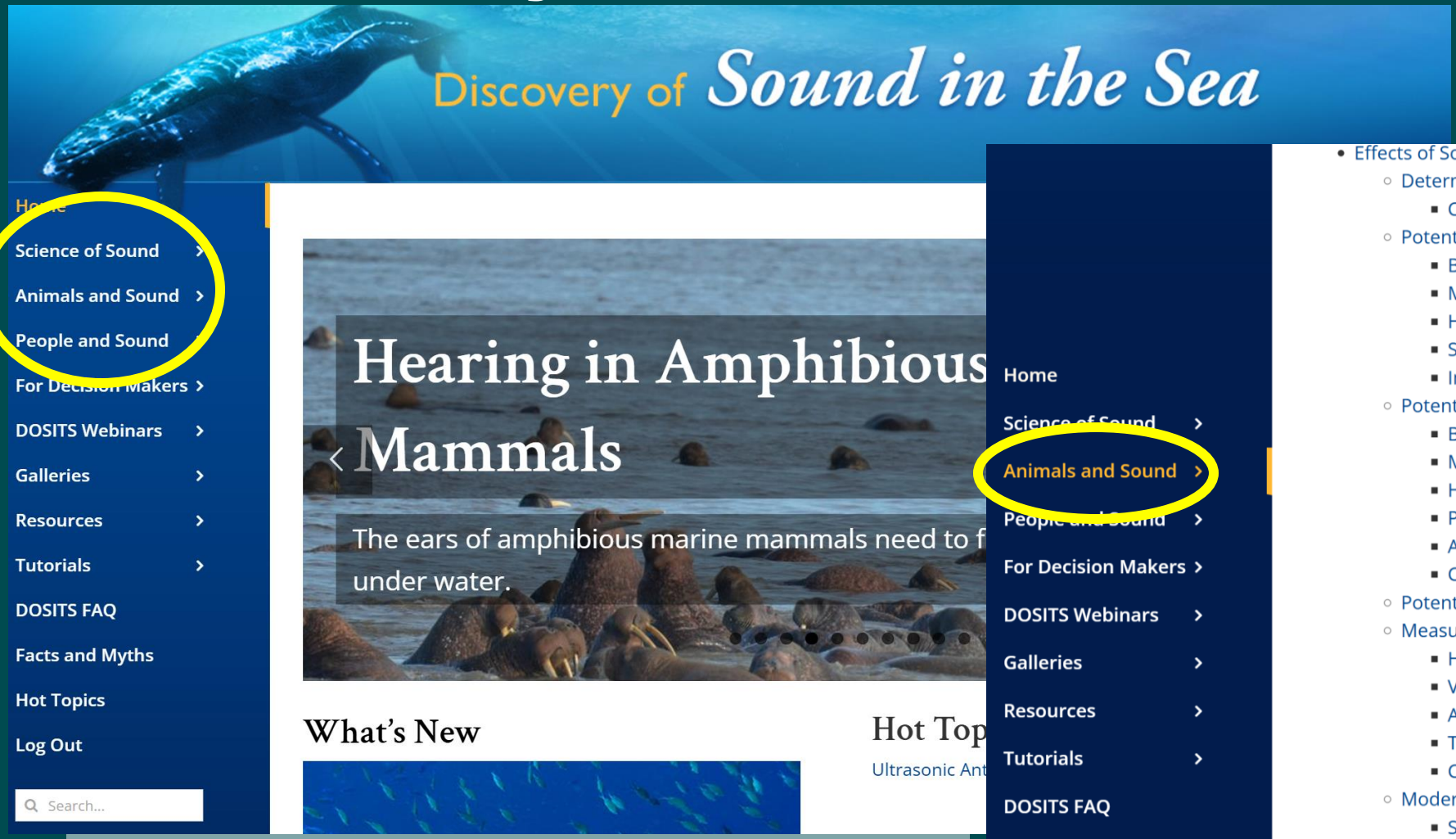
I. Stakeholder Engagement

Crucial conversations: State the Facts



Discovery of Sound in the Sea

dosits.org



Discovery of Sound in the Sea

DOSITS Resources for Decision Makers

dosits.org/decision-makers/resources/

Videos

- Science of Sound Video
- Marine Mammal Hearing
- Hearing in Marine Fishes
- Determining Mitigation and Mon

- Decision Maker Tutorials
  - Decision Makers Effects of Sound Tutorial Introduction
  - Determine if a Sound Affects a Marine Animal Tutorial Introduction
  - Decision Makers Science of Sound Tutorial Introduction
  - Decision Makers Sound Source Tutorial Introduction

