Ocean Noise Variability and Noise Budgets

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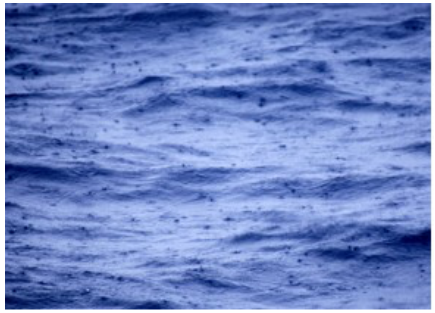
DOSITS Webinar
November 13, 2015

The ocean is full of noise

- Ships
- Geophysical exploration
- Marine mammals
- Wind waves
- Rain
- Sonar



Ocean Noise Budgets

- **A proper accounting of the global ocean noise budget must include both the background ambient component and the contributions from identifiable sources.**

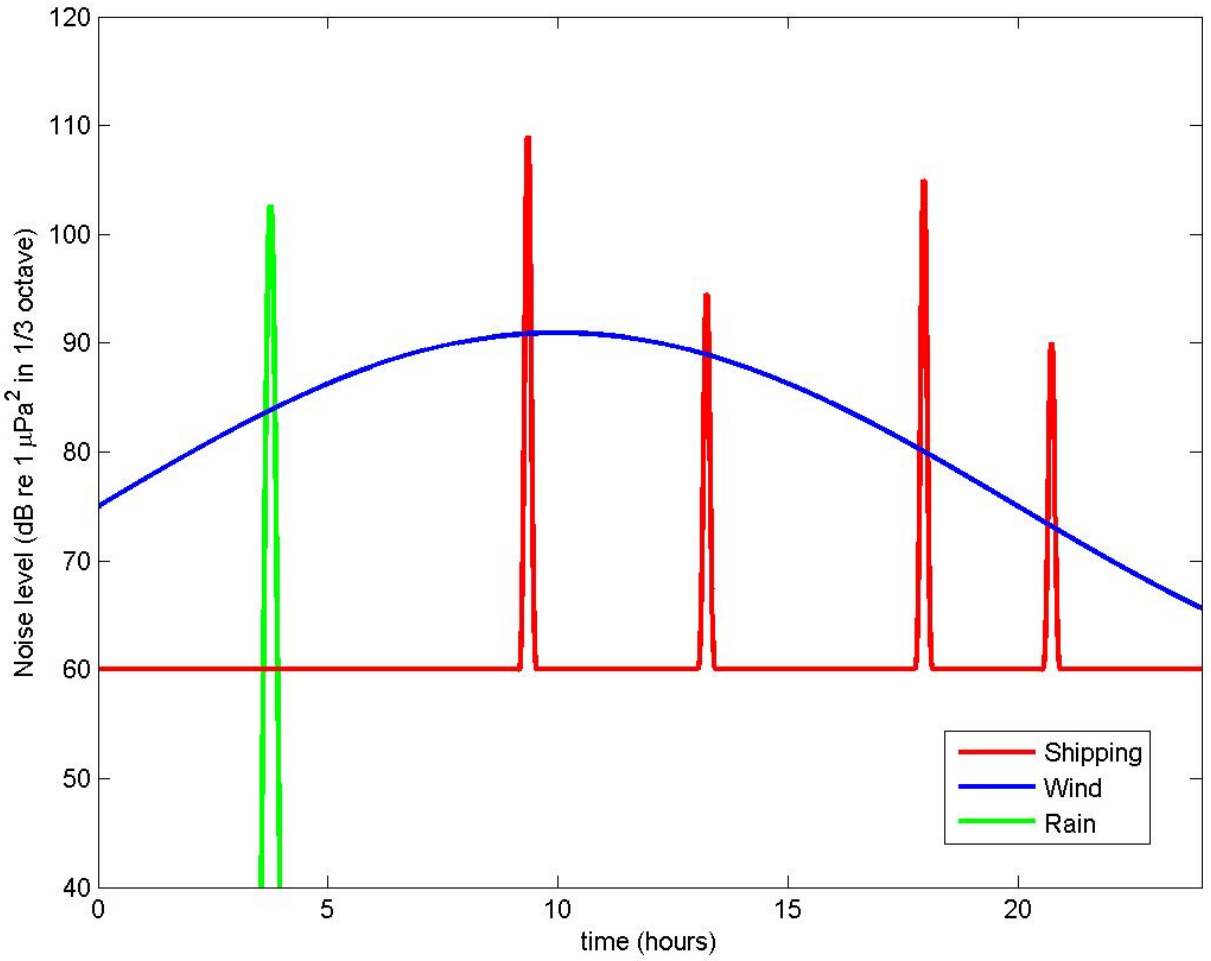
G. Frisk, D. Bradley, J. Caldwell, G. D'Spain, J. Gordon, M. Hastings, D. Ketten, J. Miller, D. L. Nelson, A. N. Popper, and D. Wartzok, *Ocean Noise and Marine Mammals*, National Academy Press, (2003).

Why Noise Budgets?

- Provides a listing of the sources of noise
- Allows for comparison between sources and context for a potential additional source
- May be biologically relevant, e.g. quantifying masking
- May be useful for outreach to media and public

A Day in a Hypothetical Noise Environment

How can we compare the relative contributions to the ambient noise field?



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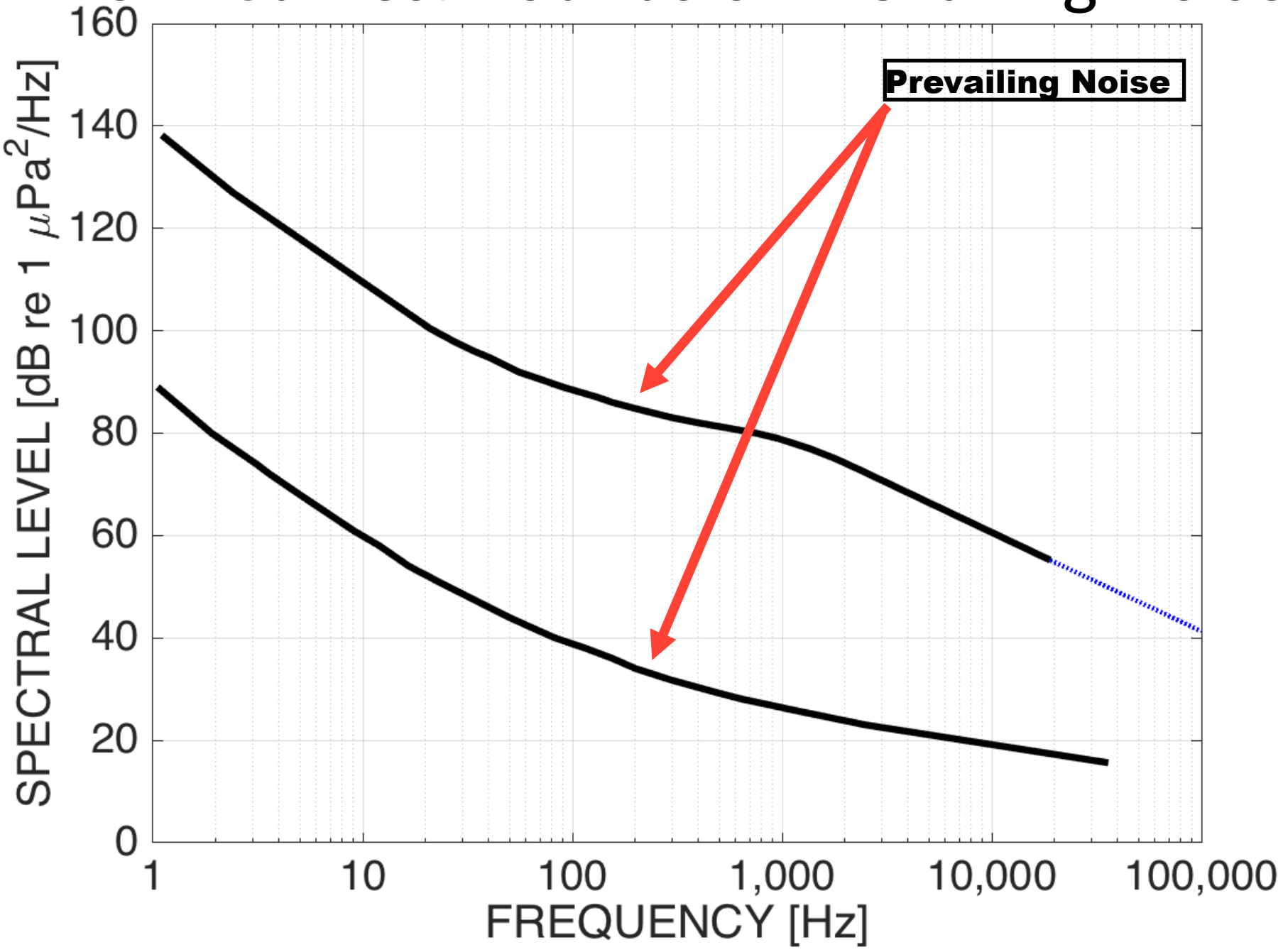
Step 1: Budget Currency: Average Intensity from nth Source

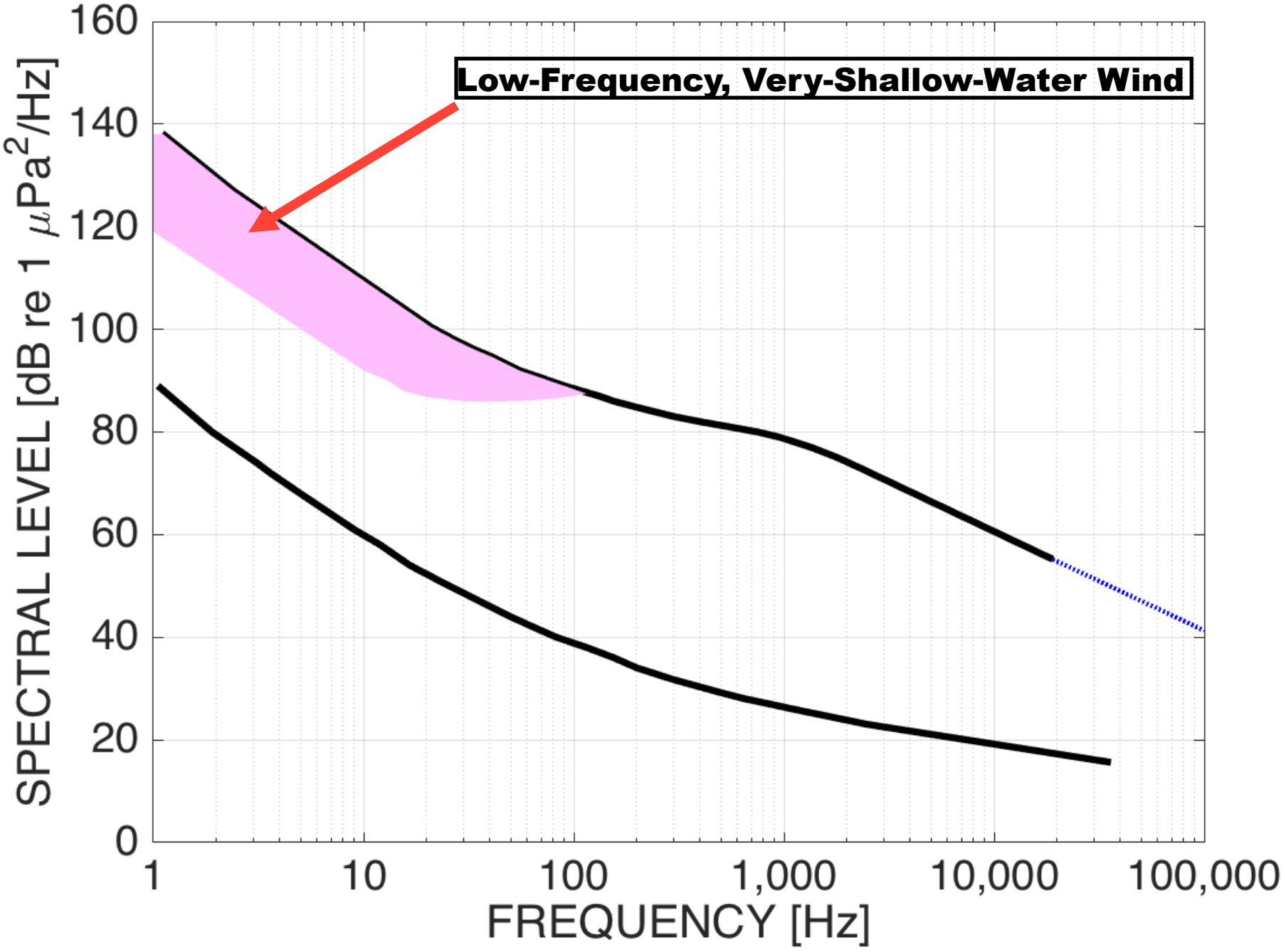
$$\left\langle I_n(f) \right\rangle = \frac{1}{T\rho} \int_0^T \left| \tilde{} \right|^2 dt$$

where **T** is the averaging time, a biologically significant duration such as a day, season, etc. over a frequency band, **f** (e.g. 1/3 octave) of the **n**th source (e.g. wind, rain, shipping, seismic, biologics, etc.)

