

Estimating Marine Mammal Response to Noise from a Tidal Energy Project

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Motivation

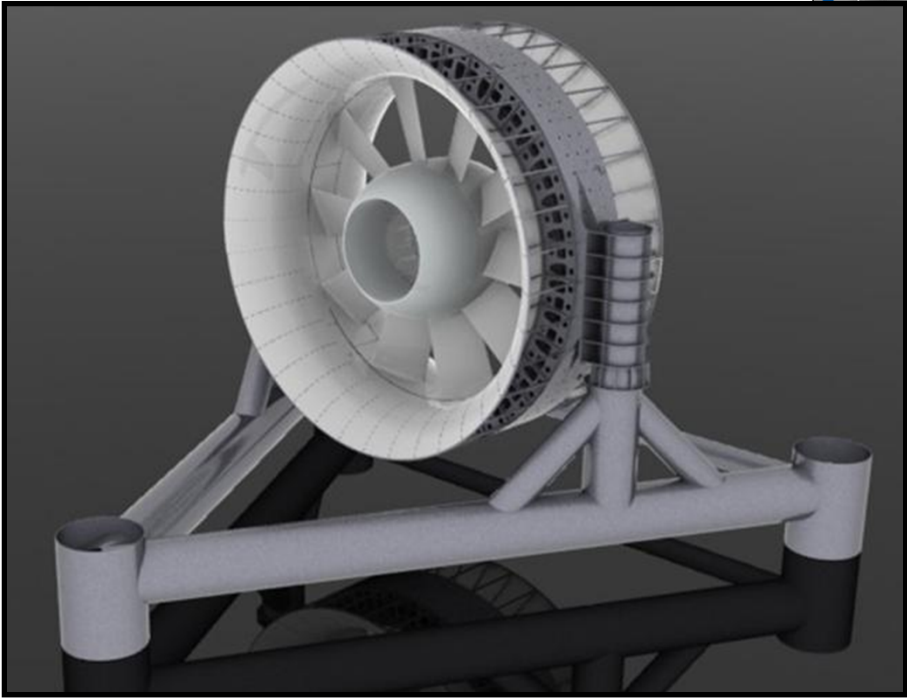
- **Noise from tidal turbine operation may disturb marine mammals**
- **High uncertainty around behavioral response**
- **Monitoring response at pilot scale projects crucial to improving understanding**
- **Given economic constraints, monitoring studies should have a high probability of measuring behavioral response**