Anthropogenic Sound Sources

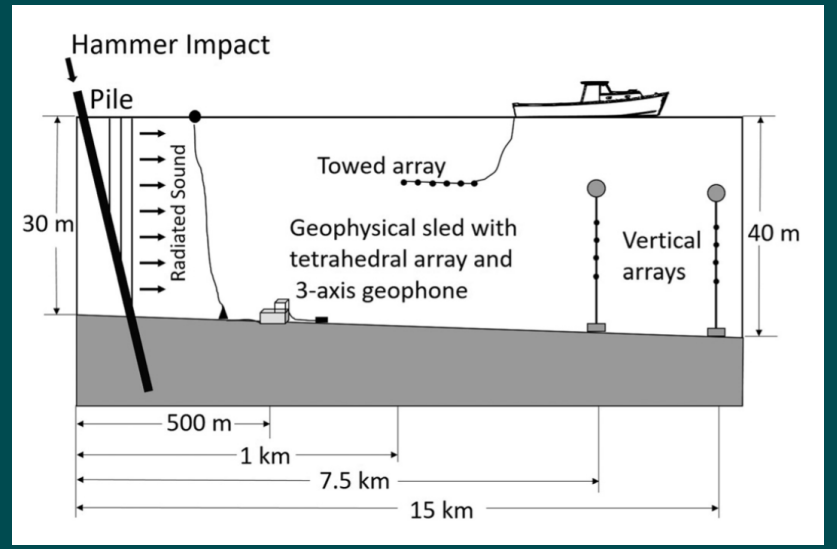
- Commercial Vessel Traffic
- Echosounders
- Pile driving
- Seismic Airguns
- Sonar
- Wind Turbine

- FAQs
- Facts and Myths
- Stranding Fact Sheet
- Seismic Airgun Fact Sheet
- Media Backgrounder – How do animal hear underwater?
- DOSITS Webinars

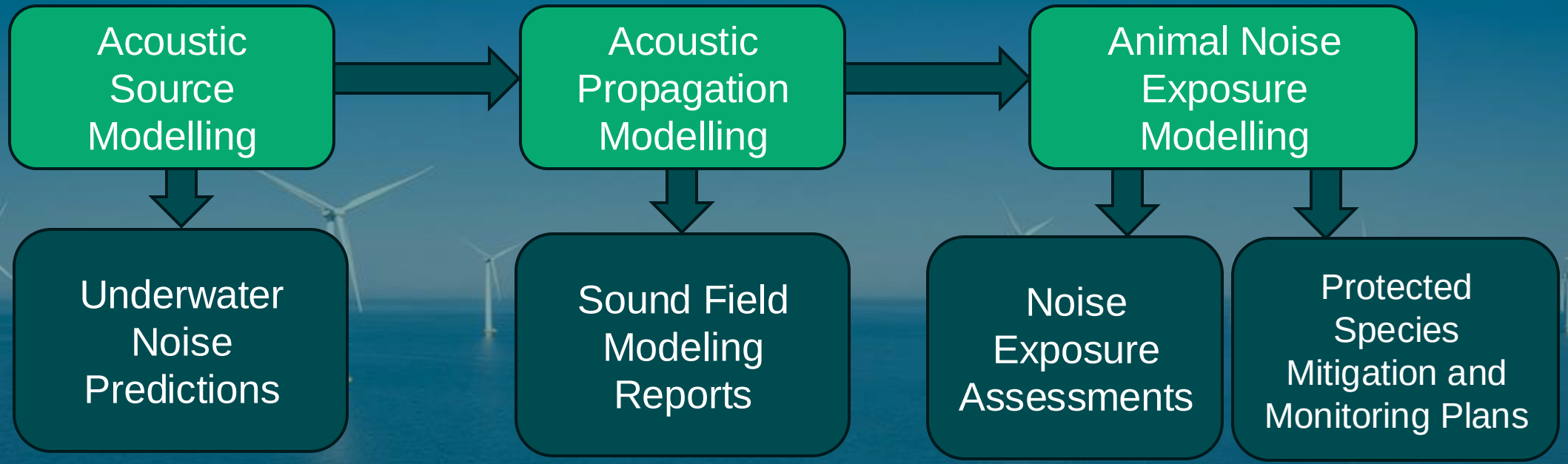
II. Baseline Underwater Sound Measurements

Lessons Learned

- Amaral et al. 2020: Identified need for 3D modelling of raked piles at Block Island Wind Farm
- Lin et al. 2019: 3D propagation model of operational wind farm sounds
- Potty et al. 2023: Particle motion as part of acoustic energy