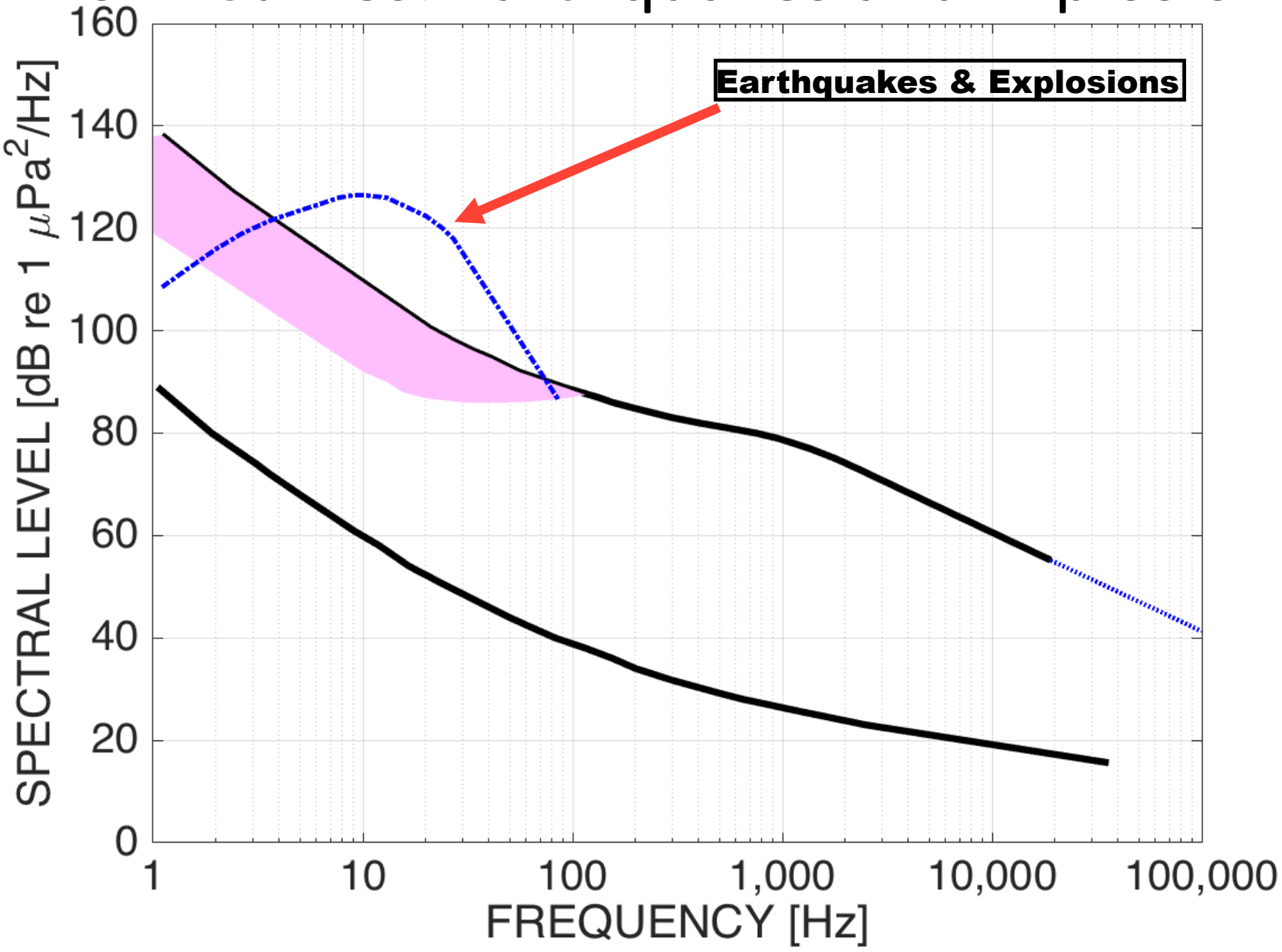
Wenz Curves: Bounds of Prevailing Noise



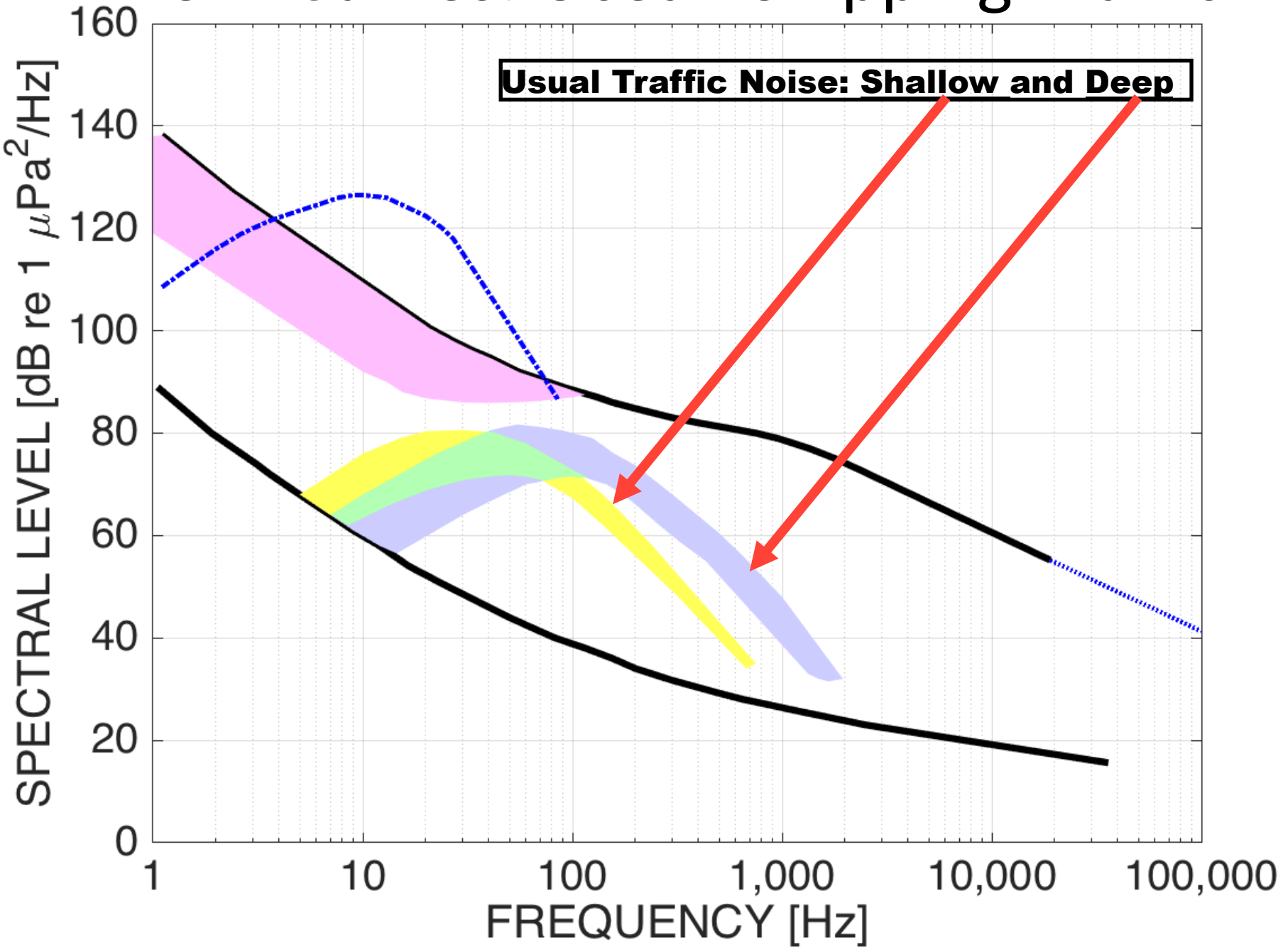
Wenz Curves: Surface Waves from Wind



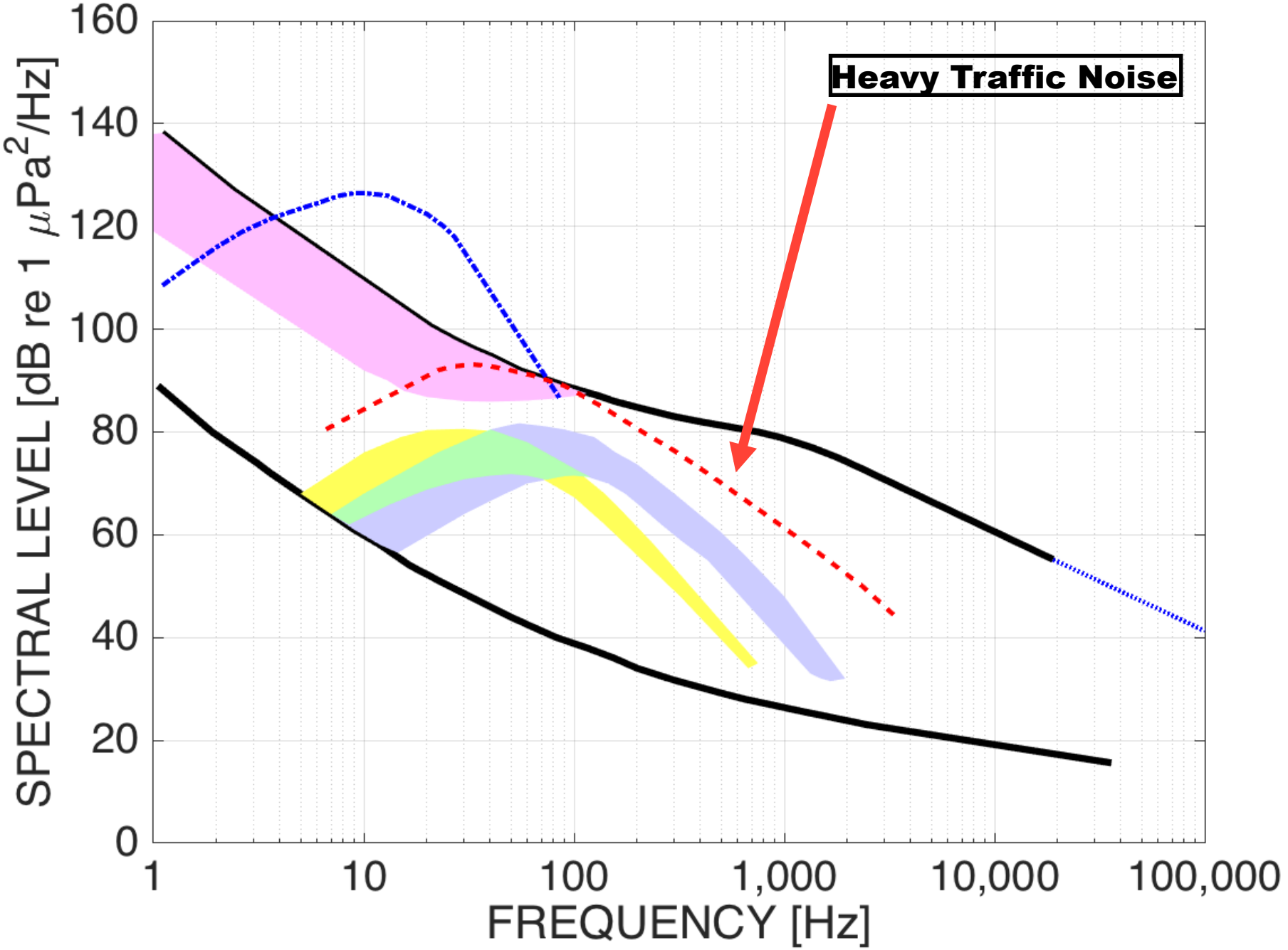
Wenz Curves: Earthquakes and Explosions



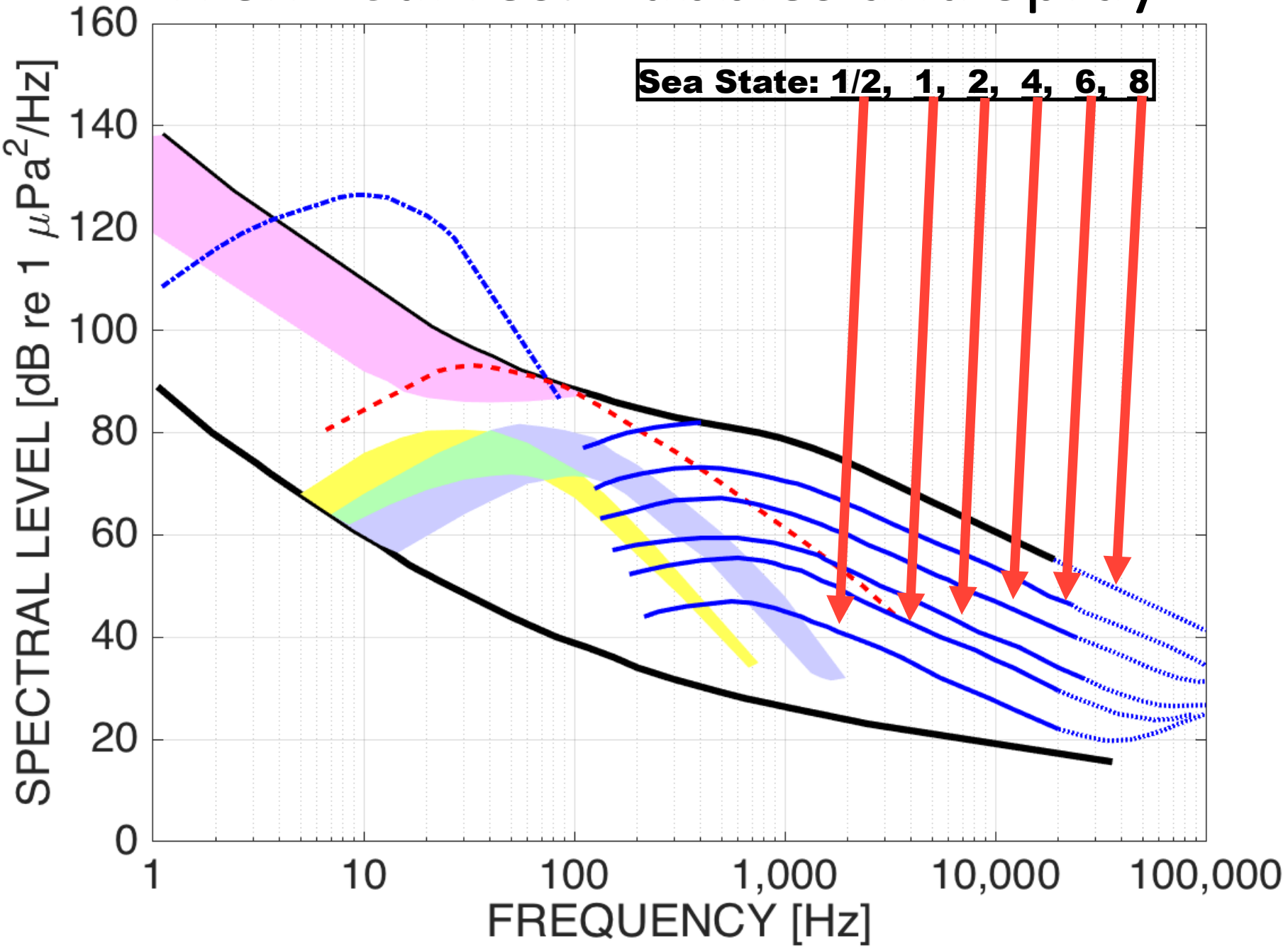
Wenz Curves: Ocean Shipping Traffic