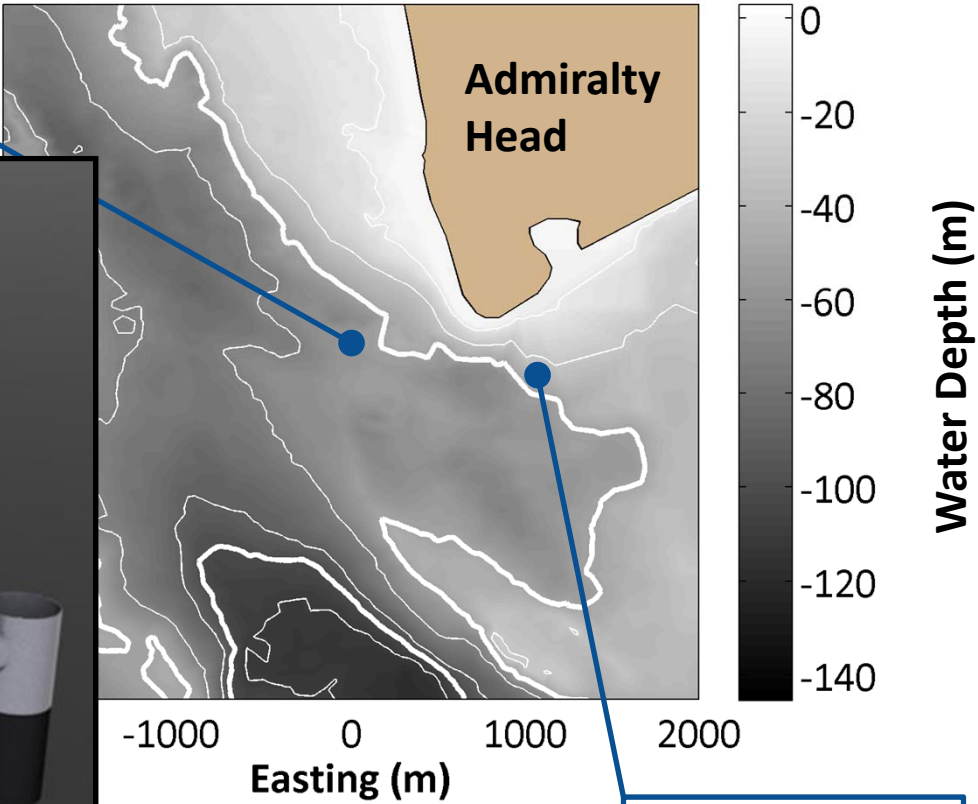
Project Overview

Admiralty Inlet, Puget Sound, WA

Turbine Site



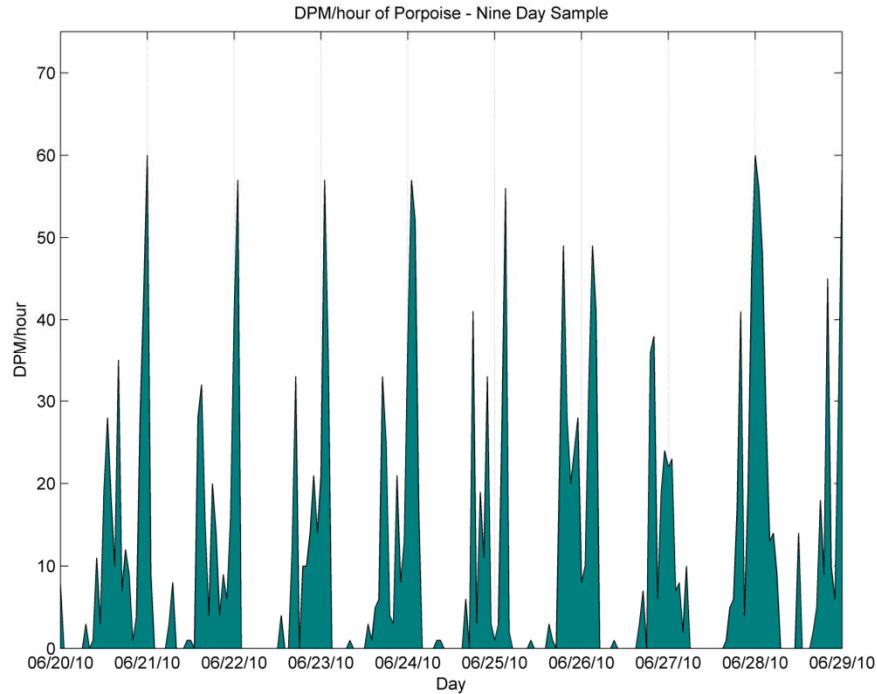
Source: OpenHydro



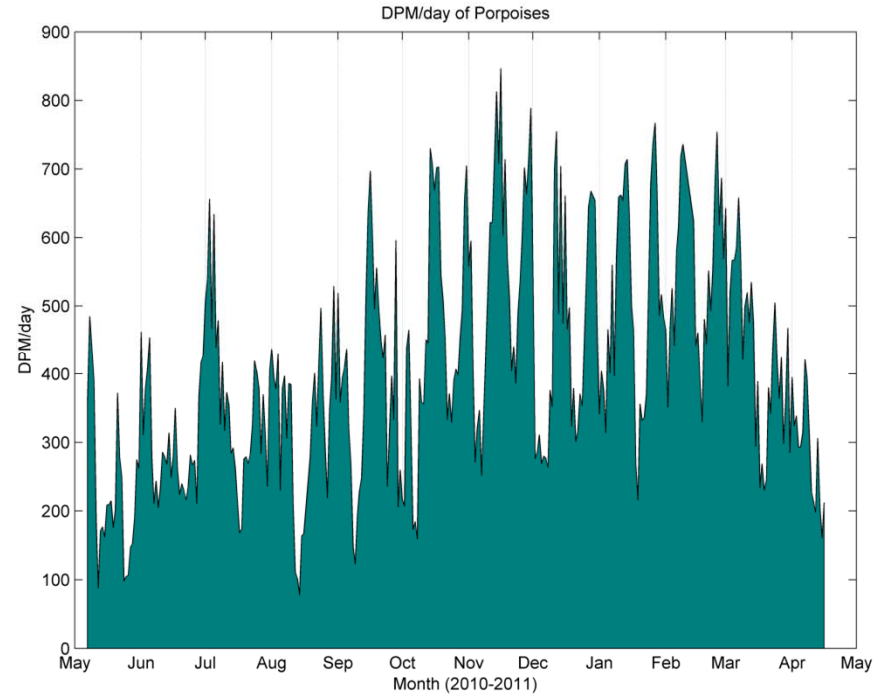
Study Site

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

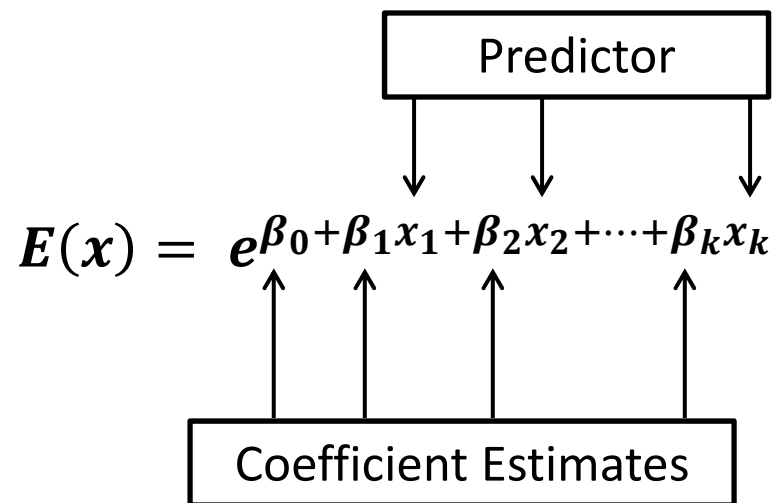


DPM per day from May 2010 – May 2011

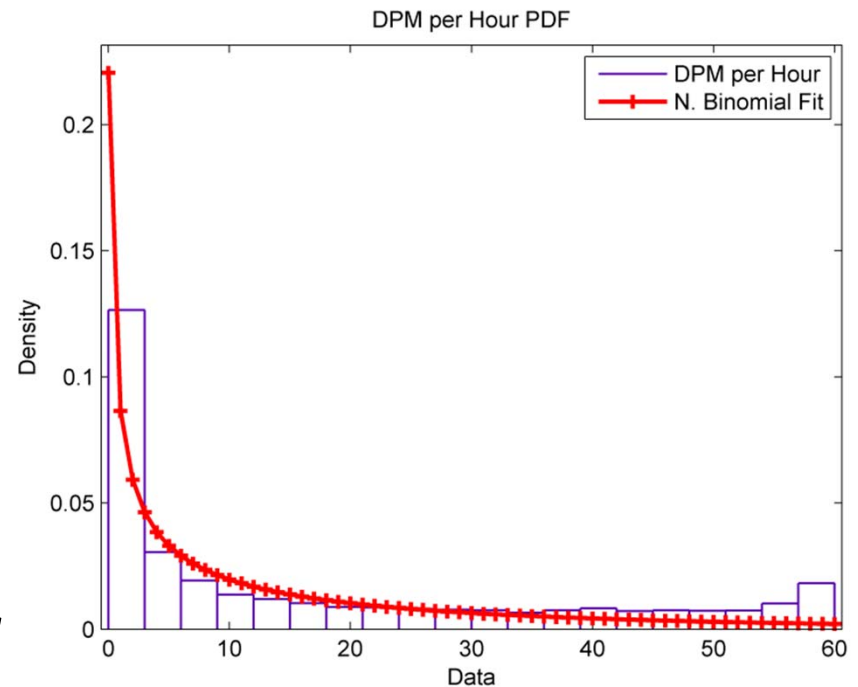
Modeling Presence Trends

■ Generalized Linear Model (GLM)