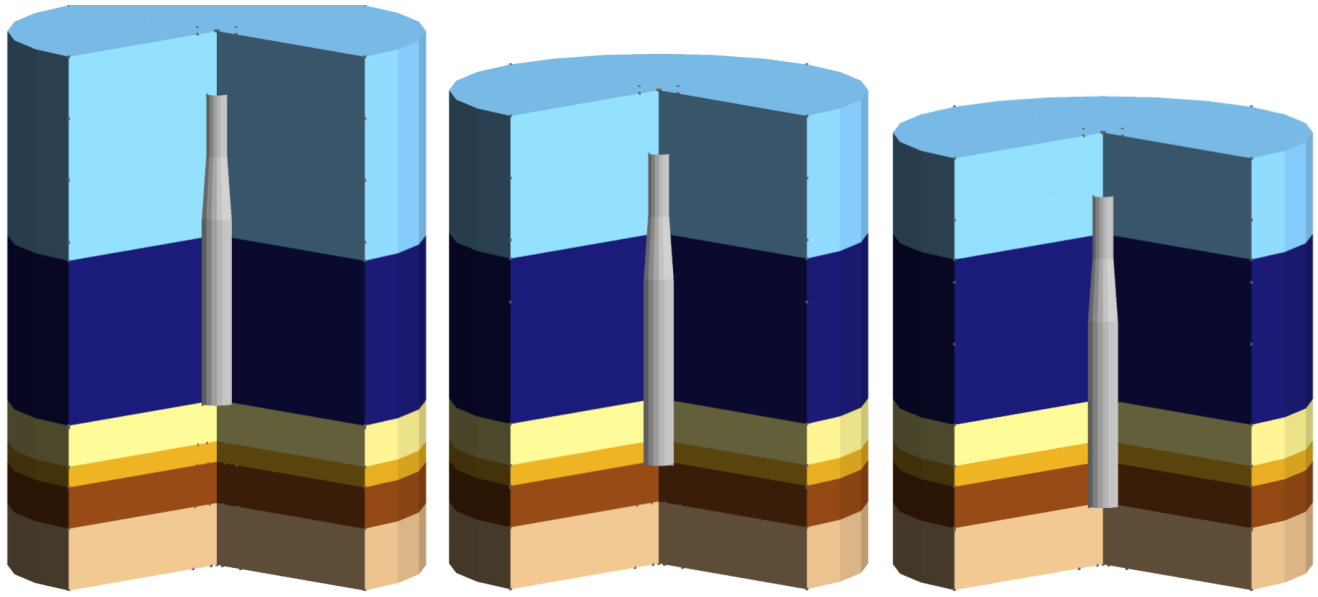
III. Flexible Modelling Structure



Pile Driving Acoustic Source Model

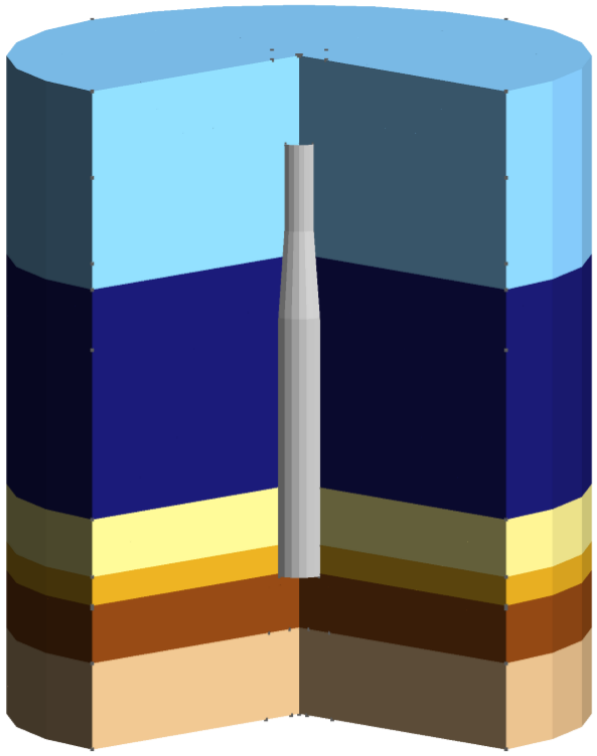
State-of-the-art numerical wave + 3D modelling provides sound field predictions accounting for:

- Pile length, diameter, thickness, and taper
- Pile penetration depth
- Hammer type and force
- Sound speed and shear speed profiles for solid and porous substrates