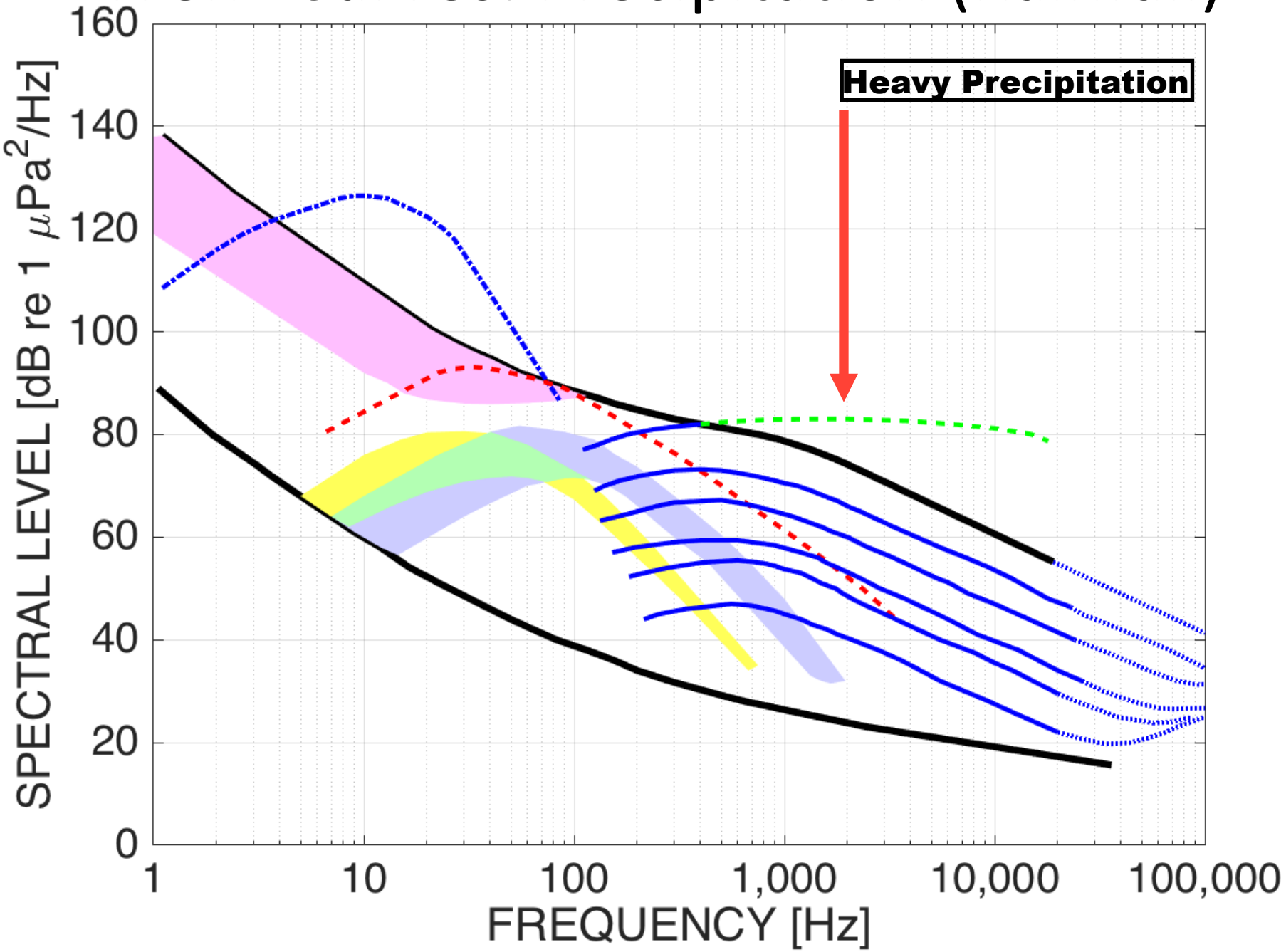
Wenz Curves: Heave Traffic Noise



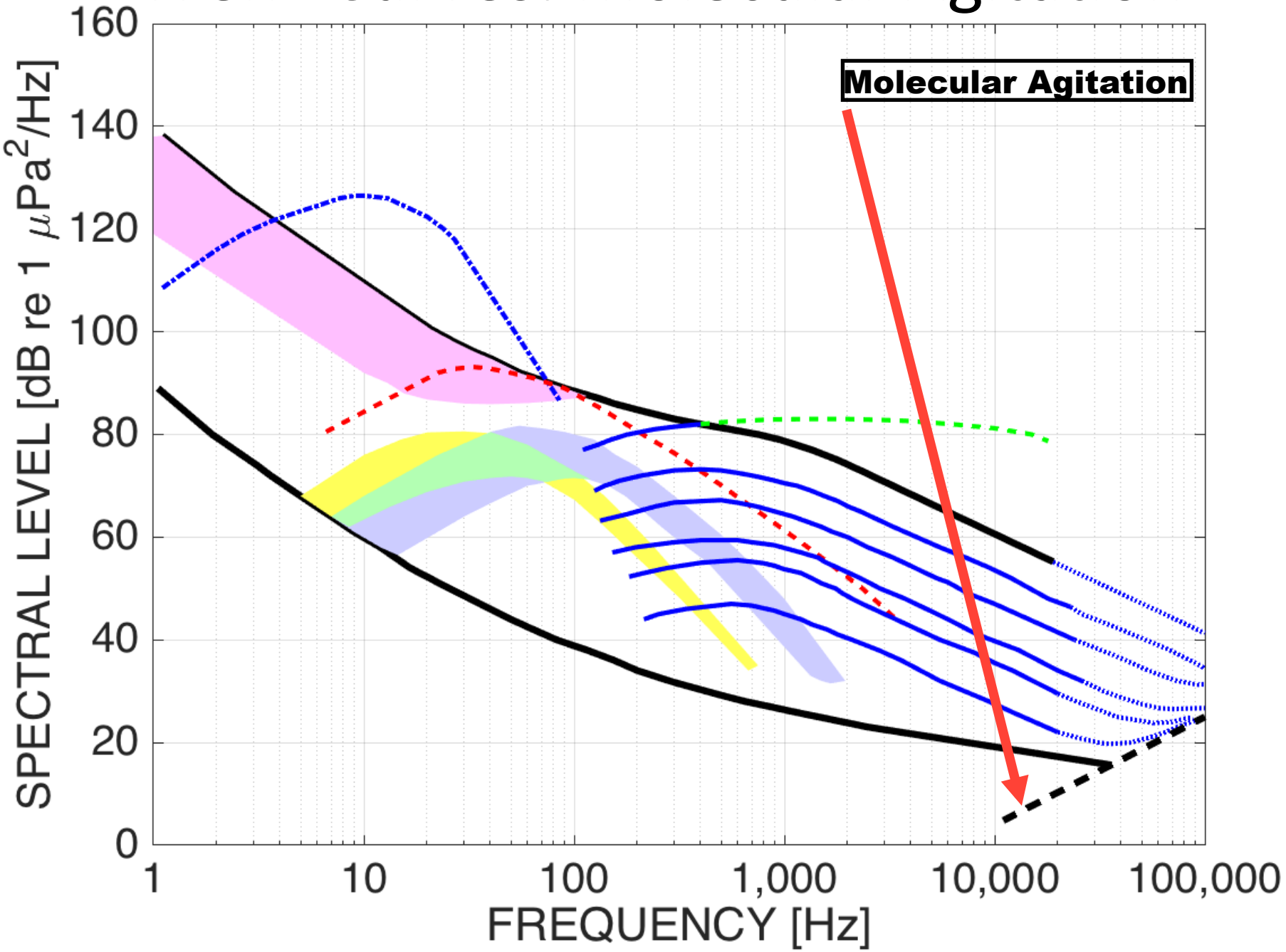
Wenz Curves: Bubbles and Spray



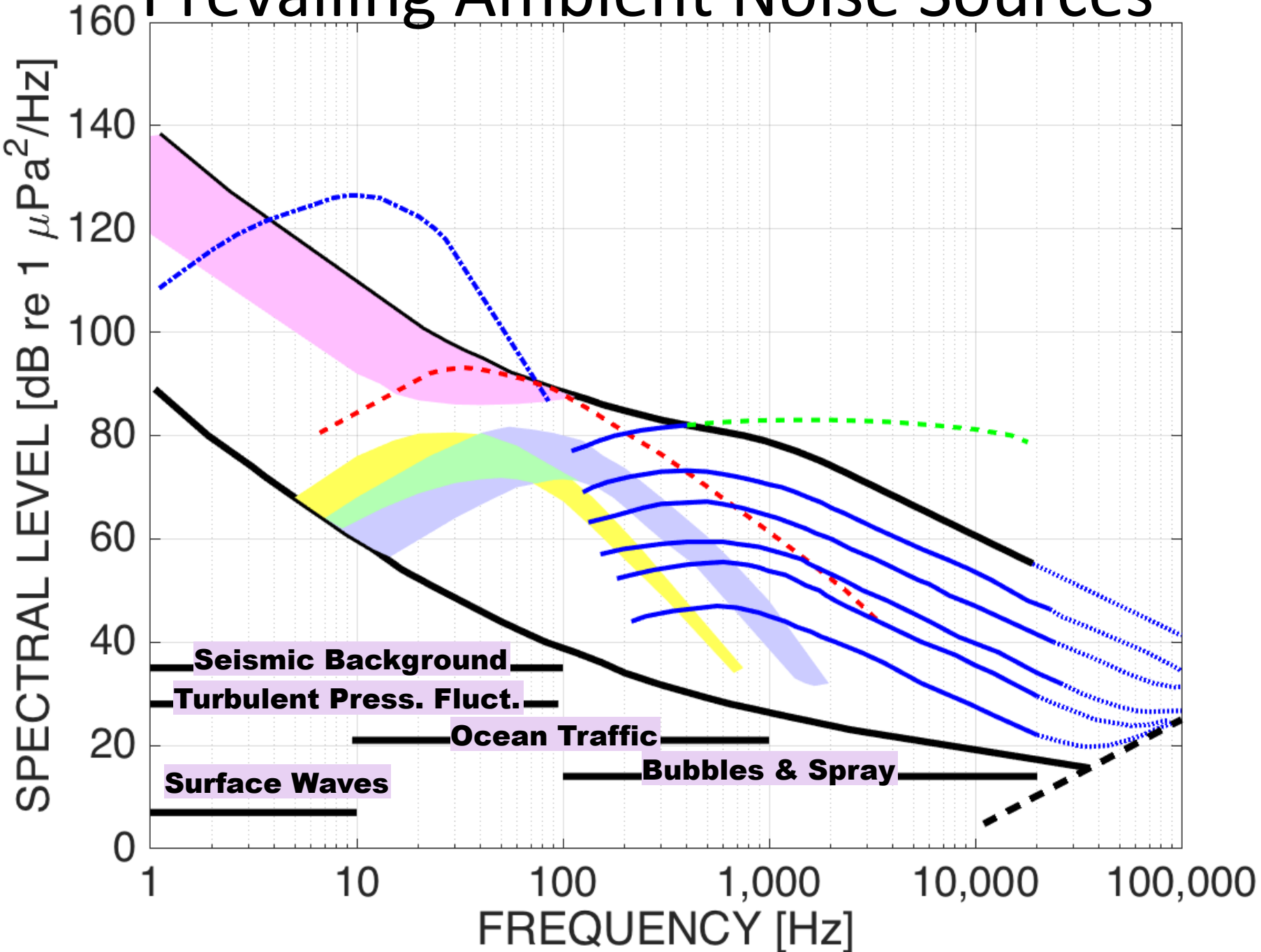
Wenz Curves: Precipitation (Rainfall)



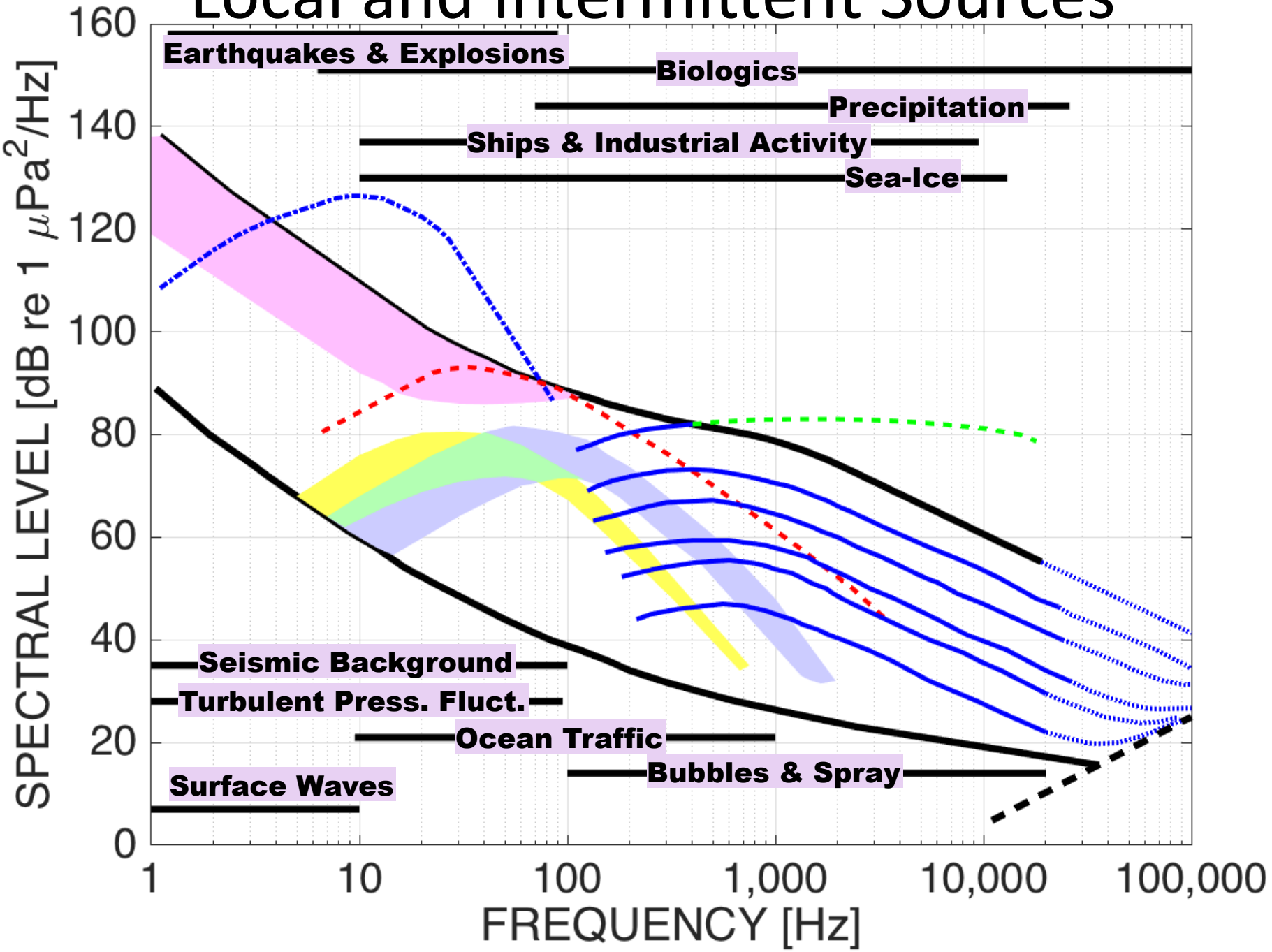
Wenz Curves: Molecular Agitation