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



- DPM data is *negative binomial* distributed



Presence Trends

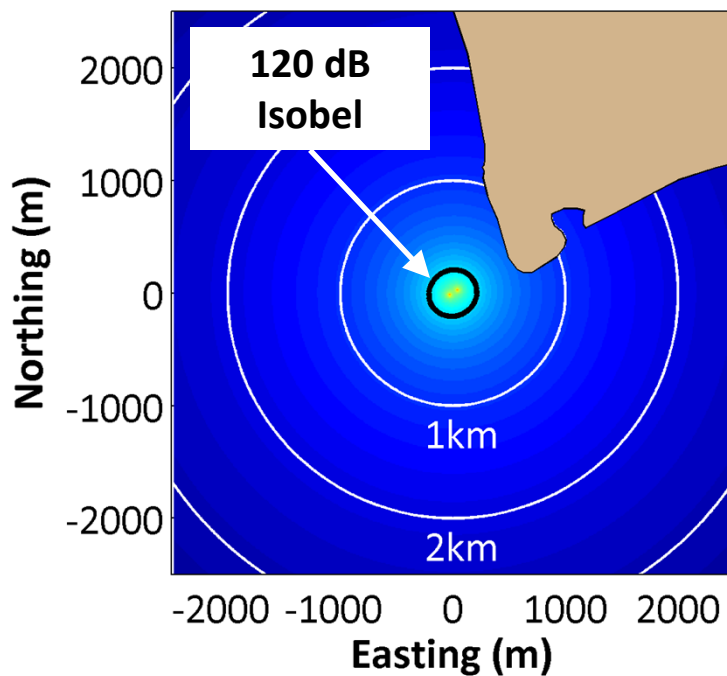
- **GLM explains relatively small amount of variation**
 - Predicted DPM values are significantly different from observed DPM ($\chi^2_{8061} p < 0.001$)
- **Deviance analysis ranks importance of regressors in fit**

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

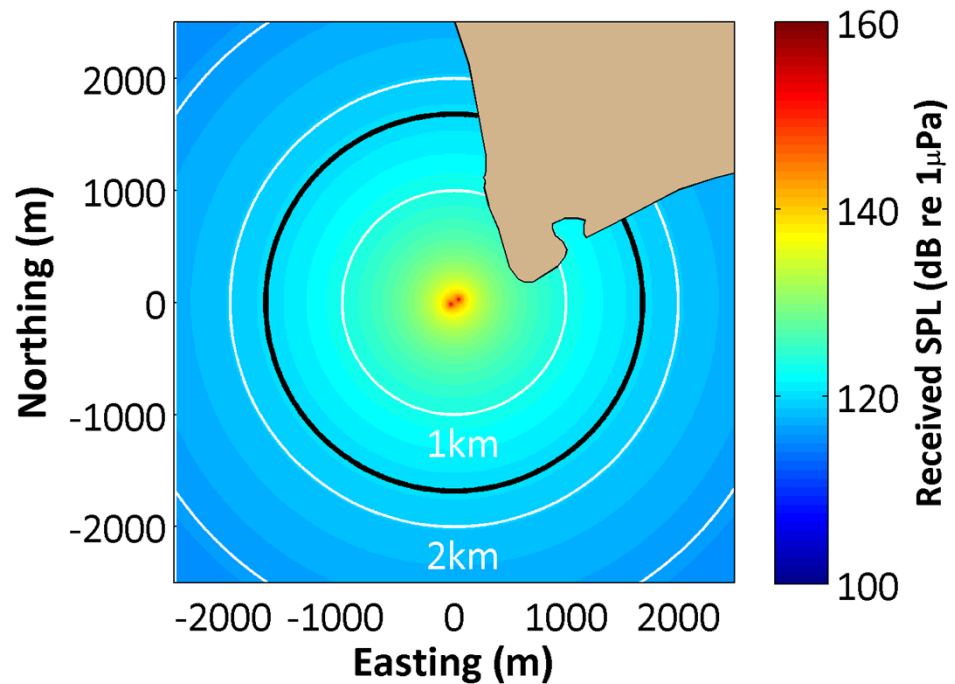


Estimating Effect of Turbine Noise

- 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



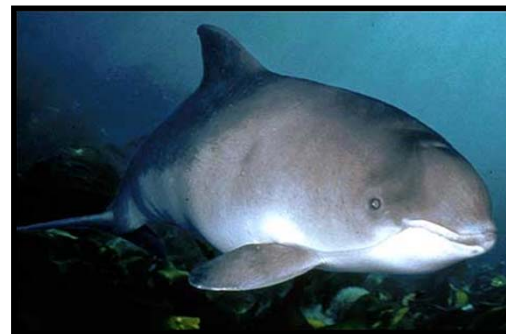
99th Operating Percentile

Study Design

- **Use passenger ferry as a pre-installation source of opportunity**
 - Broadband source level: 173 dB re 1 μ Pa at 1 m
 - Source duration in C-POD range \approx 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