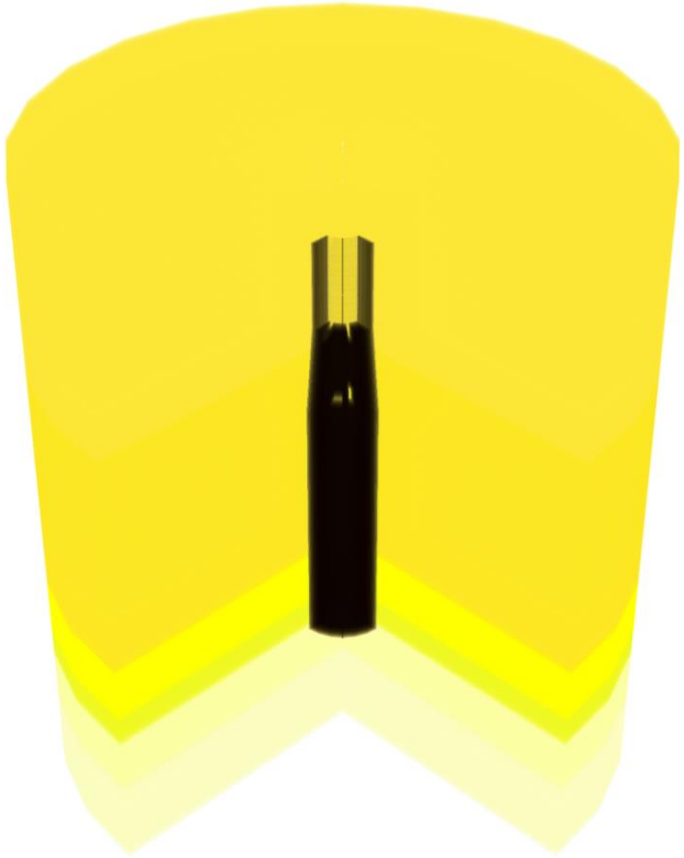


3D renders of a common XXL monopile in a stratified substrate

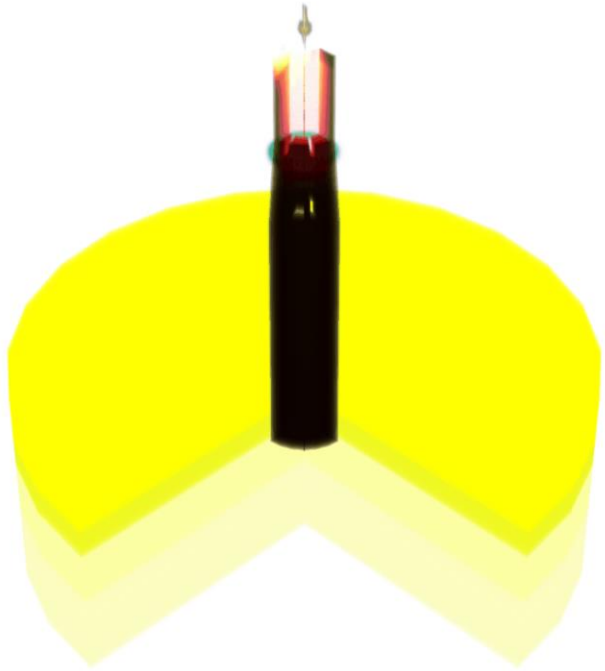
Pile Driving Model: 3D Sound



3D Render



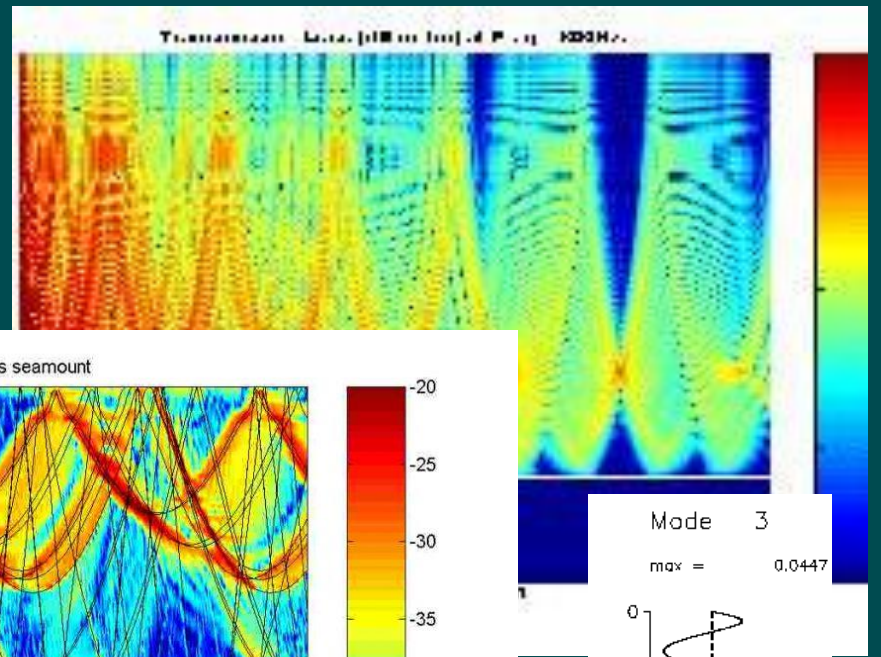
Impact Pile Driving

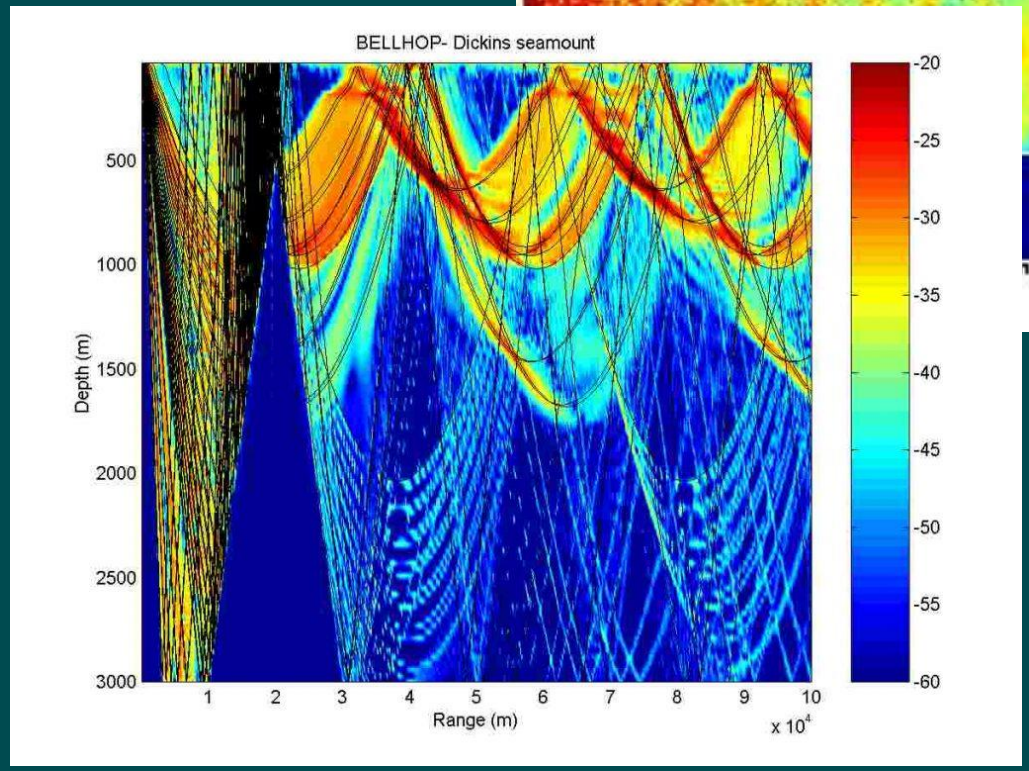


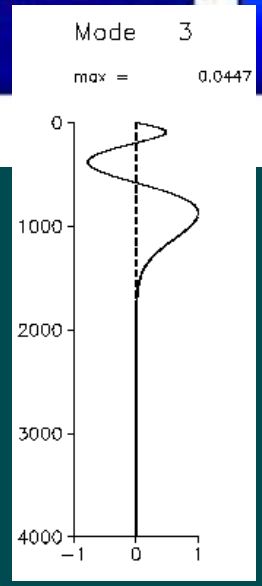
Vibratory Pile Driving

Acoustic Propagation Modelling

- Incorporates environmental conditions (bathymetry, water column profiles, sediment properties)
- Acoustic propagation models:
  - Parabolic Equation (PE)
    - RAMGeo: acoustic-elastic bottom with multiple sediment layers
    - 3D PE: horizontal refraction out of range-depth plane
  - Ray modelling: Bellhop
  - Normal mode: KRAKEN