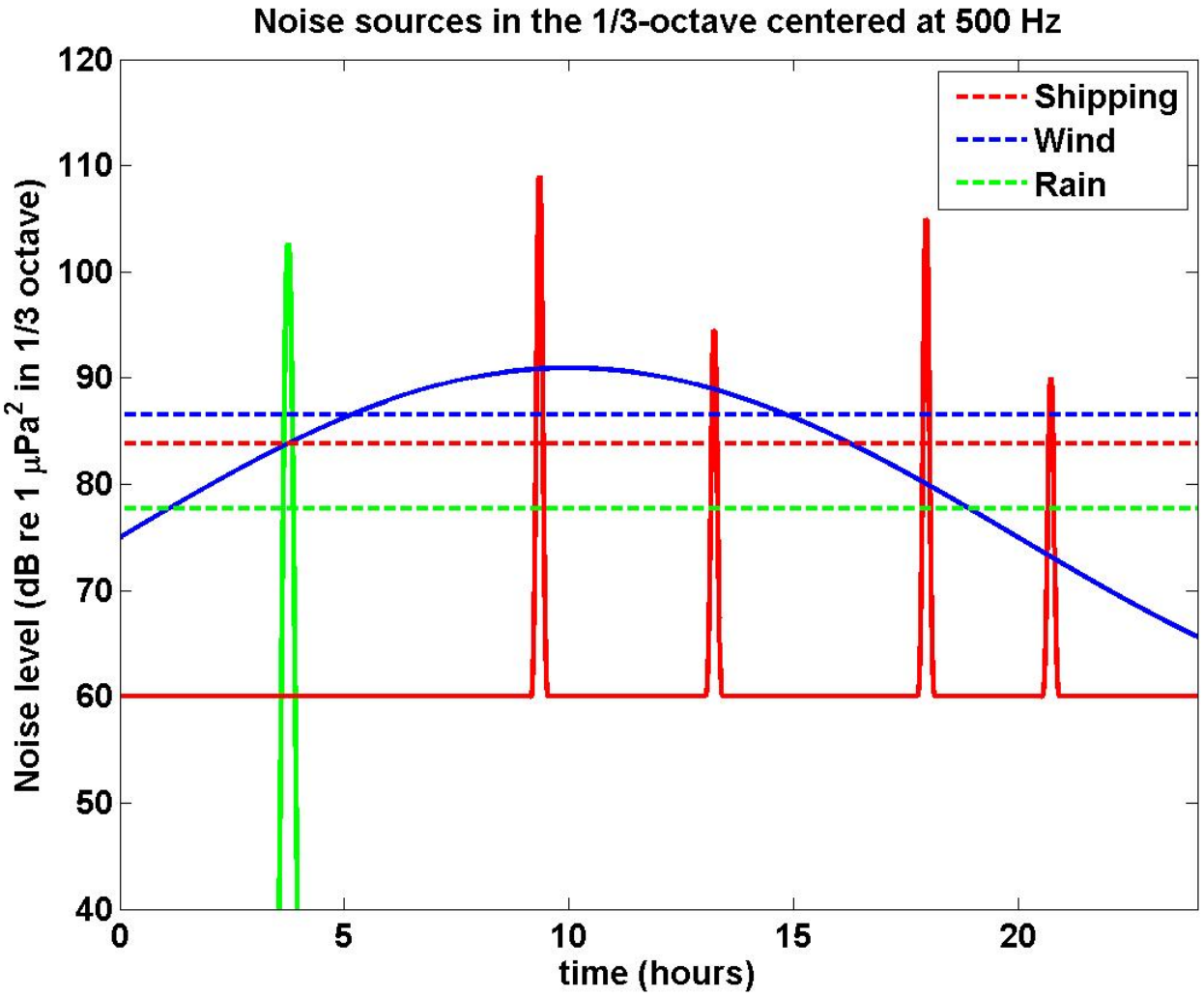
Prevailing Ambient Noise Sources



Local and Intermittent Sources



A Day in a Hypothetical Noise Environment



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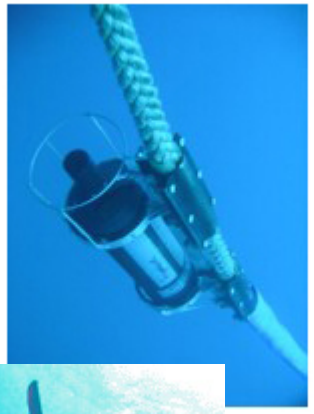
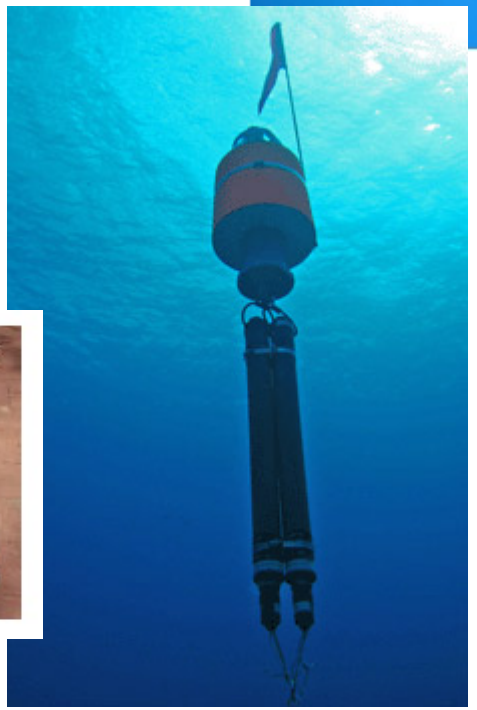
How are data measured?