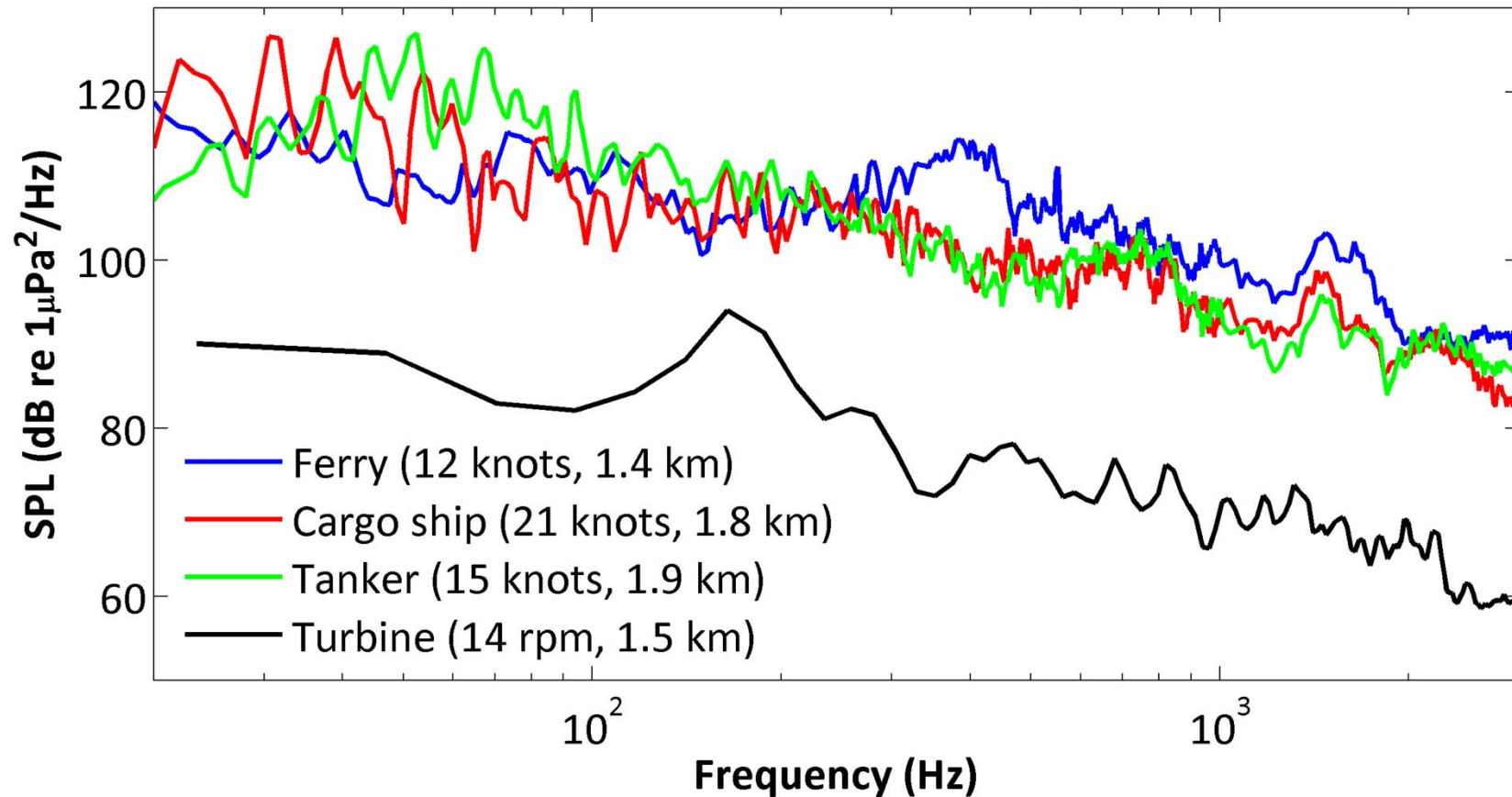
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Analogue Suitability

