Estimating Marine Mammal Response to Noise from a Tidal Energy Project

Brian Polagye, Rob Cavagnaro, and Chris Bassett

Northwest National Marine Renewable Energy Center
University of Washington

Jason Wood and Dom Tollit

Sea Mammal Research Unit, Ltd.

bpolagye@uw.edu
+1 206 543 7544

Motivation

- **Noise from tidal turbine operation may disturb marine mammals**

- **High uncertainty around behavioral response**

- **Monitoring response at pilot scale projects crucial to improving understanding**

- **Given economic constraints, monitoring studies should have a high probability of measuring behavioral response**
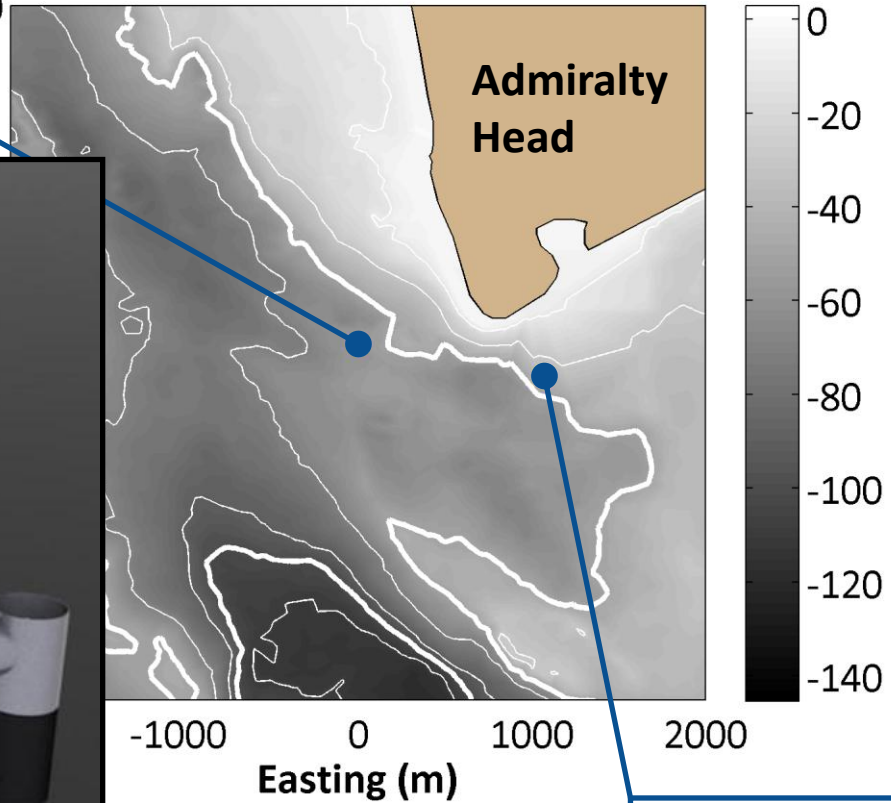
Project Overview

Admiralty Inlet, Puget Sound, WA
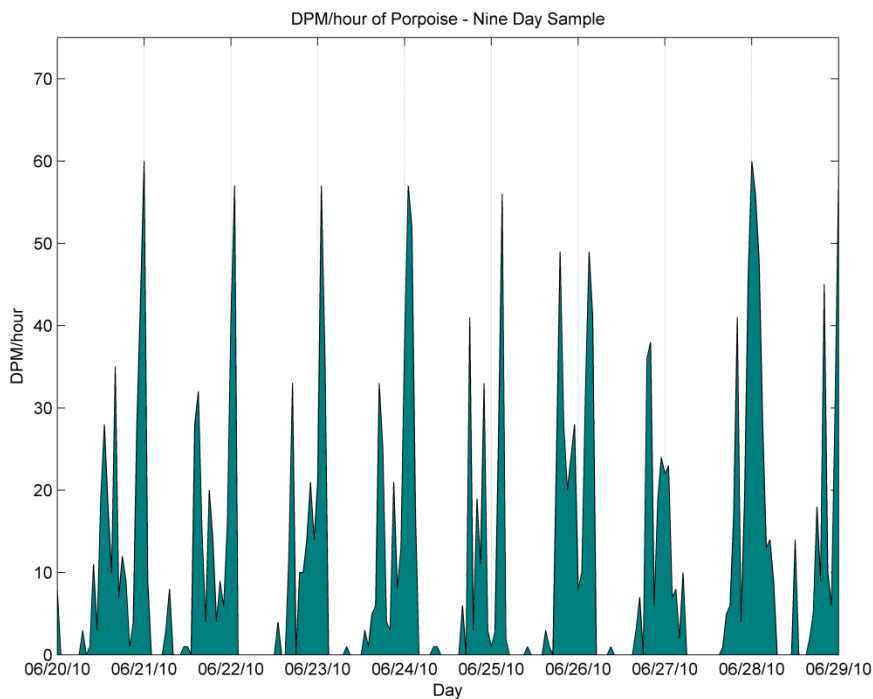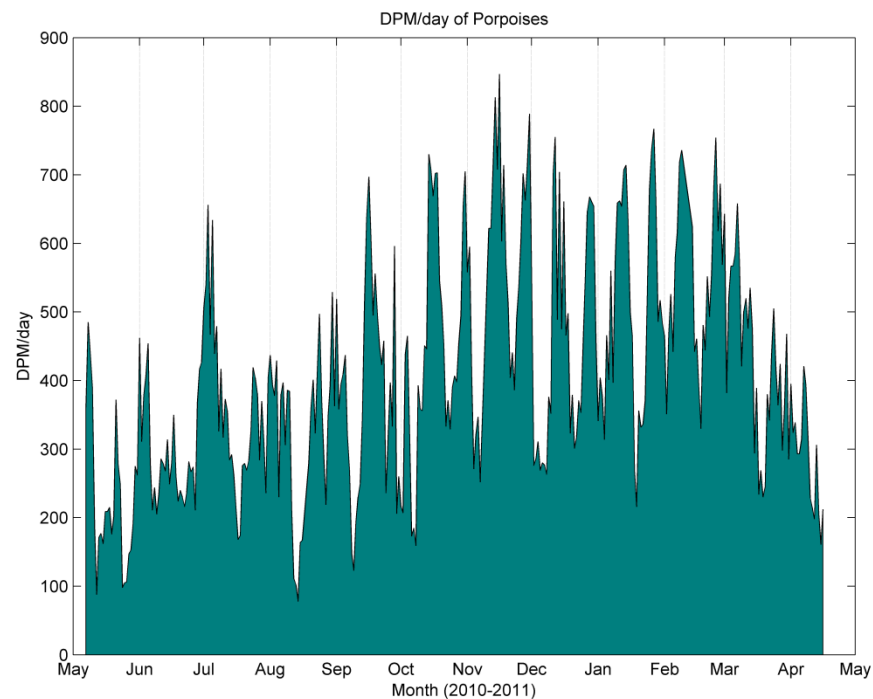
Turbine Site
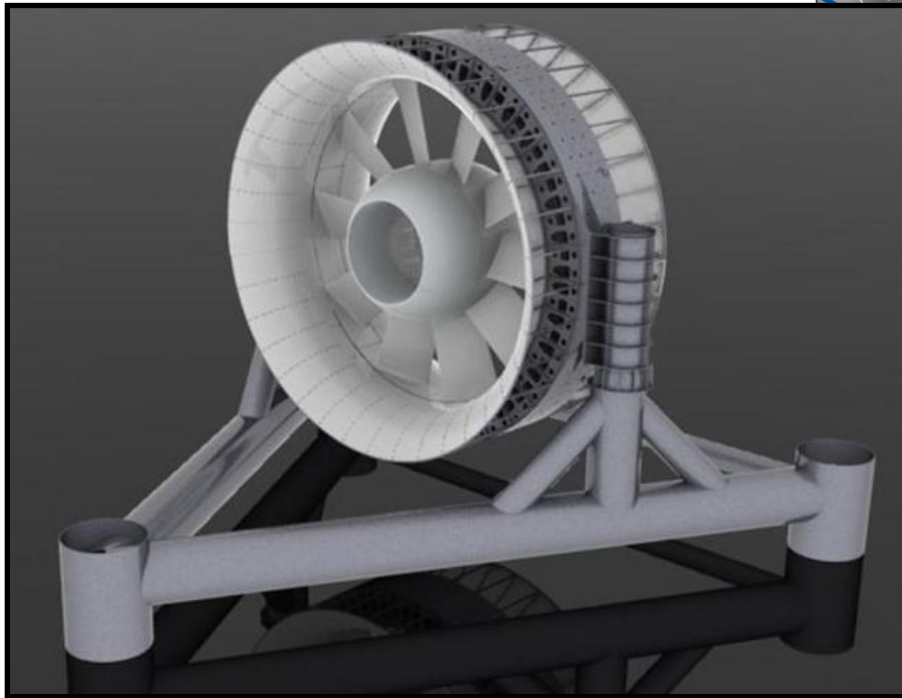
Study Site