Archival acoustic recorders

- Acoustic Rain Gauge (ARG) or Passive Acoustic Listeners (PAL)
- Acoustic Datalogging Systems
- Archival Marine Acoustic Recording Units





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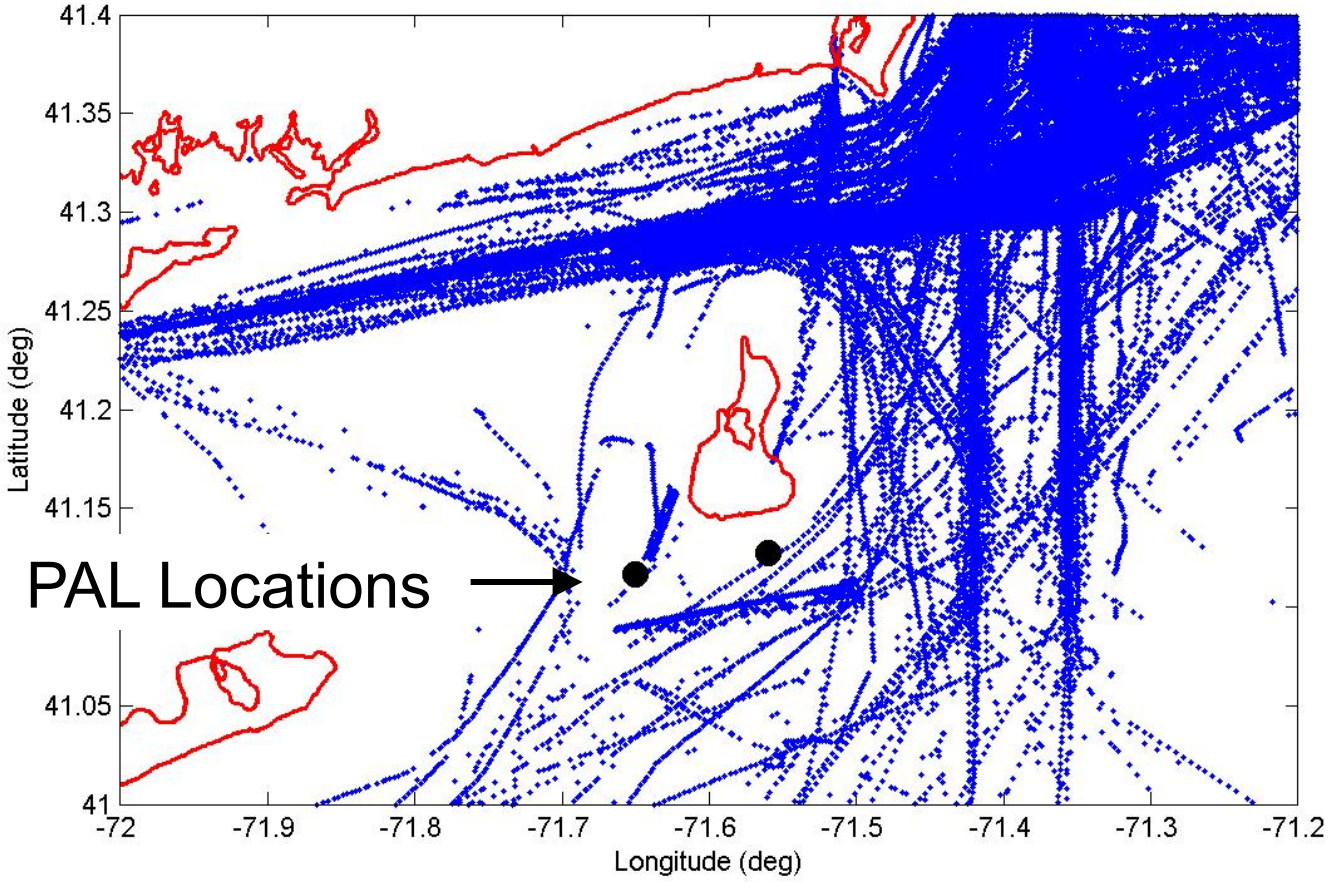
Block Island Wind Farm

- Two PALs deployed
- AIS-Derived Ship Positions Near Block Island



October 6 – November 14, 2008

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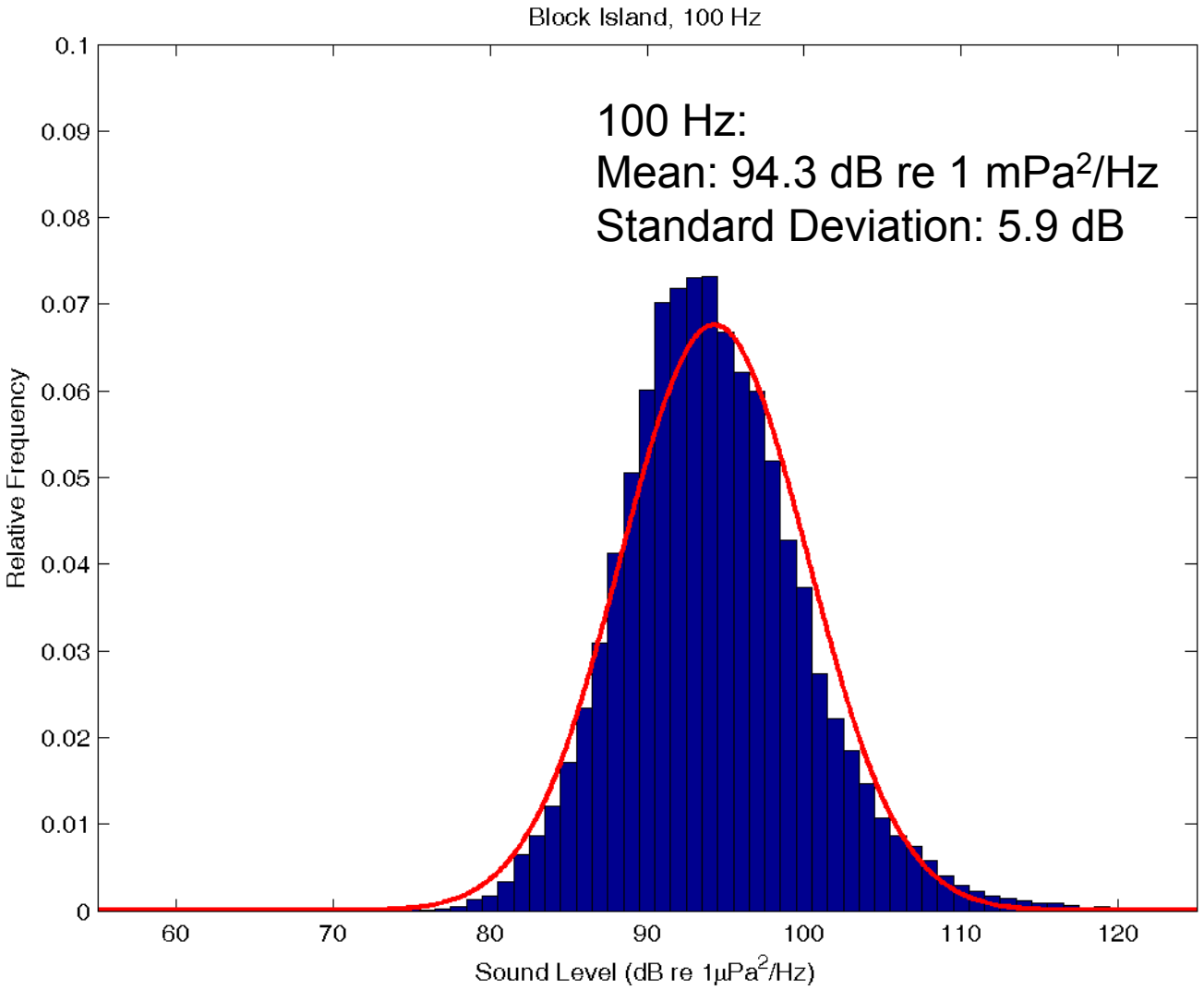
Passive Monitoring Results



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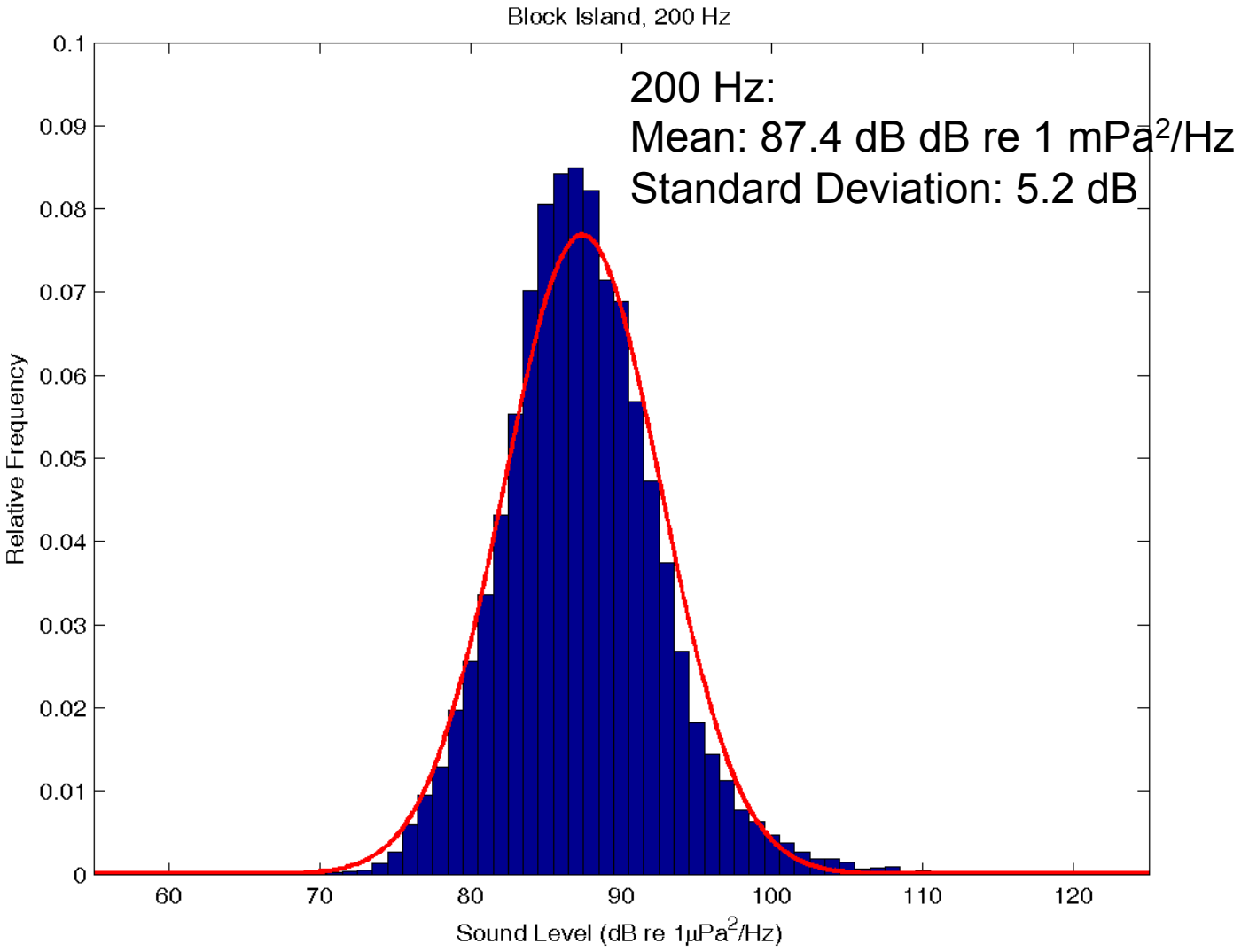
Passive Monitoring Results