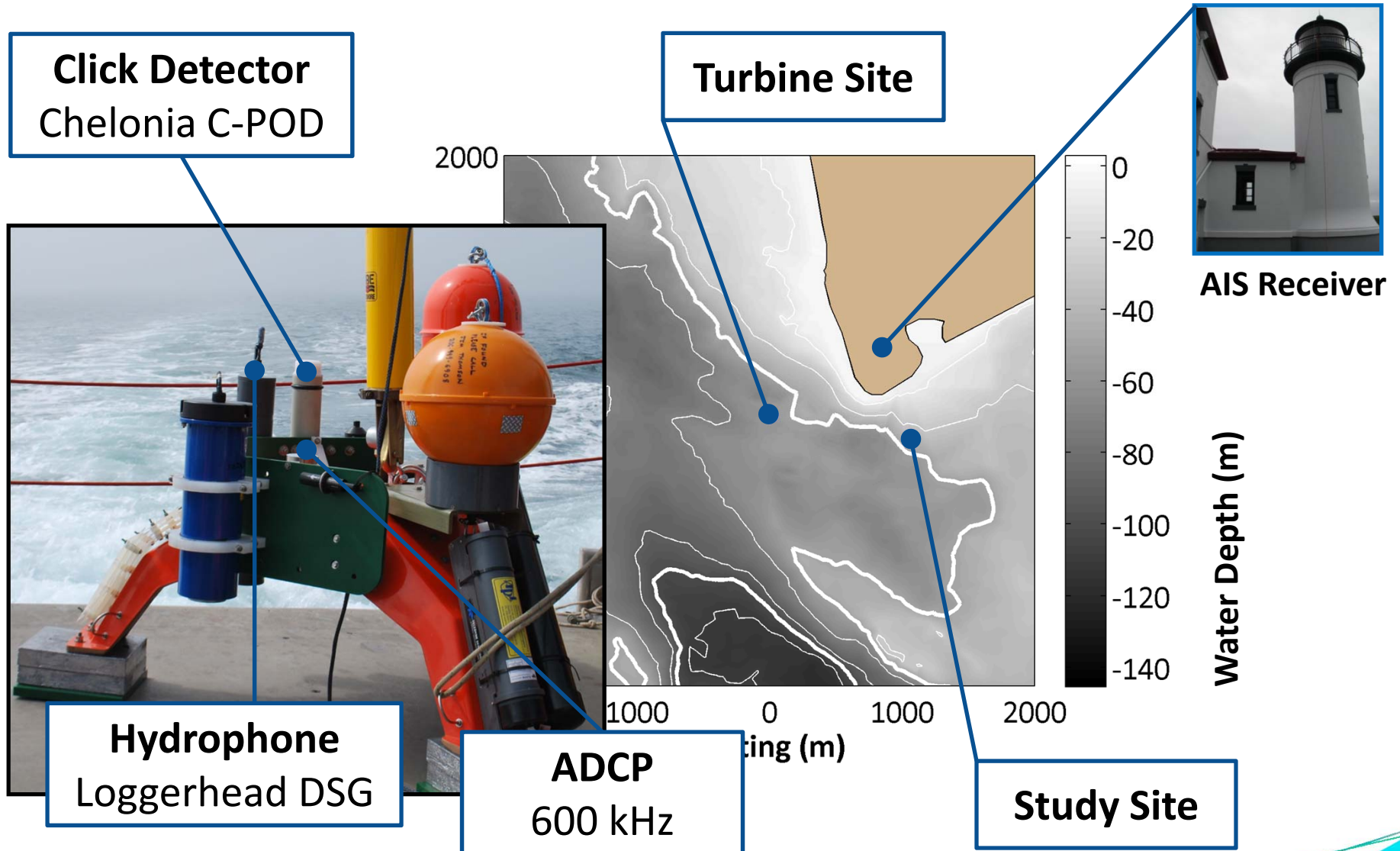


Ferry noise louder than turbine noise
Turbine noise more continuous

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

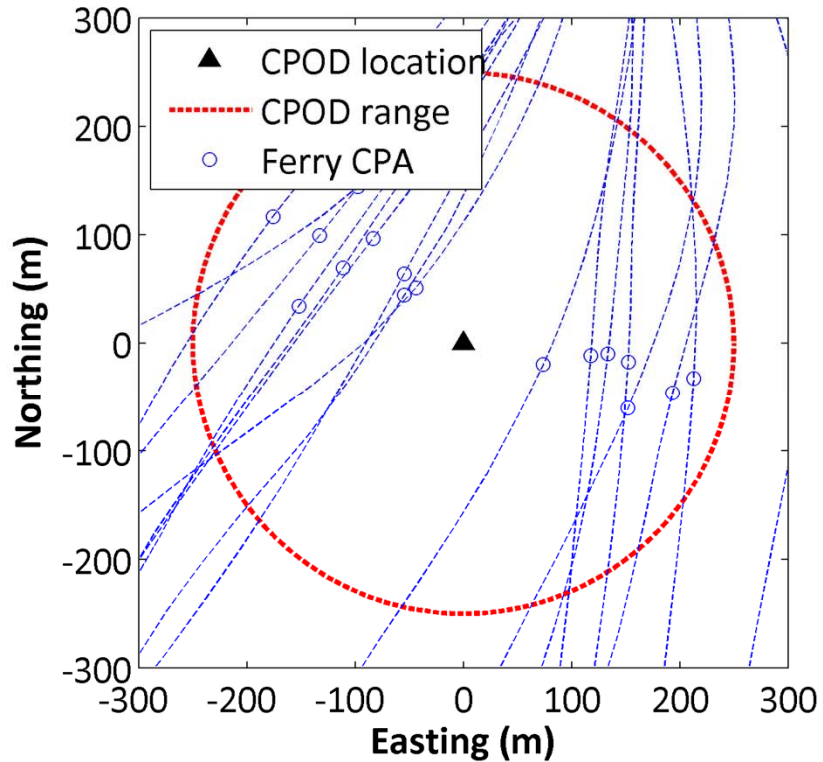


Monitoring Instrumentation