Source: OpenHydro

Porpoise Presence and Absence

- **Echolocation monitored by a C-POD**

- **DPM is indicator of porpoise presence**

  — A minute in which an echolocation is detected is 1 DPM
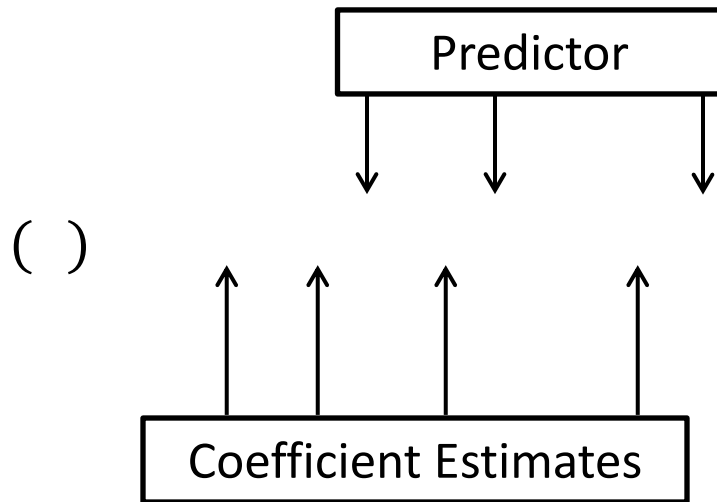

DPM per hour – 9 day sample
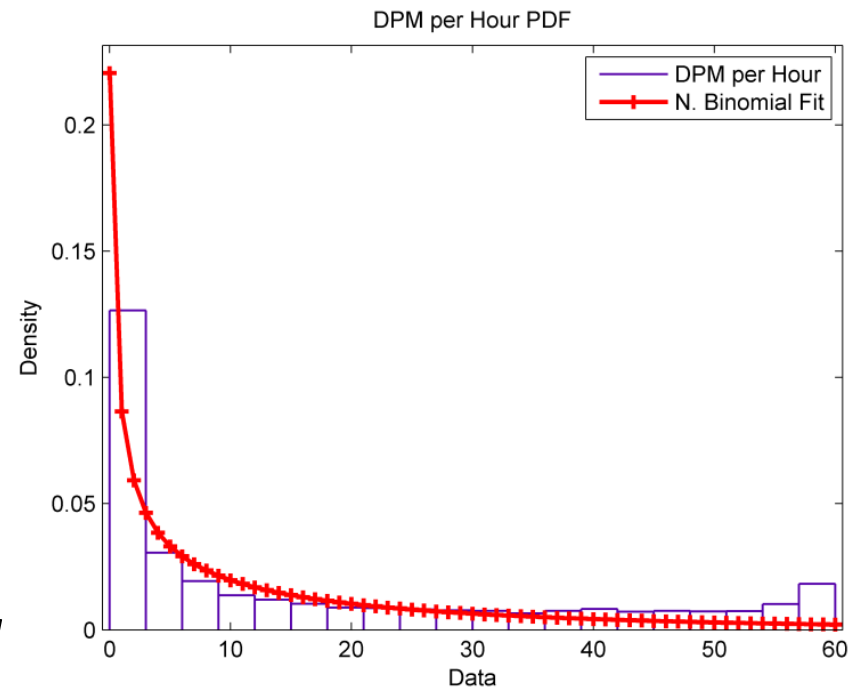
DPM per day from May 2010 – May 2011