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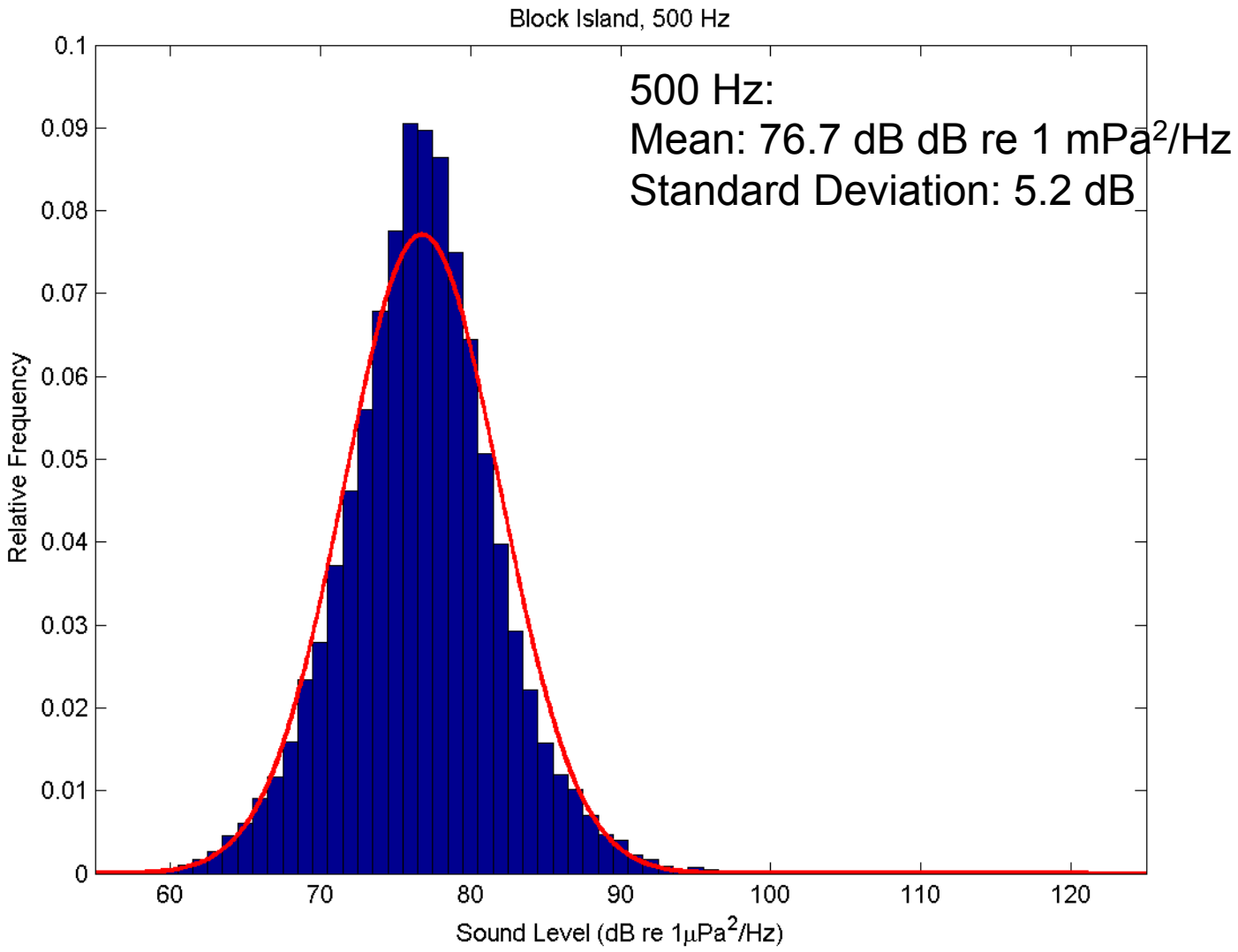
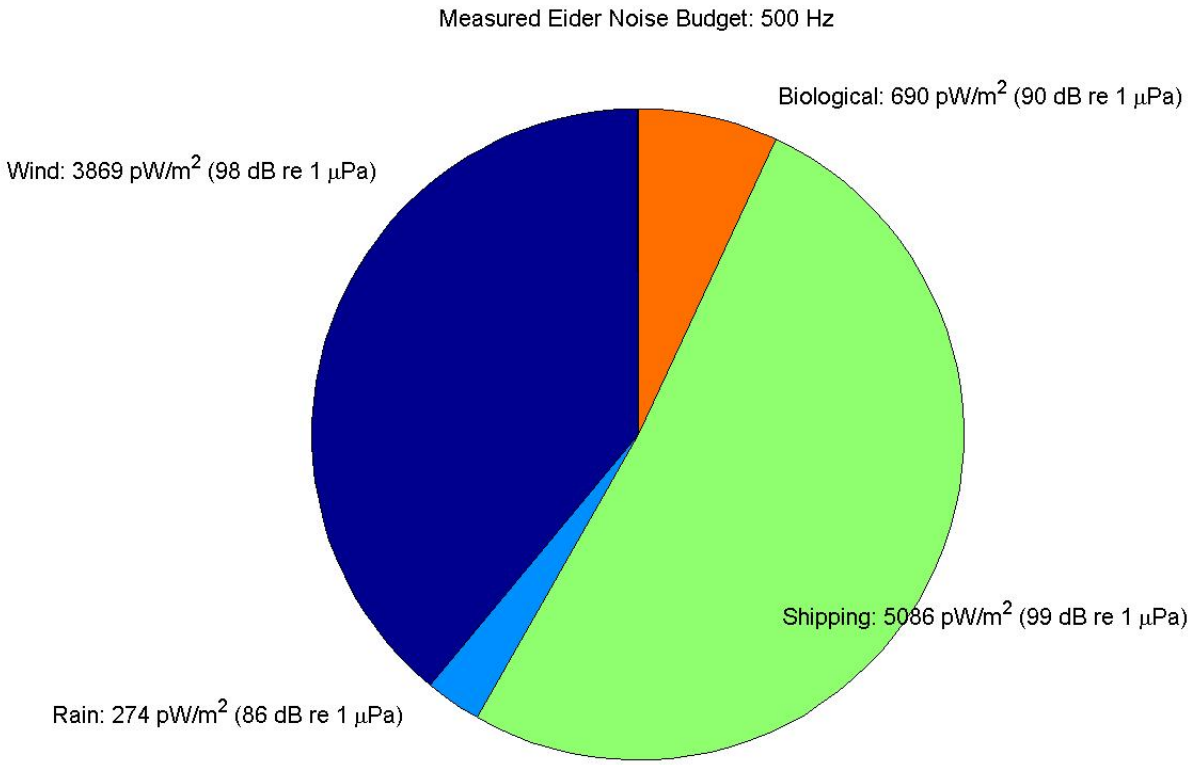


1/3 Octave Noise Budget for Block Island Sound Without Turbine Noise



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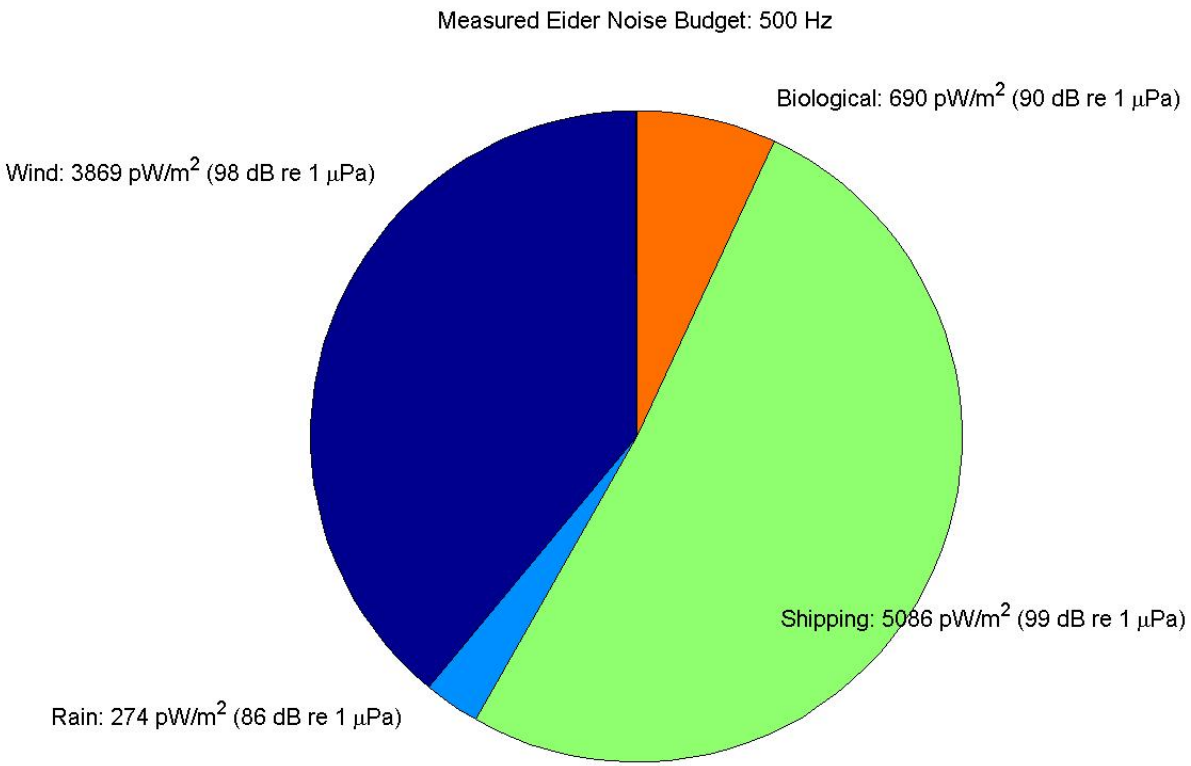
Wind Turbine Noise

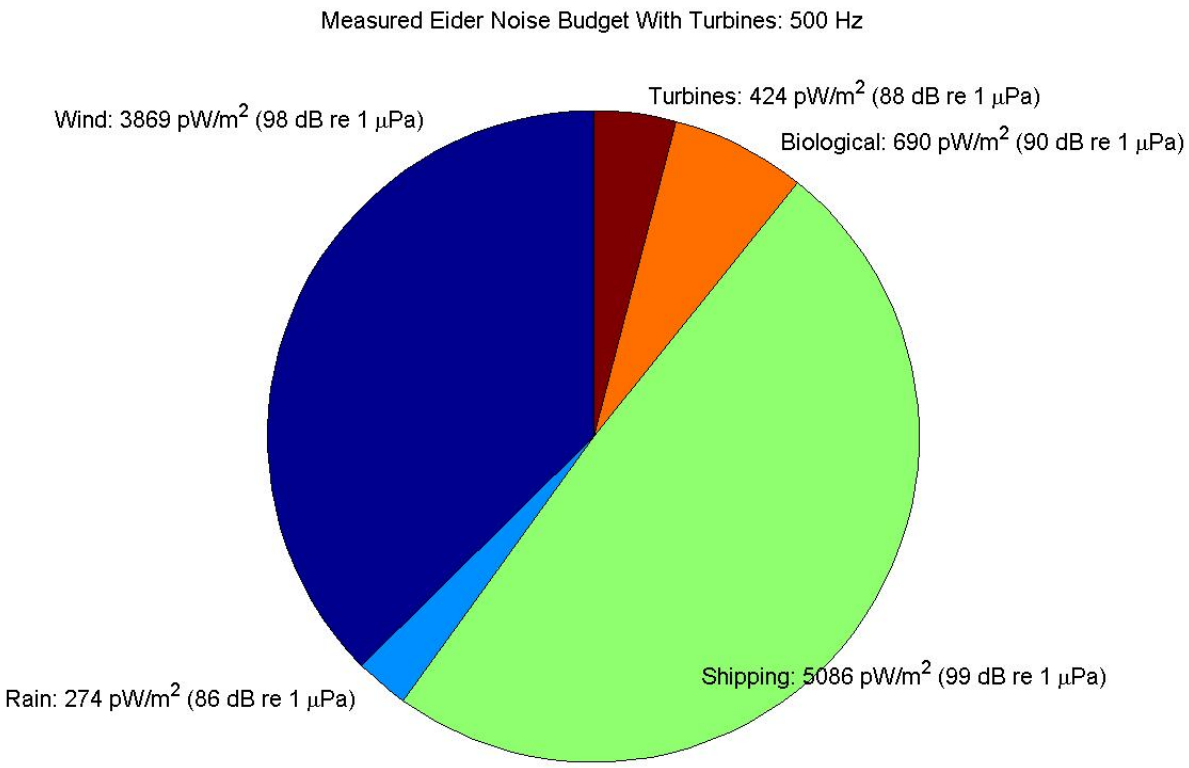
- Utgrunden (Sweden): 1.5 MW
- Moderate-strong wind speed: 12 m/s
- 1/3 Octave Leq:
  120 - 142 dB re 1 µPa at 1m
- Main frequency 50 / 150 Hz

(Thomsen et al. 2006)

1/3 Octave Noise Budget for Block Island Sound Without Turbine Noise



1/3 Octave Noise Budget for Block Island Sound With Turbine Noise



Back up Slides

Measurements of Underwater Noise from Wind Turbines in Utgrunden Wind Farm, Sweden