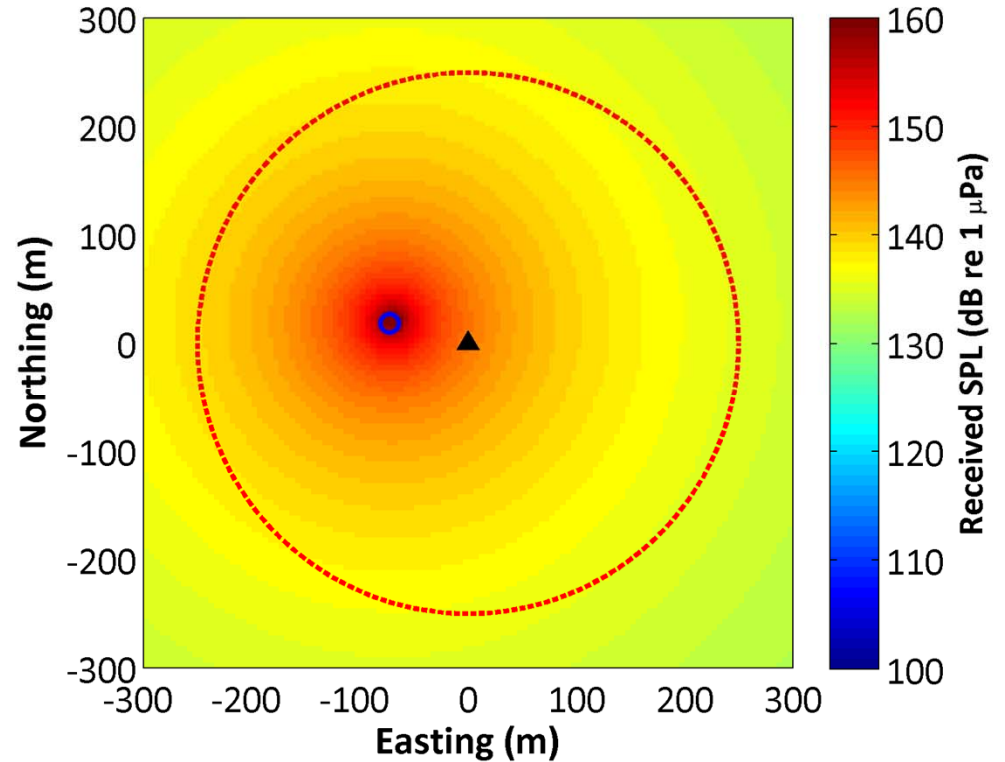


Ferry Acoustic Stressor

Measured Ferry Positions



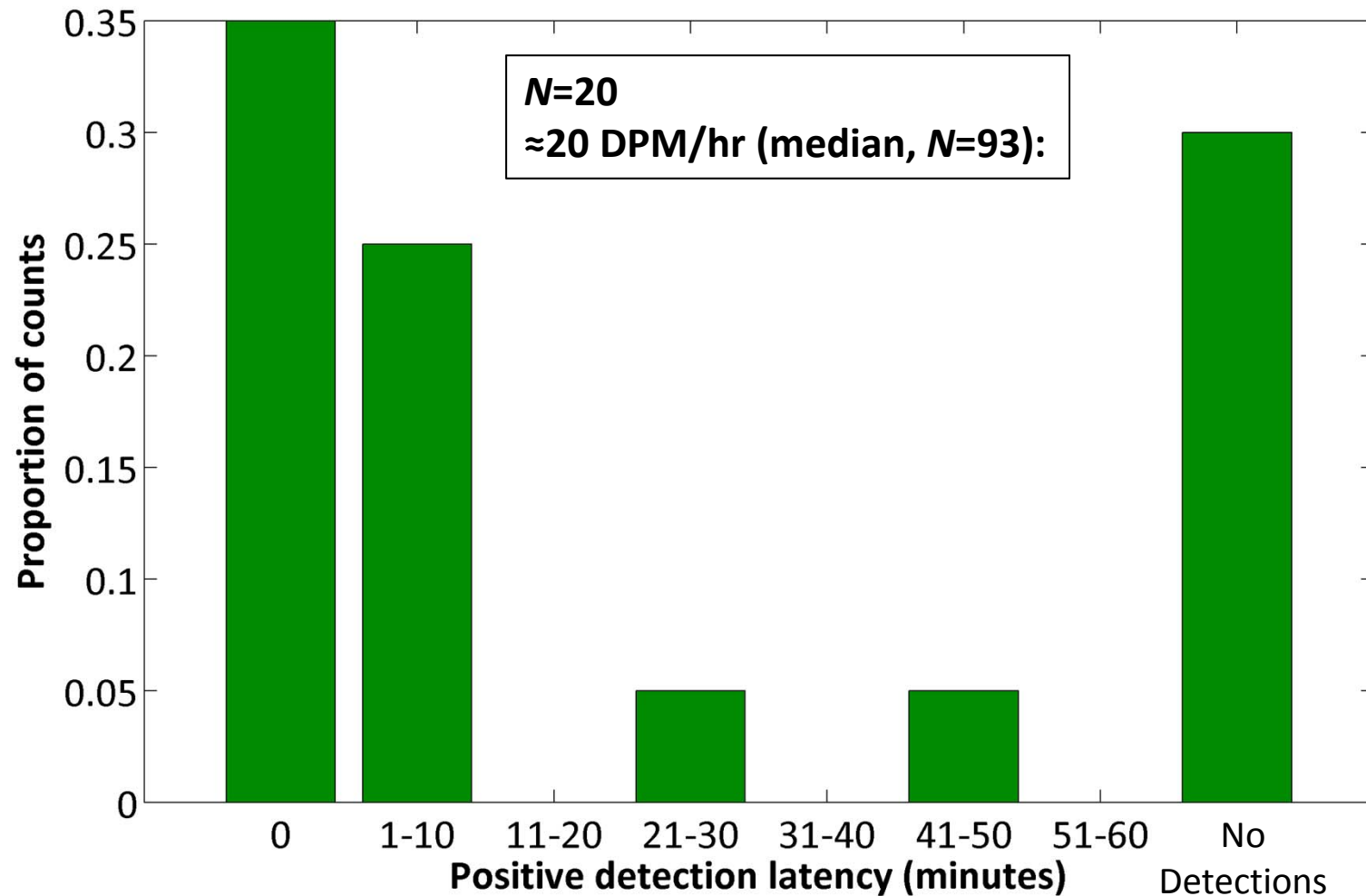
Modeled Received Levels



➔ At closest point of approach, ferry is quite loud

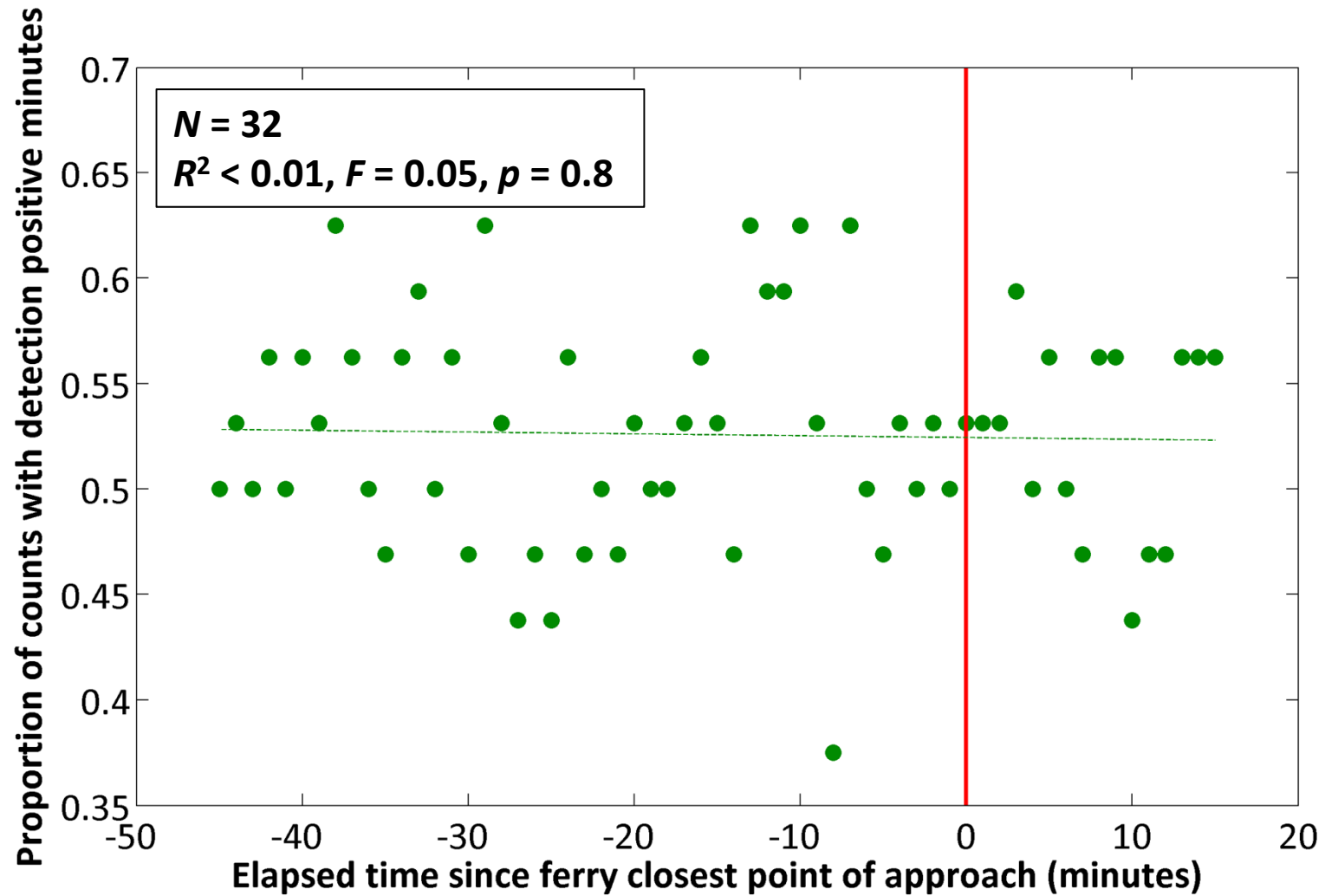