Modeling Presence Trends

■ **Generalized Linear Model (GLM)**

— Regression model fitting response data (DPM/hour) to a distribution from the exponential family

Predictor

( )

Coefficient Estimates

DPM per Hour PDF

— DPM data is *negative binomial* distributed

Presence Trends

- **GLM explains relatively small amount of variation**

    — Predicted DPM values are significantly different from observed DPM ($p < 0.001$)

- **Deviance analysis ranks importance of regressors in fit**

| Predictor	β	p	Residual Deviance	Amount Improved
Constant	2.831	< 0.001	10730	-
Current Velocity	**-0.178**	< 0.001	10263	467
Neap/Spring	-0.104	< 0.001	10241	22
Day/Night	**0.950**	< 0.001	9350	891
Season	-0.054	> 0.03	9341	9
Month	0.007	> 0.1	9340	1
Turbine Power Output	**-25.2**	< 0.001	9255	85

Estimating Effect of Turbine Noise

- **Harbor porpoises expected to display avoidance to high received levels of noise**
  - Exposures exceeding 140 dB re 1 μ Pa result in sustained avoidance (Southall et al. 2007)
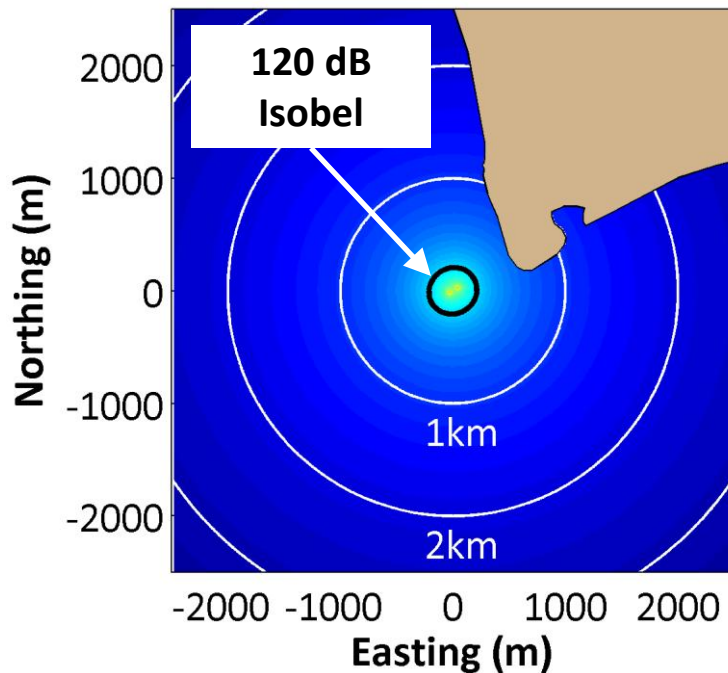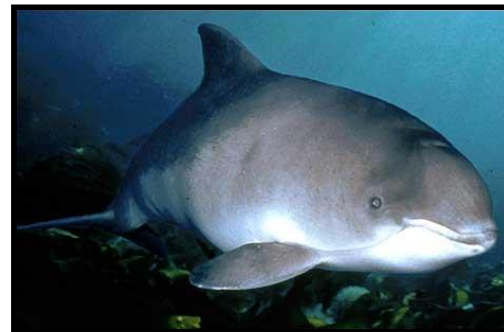

75th Operating Percentile
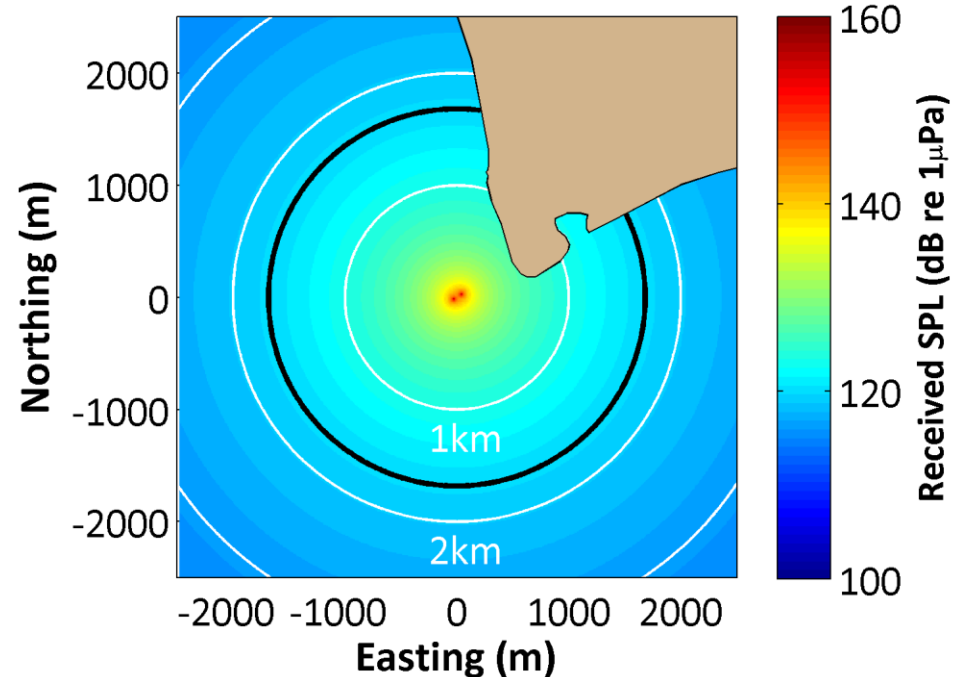
99th Operating Percentile

Study Design

- **Use passenger ferry as a pre-installation source of opportunity**
  - Broadband source level: 173 dB re 1 μPa at 1 m
  - Source duration in C-POD range ≈ 1 minute