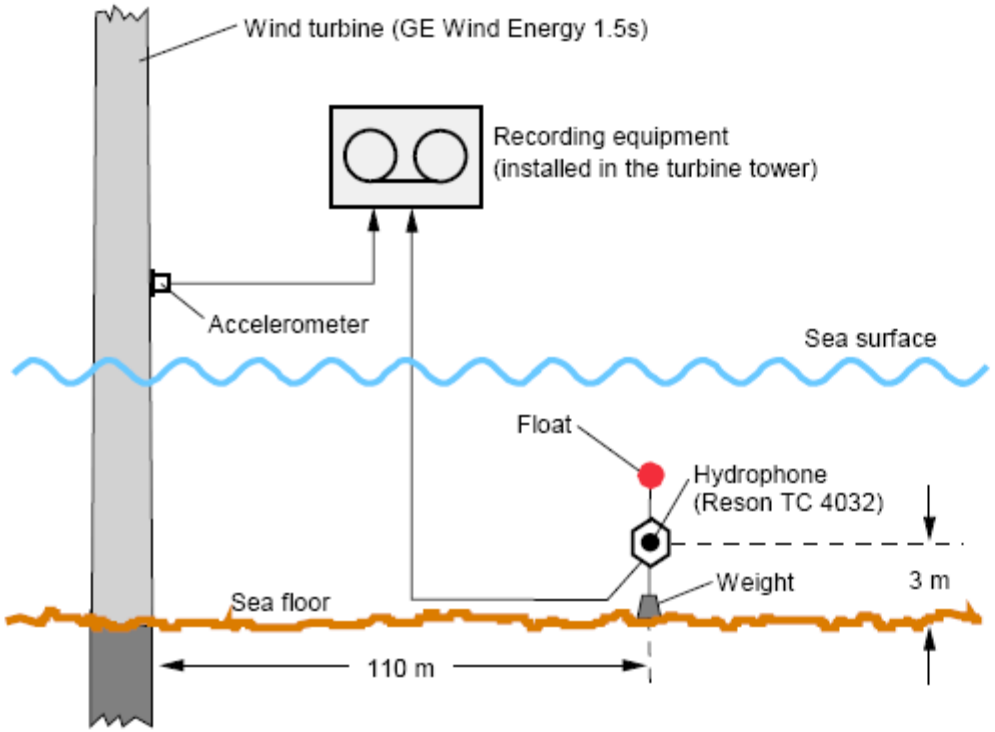


Figure 2: Measurement setup for monitoring underwater noise induced by an offshore wind turbine. Water depth was about 10 m. (from Betke, 2004)

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Measurements of Underwater Noise from Wind Turbines in Utgrunden Wind Farm, Sweden

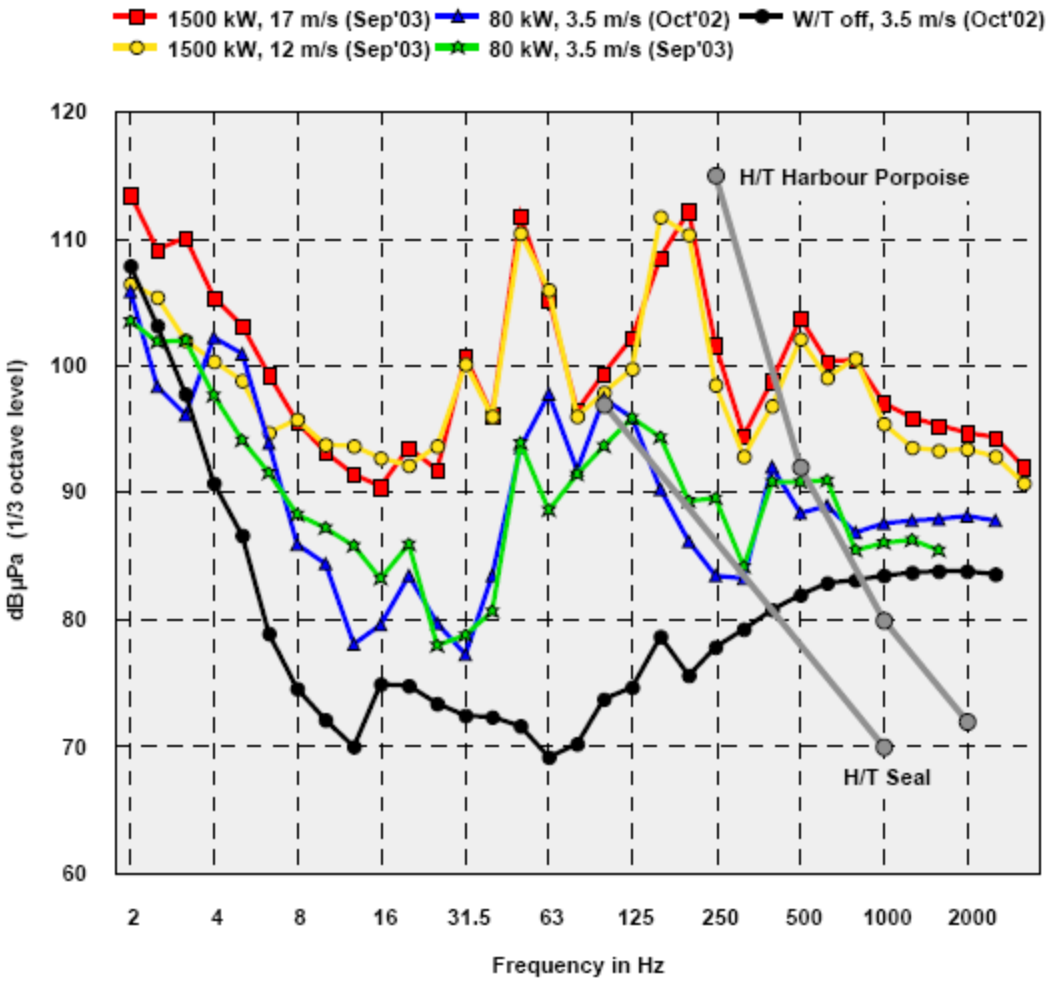
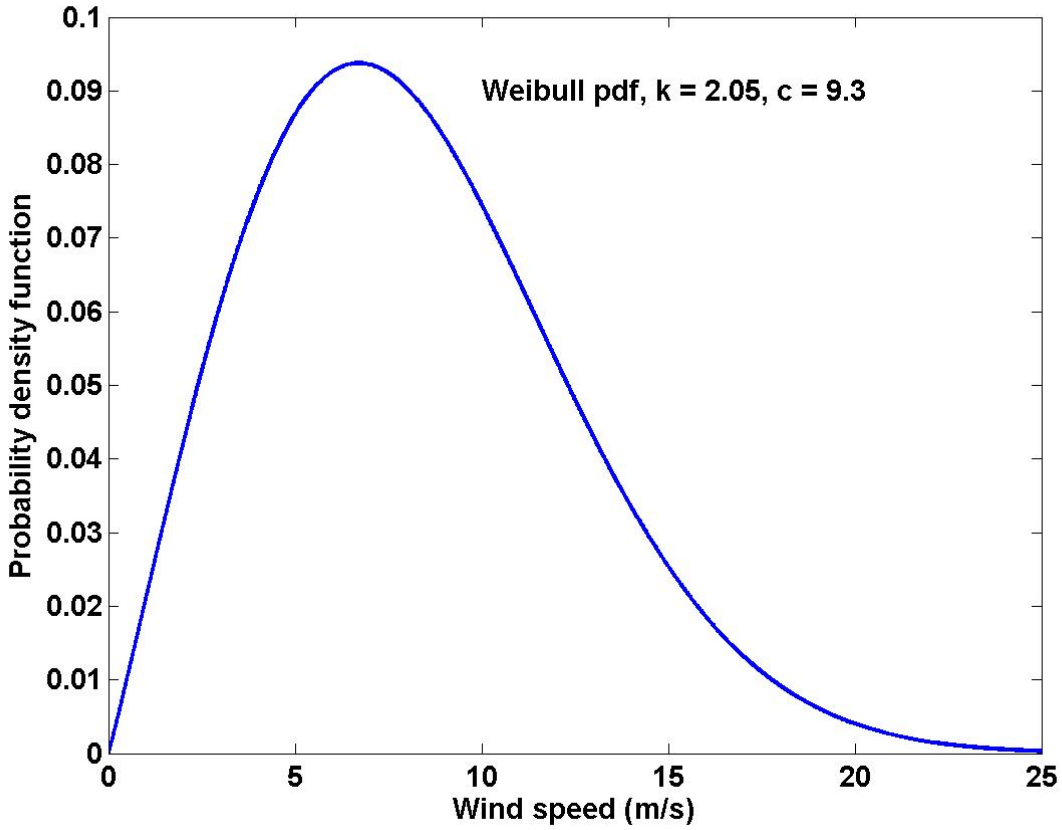


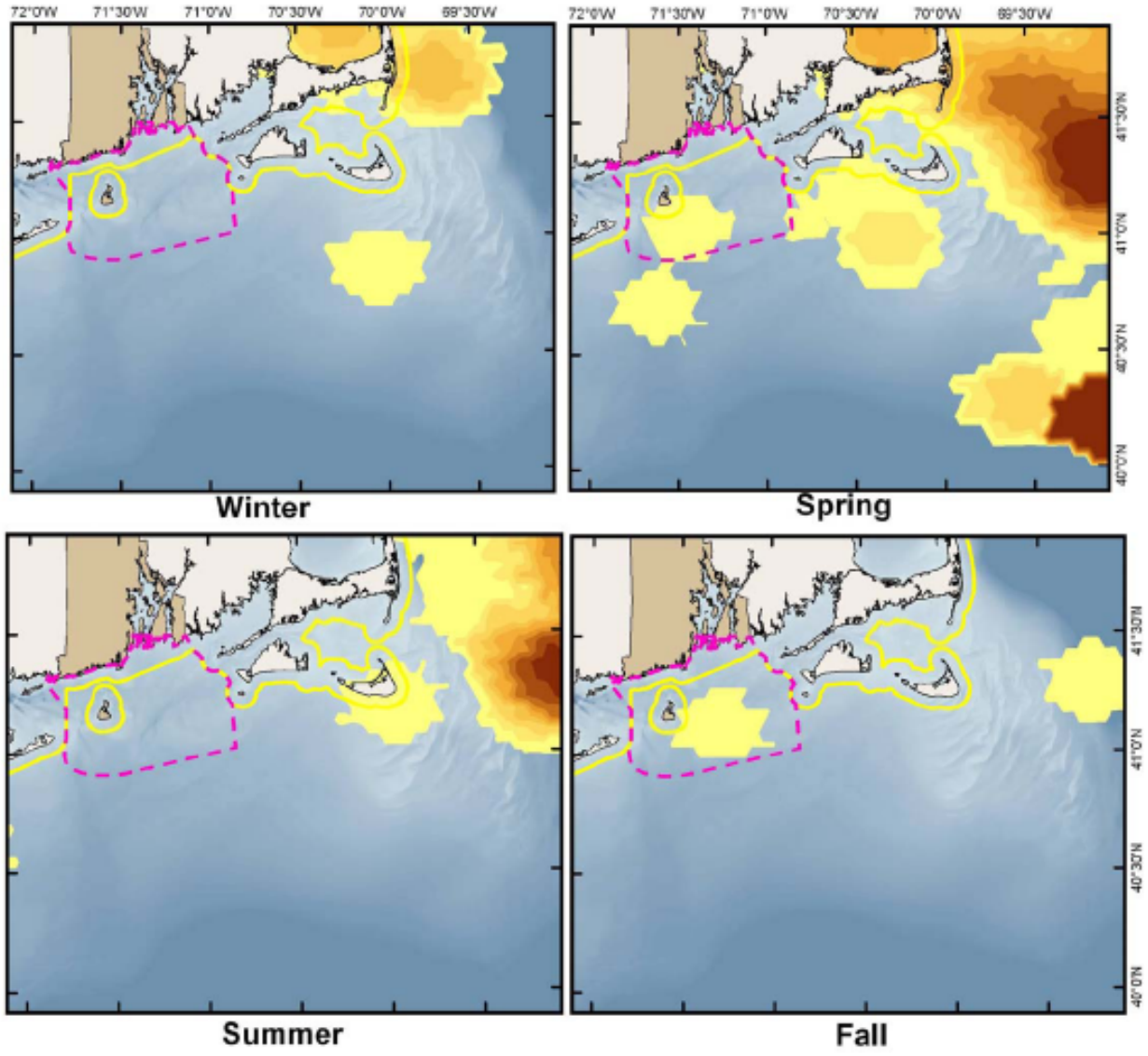
Figure 3: Underwater sound pressure levels (1/3rd octave spectra) recorded at 110 m distance from the turbine for different turbine states. Wind speeds refer to hub height (nacelle anemometer). Low frequency parts of hearing thresholds for two marine mammals are shown for comparison.