Strong Behavioral Change

Is there an extended period of inactivity after ferry passes?



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

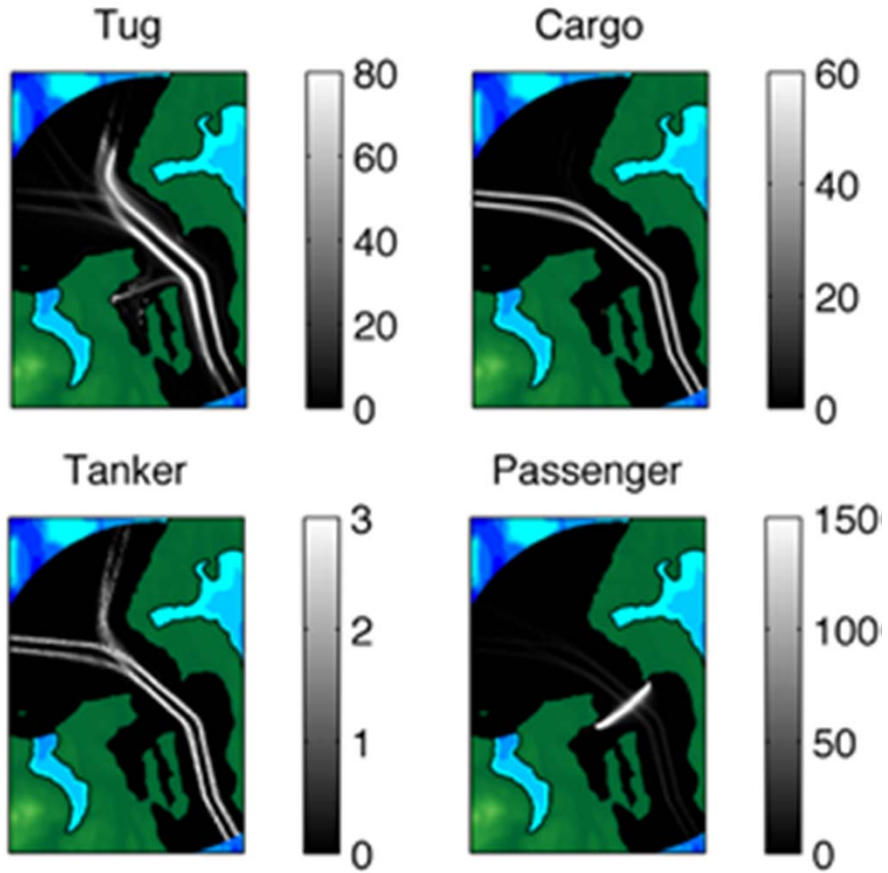


But... no detectable change in presence. Why?