- **Monitor echolocation activity as a proxy for avoidance, focusing on temporal trends**
  - Latency after last outbound ferry passage
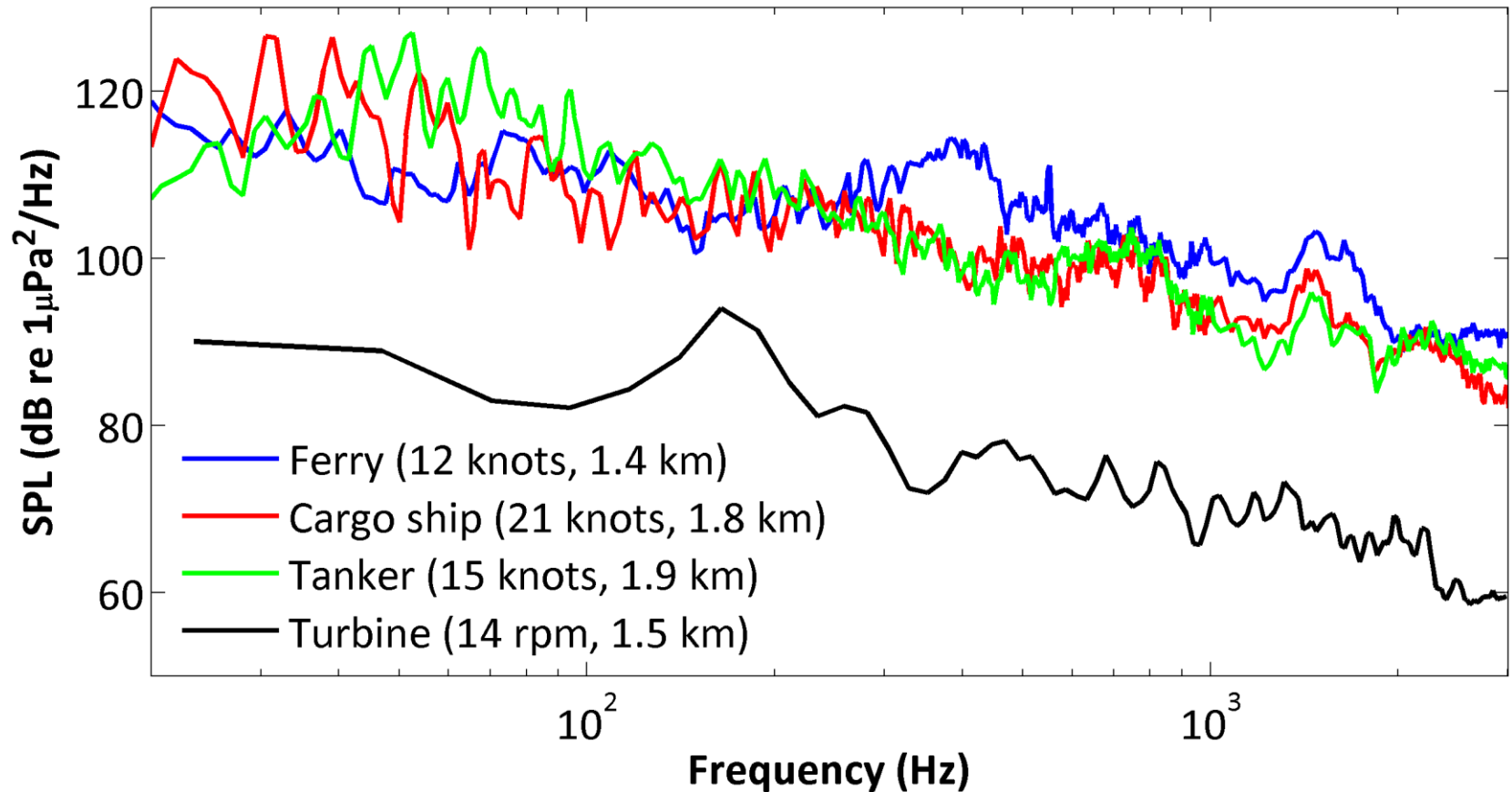 - Decrease after first inbound ferry passage

 + **=** **?**

Analogue Suitability

Legend:
- Ferry (12 knots, 1.4 km) — blue
- Cargo ship (21 knots, 1.8 km) — red
- Tanker (15 knots, 1.9 km) — green
- Turbine (14 rpm, 1.5 km) — black

Y-axis: SPL (dB re $1\mu Pa^2/Hz$)
X-axis: Frequency (Hz)

➡ **Ferry noise louder than turbine noise**
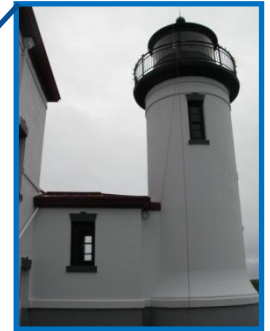
Turbine noise more continuous

Acoustic data for turbine courtesy of OpenHydro and Scottish Association for Marine Science
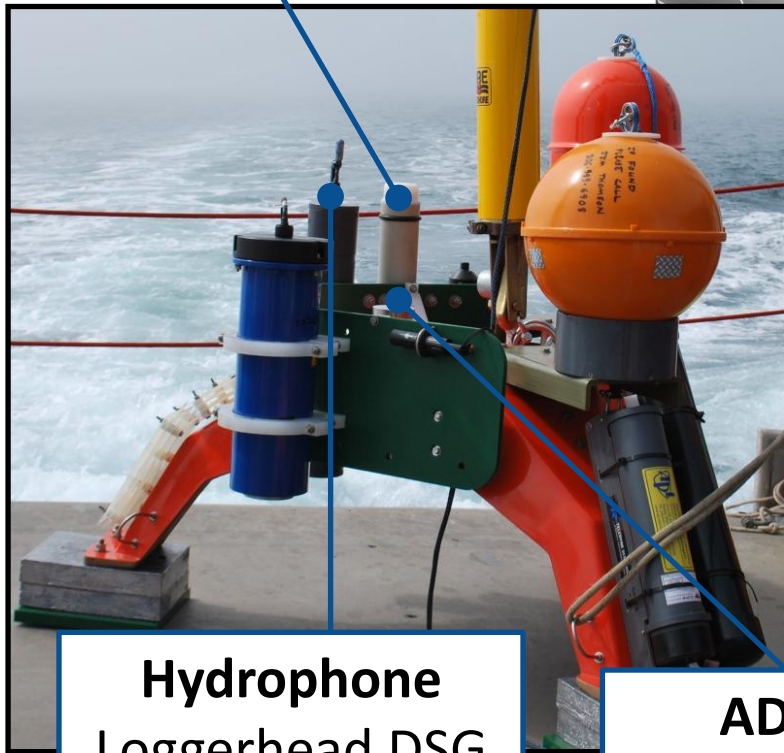
Monitoring Instrumentation