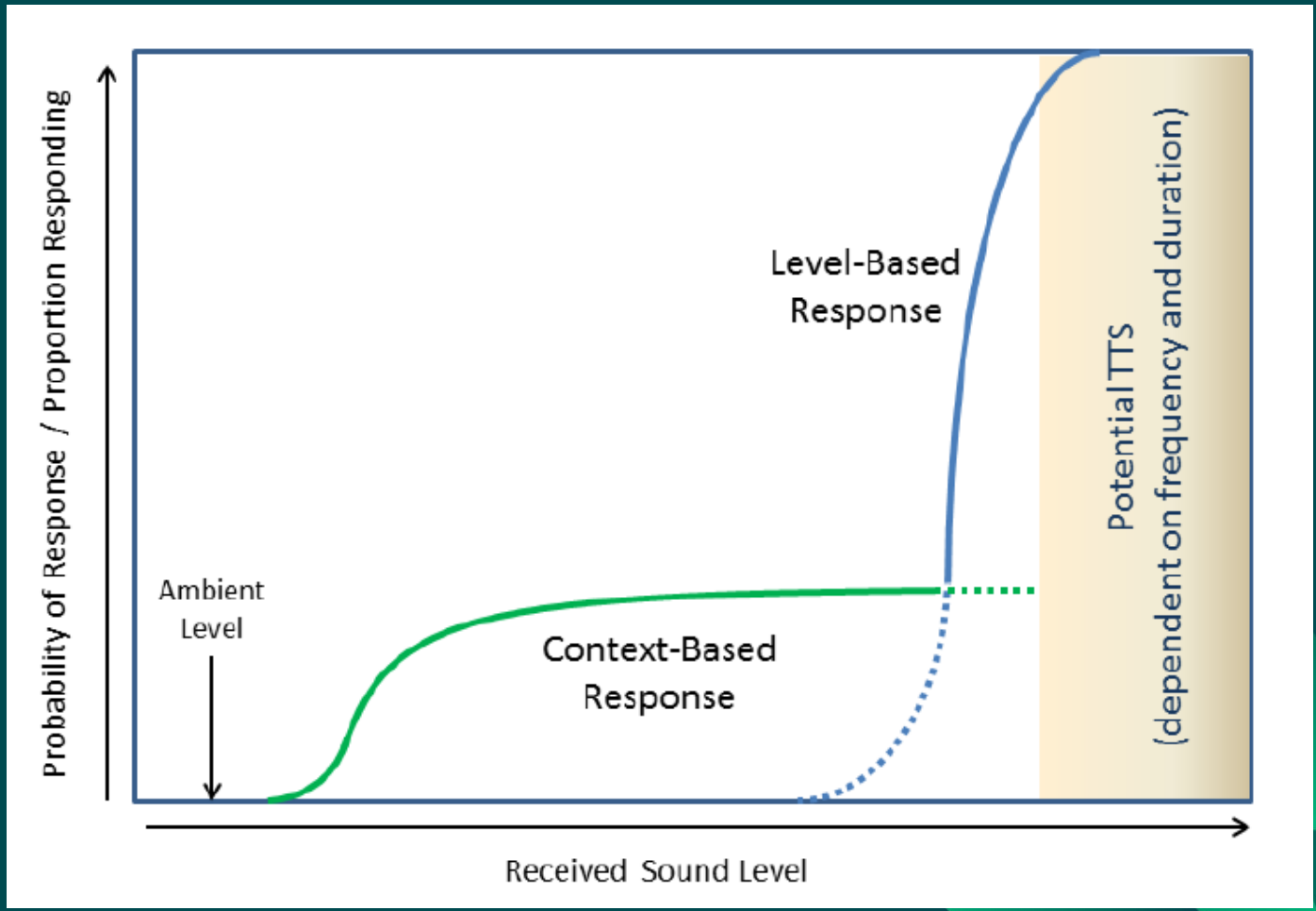


Pitfall to Avoid: Underestimating the Complexity of Evaluating Potential Effects

Develop meaningful thresholds

- One value does not reflect the science that shows animals react based on the context under which they are exposed