(from Betke, 2004)

Wind Speed PDF Off Block Island



Northern right whale relative abundance



Kenney, 2009

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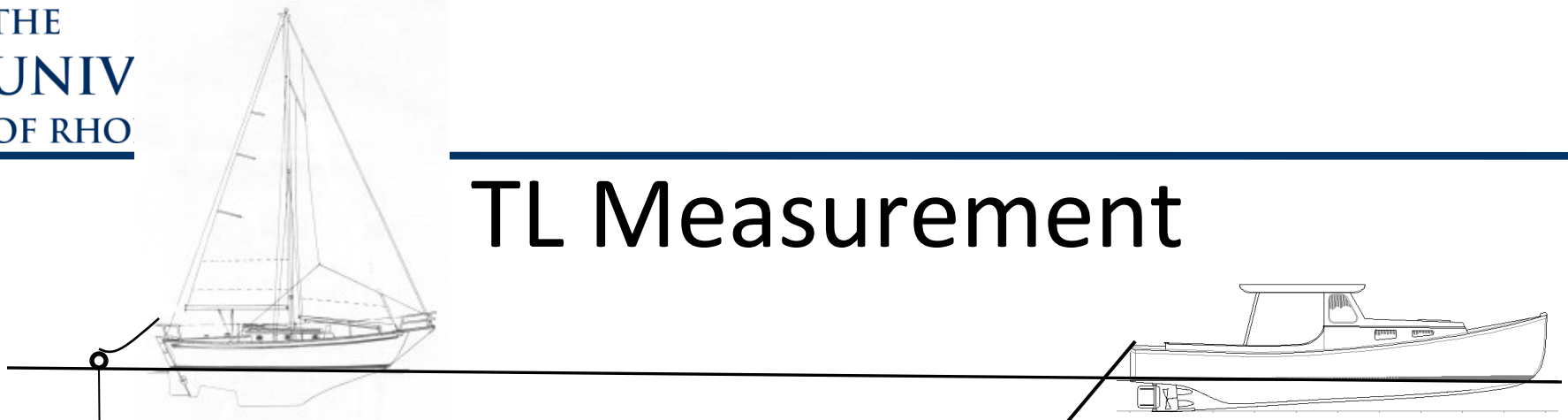
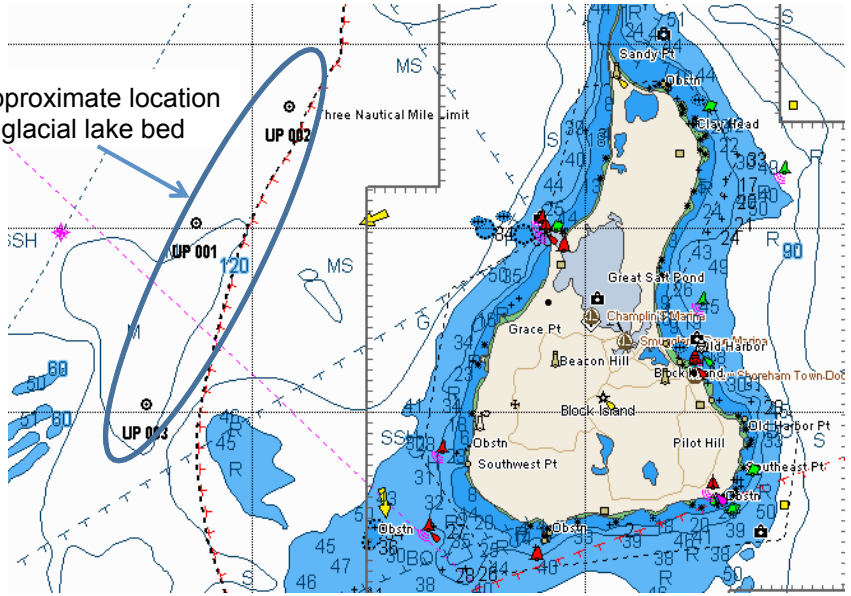
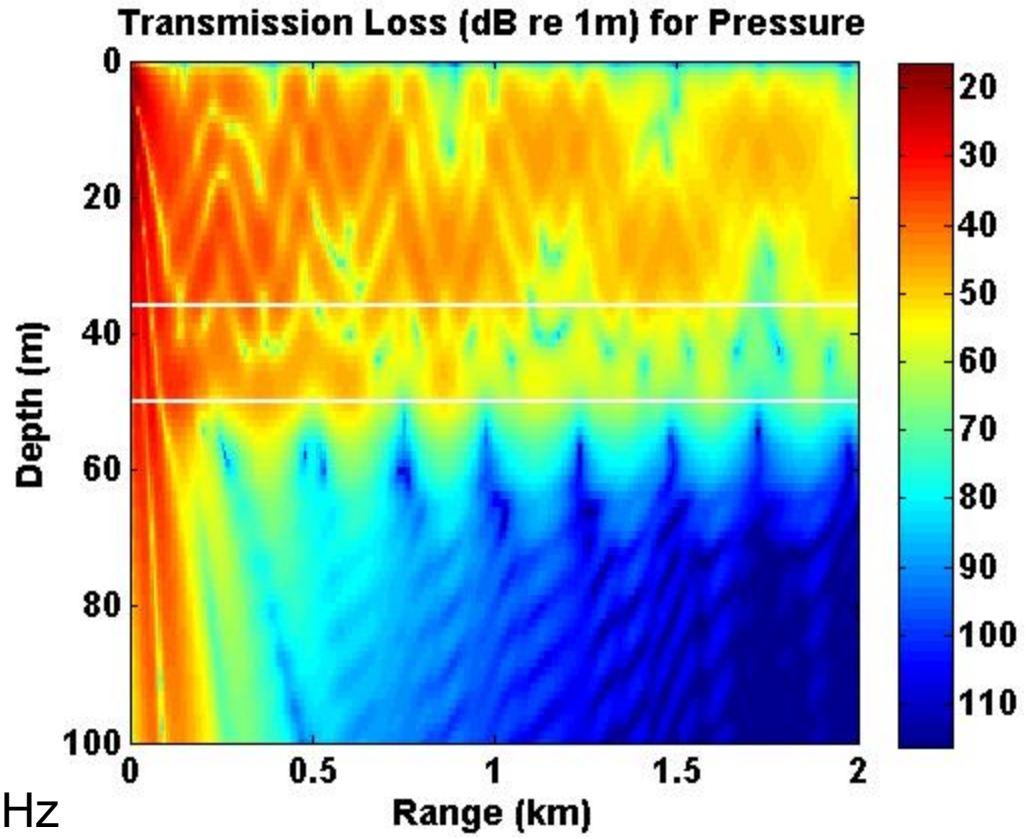
TL Measurement

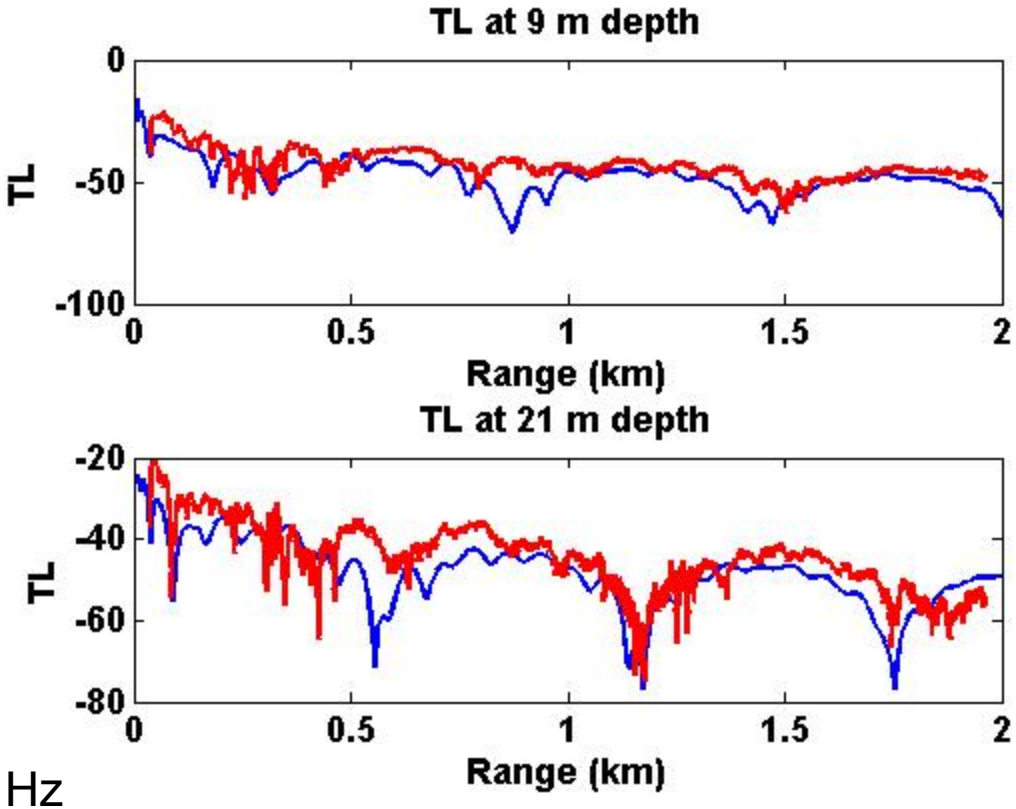


500 Hz J-15 tow to measure TL, estimate sediment properties, and calibrate PE model





Frequency 200 Hz
bathymetry: 35 m
Top sediment layer 15 m thick
Sediment speed- 1590 m/s
Basement speed - 1770 m/s



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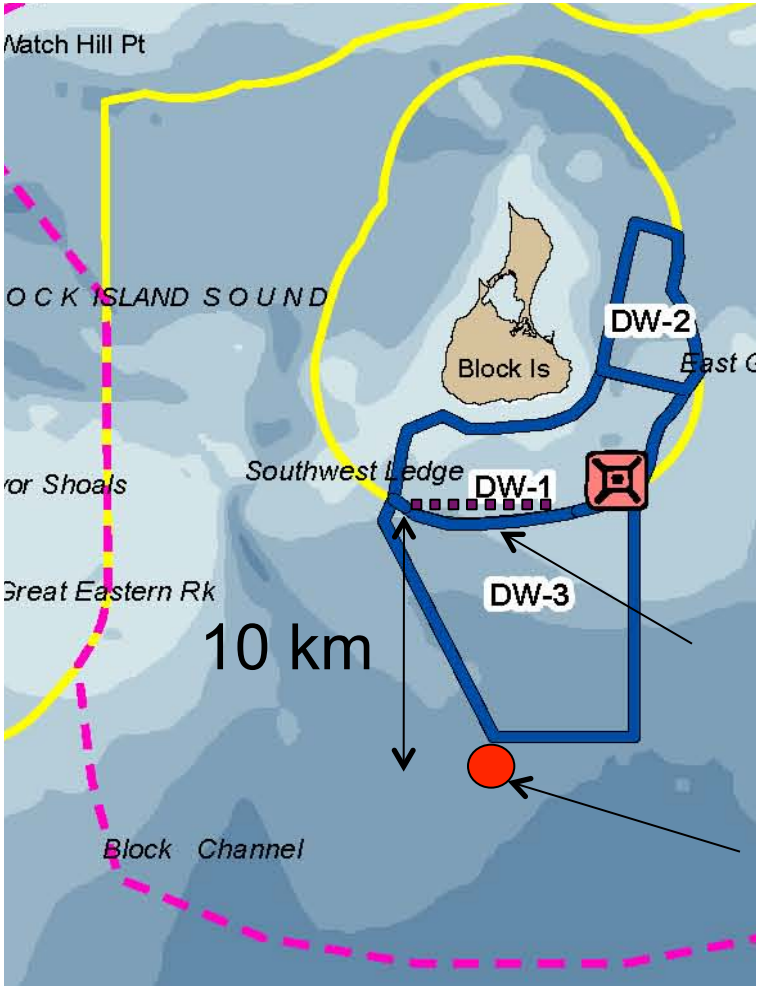
Wind Farm Operational Noise Scenario



8 wind turbines

sensitive habitat

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Step 1: Budget Currency:

Average Intensity from nth Source

$$\left\langle I_n(f) \right\rangle = \frac{1}{T\rho c}\int_0^T \left|\tilde{p}_n(f,t)\right|^2 dt$$

where **T** is the averaging time, a biologically significant duration such as a day, season, etc. over a frequency band, **f** (e.g. 1/3 octave) of the **n**th source (e.g. wind, rain, shipping, seismic, biologics, etc.)

The main source of underwater noise from these GE wind turbines seems to be gear noise

Interpolated Underwater Noise from a Wind Turbine