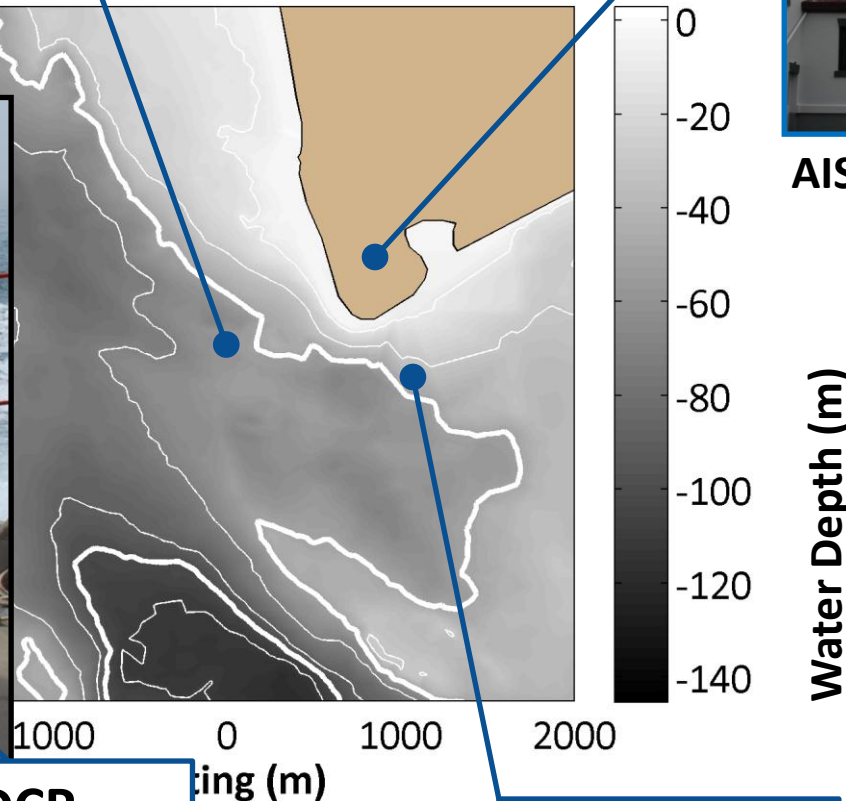
Click Detector
Chelonia C-POD

Turbine Site

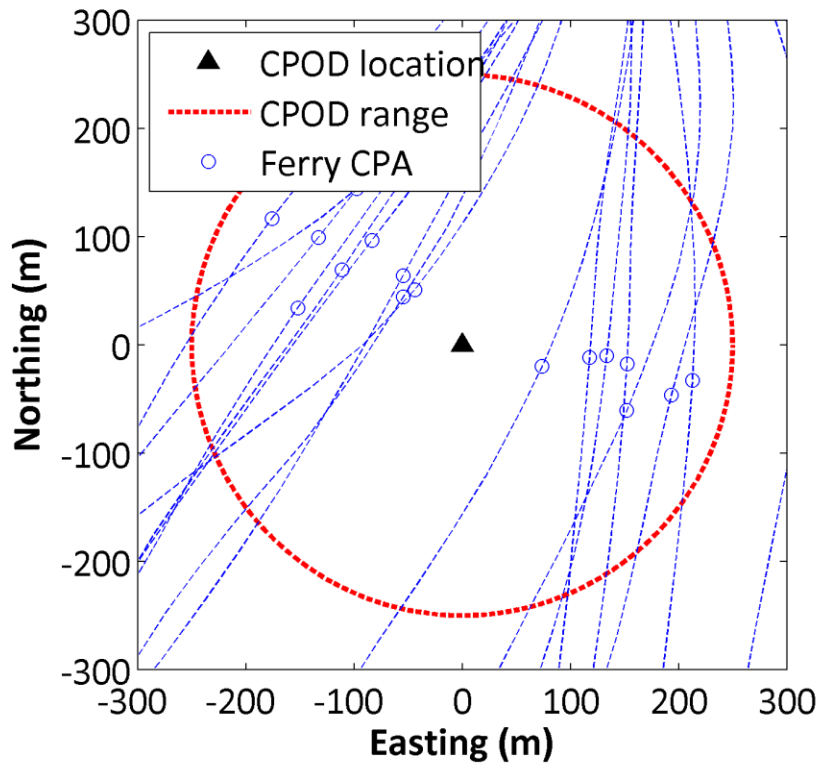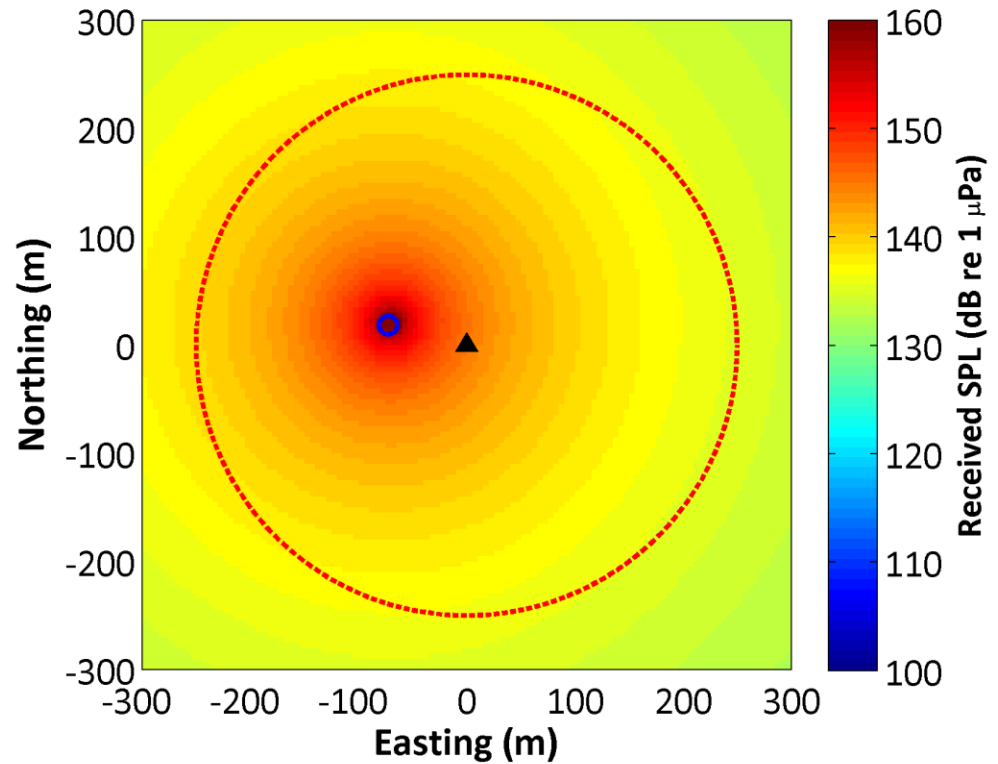**AIS Receiver**