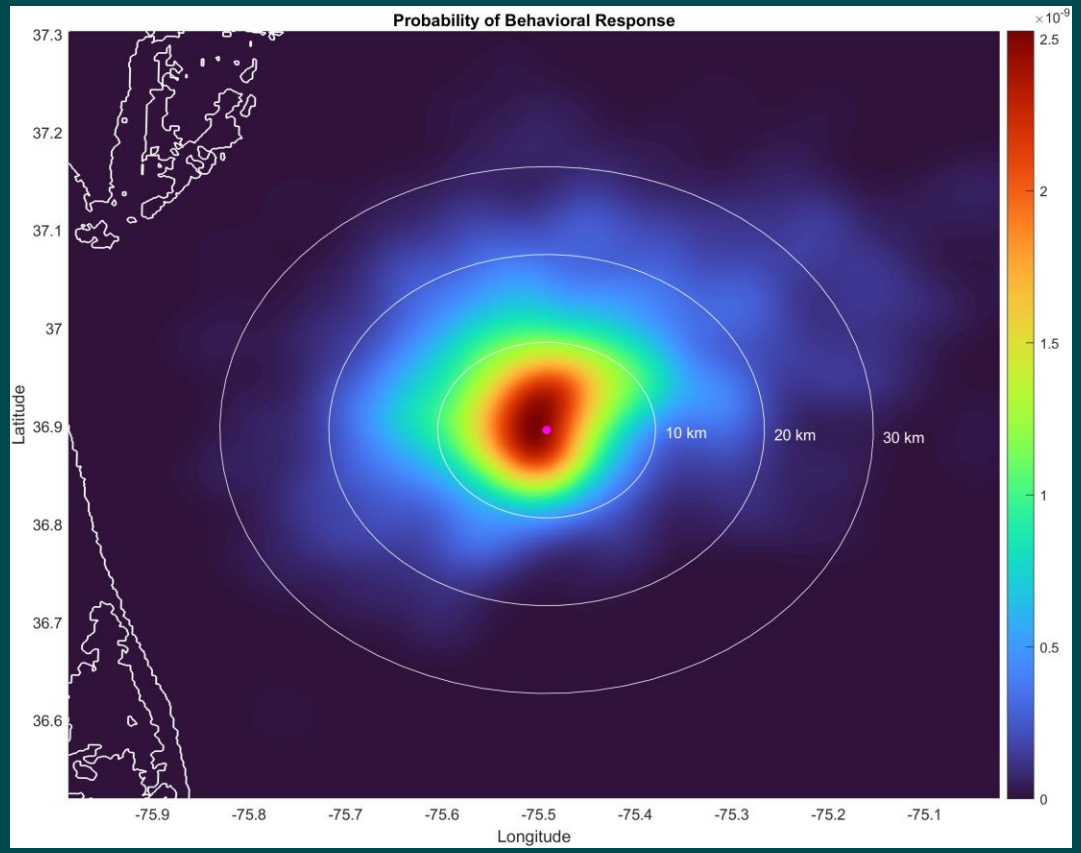
- At a certain level, almost all animals begin to have a response



U.S Navy, 2024

Animal Exposure Modelling

- The source and propagation modelling produce a sound field (a pressure timeseries at points in a 3D volume).
- Monte Carlo simulations of animals moving through the sound field, accumulating energy
- Output: 2D maps showing the probability density of a chosen animal species exceeding a selected threshold, accounting for species specific information such as
  - Historical population density (monthly)
  - Diving behaviour and swim speed
  - Hearing sensitivity and aversion to sound levels



Possibility with Few Data: Biologically Relevant Risk Assessment Framework

Vulnerability Score

- Population status, trend, size
- Habitat, temporal overlap
- Masking overlap
- Other environmental stressors