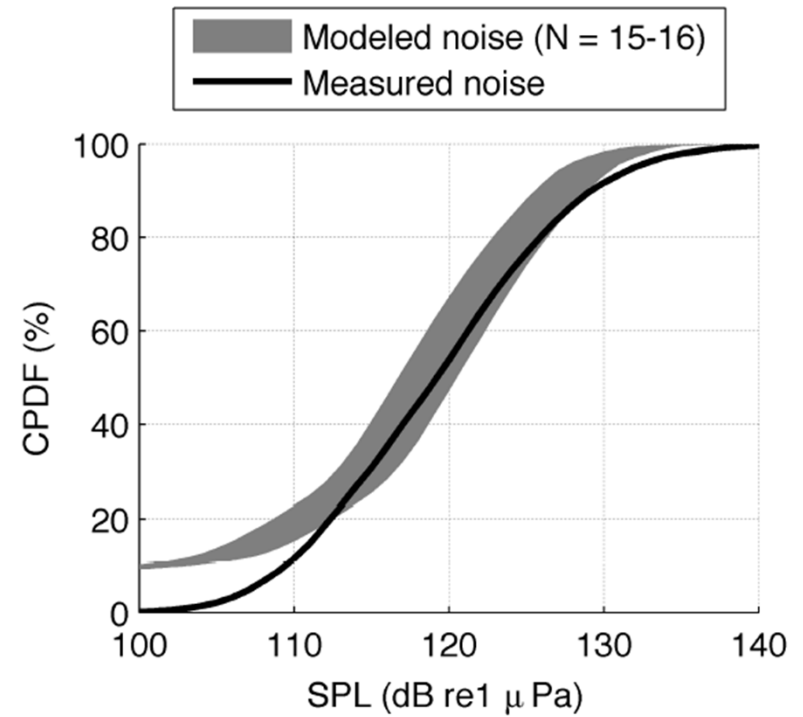
- Changes not detectable by C-PODs?
- Noise habituation?



Environmental Context – Habituation?



Vessel density (vessel-minutes)

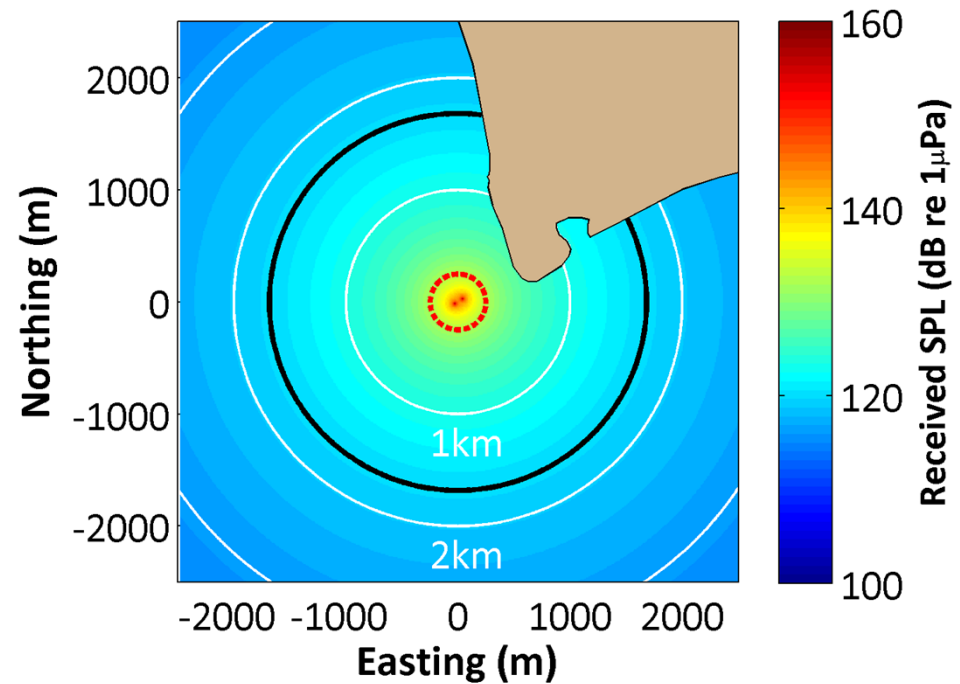
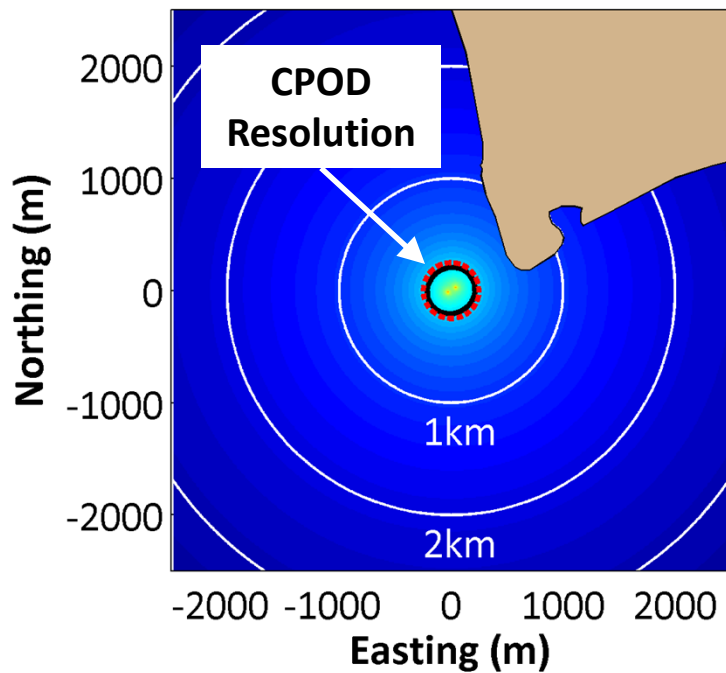


Ambient noise reconstruction based only on vessel traffic

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



Questions?

Acknowledgements

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