Hydrophone
Loggerhead DSG

ADCP
600 kHz

Study Site

2000

1000   0   1000   2000

ting (m)

Water Depth (m)

0

-20

-40

-60

-80

-100

-120

-140

Ferry Acoustic Stressor
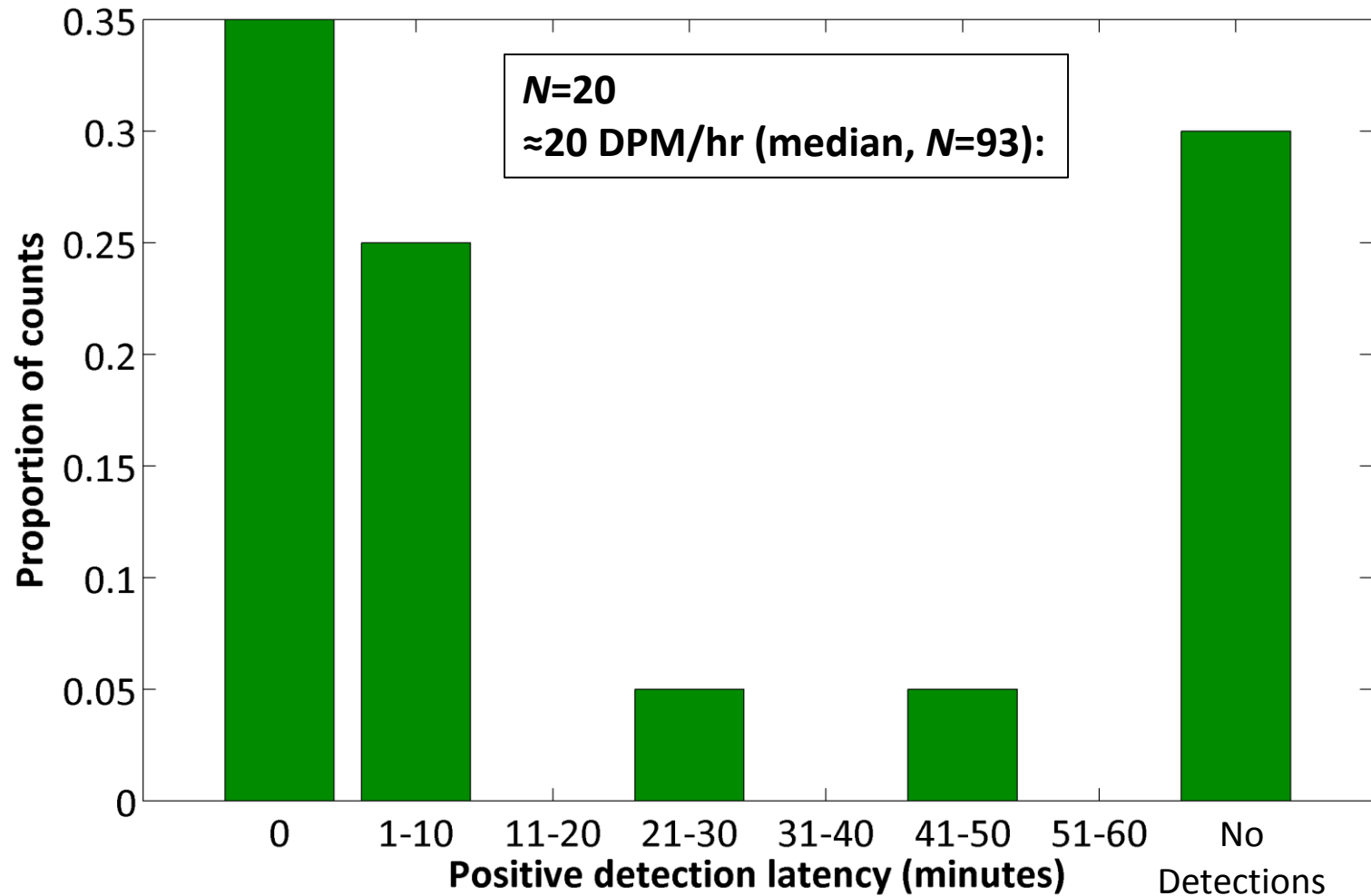

Measured Ferry Positions

Modeled Received Levels
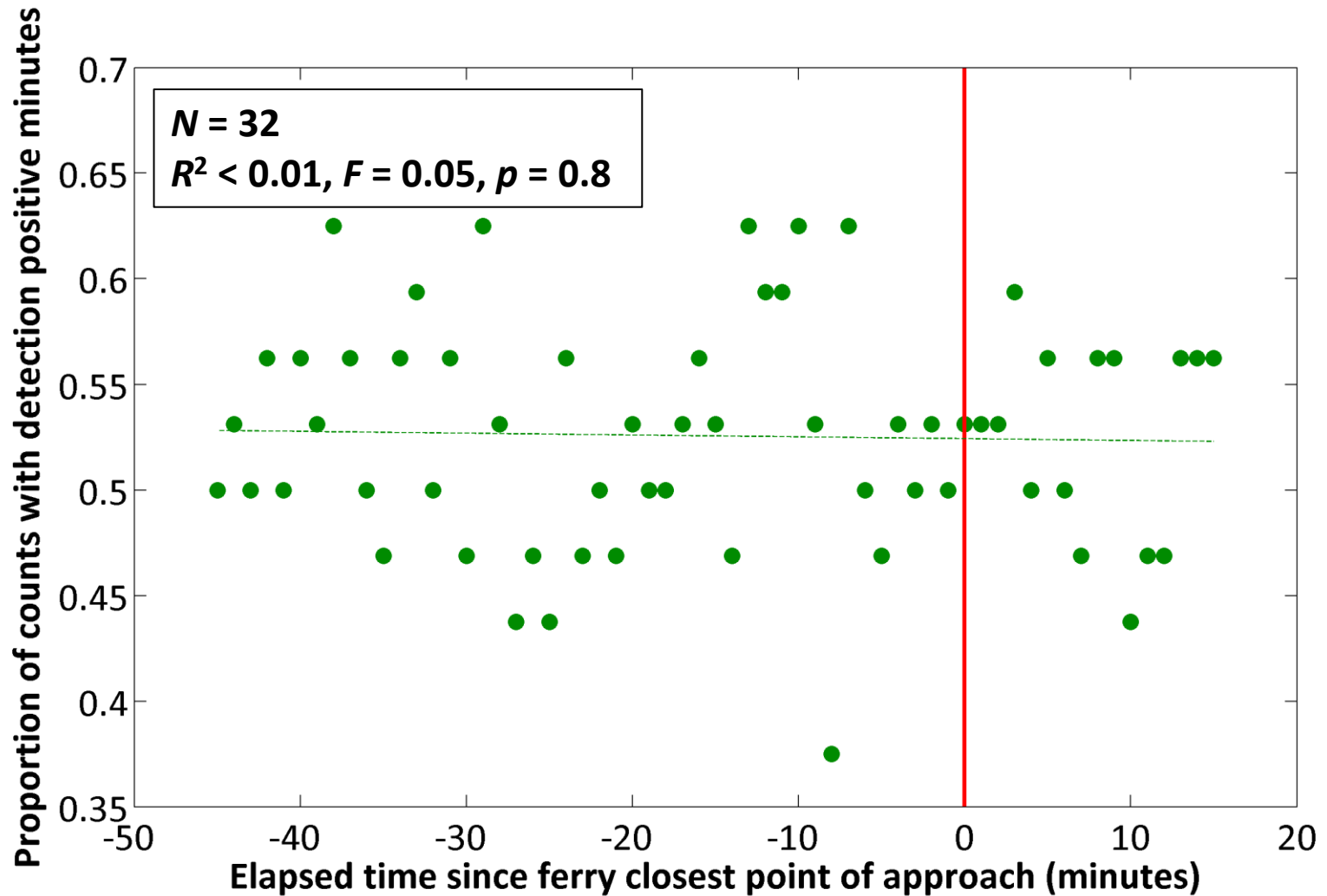
At closest point of approach, ferry is quite loud

Strong Behavioral Change

Is there an extended period of inactivity after ferry passes?