Exposure Index

- Activity index
- Spectral index

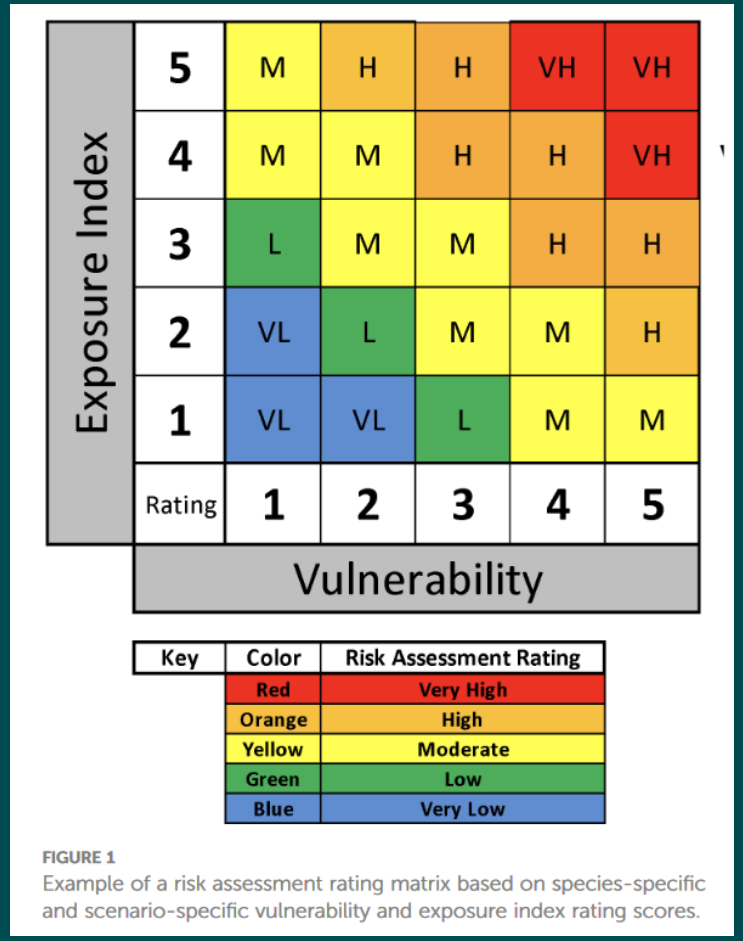


FIGURE 1
Example of a risk assessment rating matrix based on species-specific and scenario-specific vulnerability and exposure index rating scores.

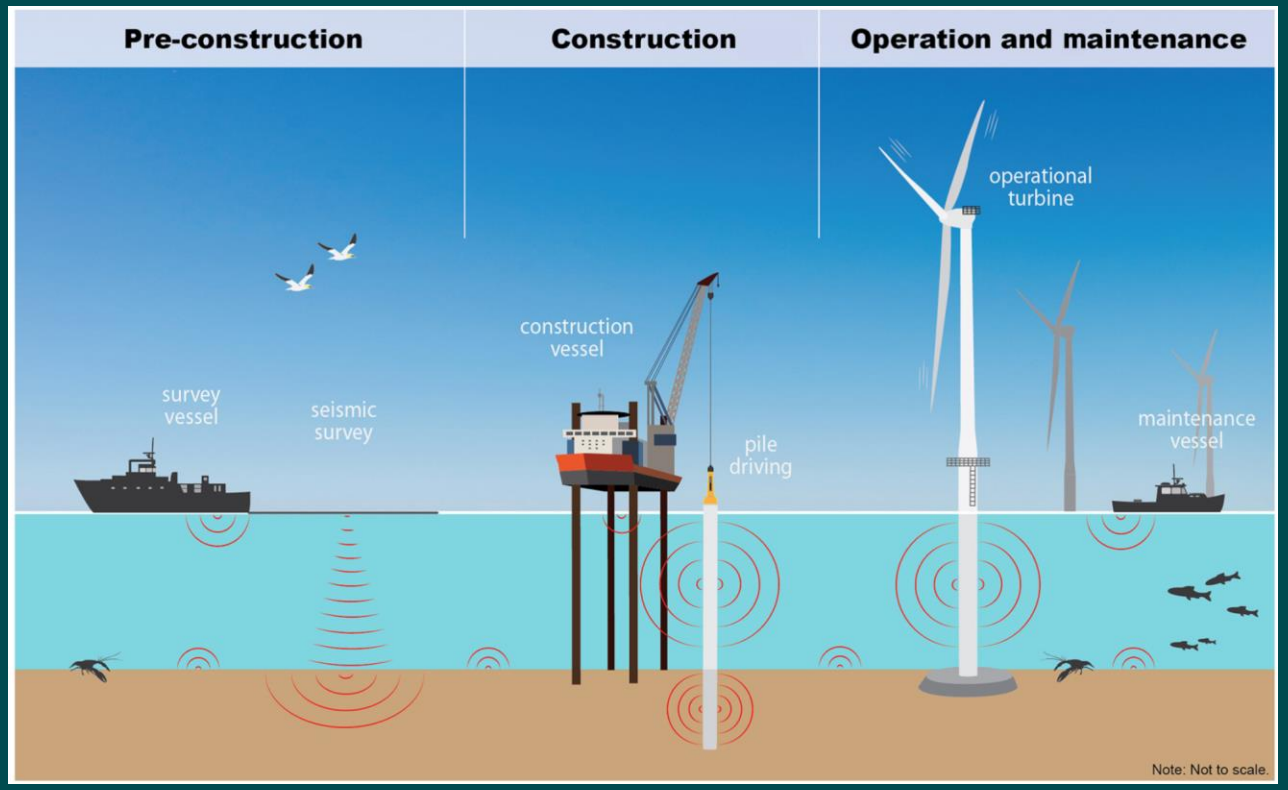
Southall et al. 2023

Cumulative Effects Analysis

Across Life Cycle of Each Wind Farm

- Multibeam Echosounder (MBES)
- Sub-bottom profilers
- Vessels
- Operational noise
- Explosives, UXO removal

Across Region, Time



Popper et al. 2022, Williams et al. 2023

Get in touch

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