N=20
≈20 DPM/hr (median, *N*=93):

Moderate Behavioral Change

Does activity decrease after passage?

Summary

- **Ferries generate quite loud noise**

- **Harbor porpoise can hear this noise**

- **We expect harbor porpoise to respond to this noise through avoidance**
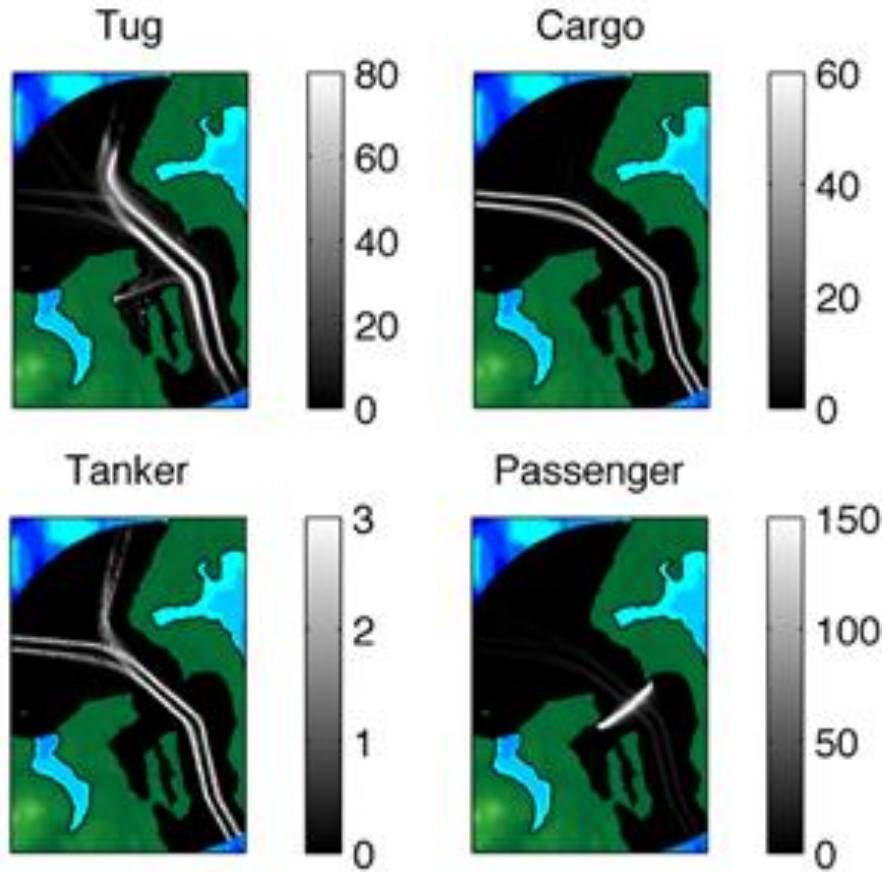
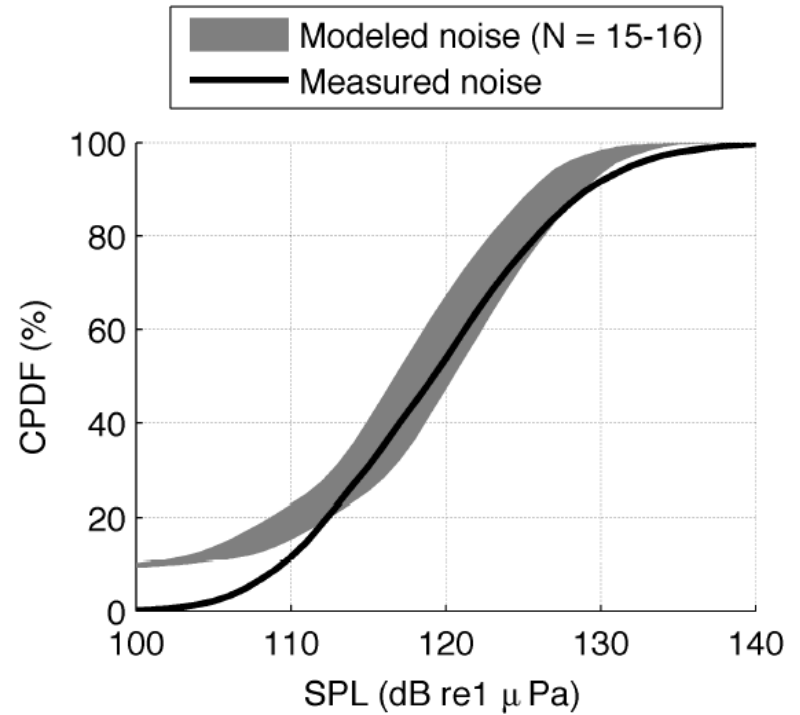➡ *But*... **no detectable change in presence. Why?**

— Changes not detectable by C-PODs?

— Noise habituation?

Environmental Context – Habituation?
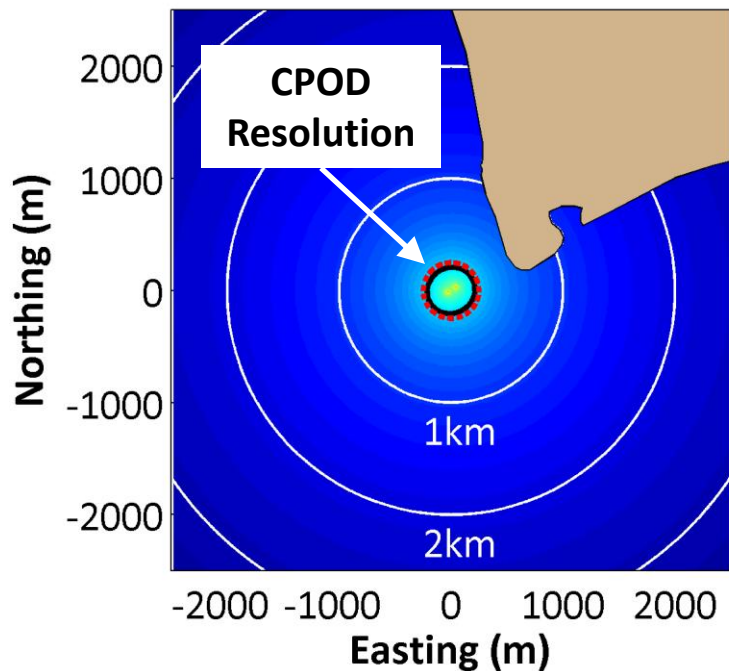

Vessel density (vessel-minutes)

Ambient noise reconstruction based only on vessel traffic

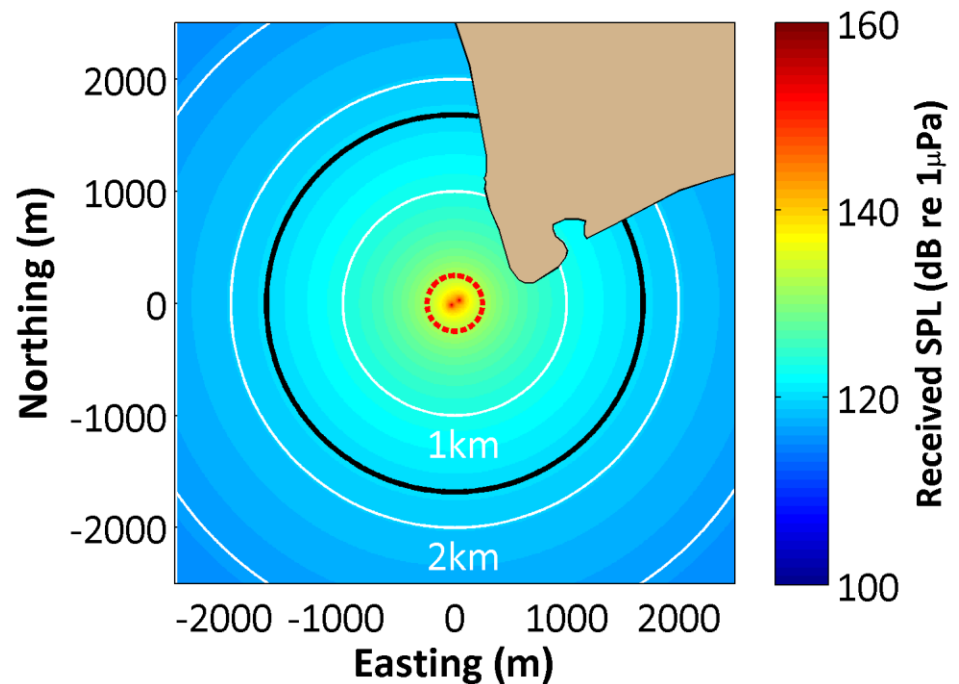Bassett et al. (*in preparation*) A vessel noise budget for Admiralty Inlet, Puget Sound, WA

Post-Installation Monitoring Implication

- **Harbor porpoises in vicinity of proposed project may be habituated to high intensity noise due to omnipresent vessel traffic**

75th Operating Percentile   99th Operating Percentile

Questions?

Acknowledgements

- Joe Talbert, Jim Thomson, and Alex deKlerk for designing and maintaining the Sea Spider.

- Washington State Parks for hosting the AIS receiver and data logger.