Motivation

- Instrumentation that will facilitate acoustic data collection as a means to reduce risk and streamline environmental permitting
- Expected source intensity levels 106-109 dB re 1 µPa in 125-250 Hz range, 25 m from source (Tougaard et al. 2015)
- Source localization can help isolate device noise from other sounds
- Real-time characterization can help with mitigation efforts.
Methods

- NoiseSpotter® passive acoustic monitoring system deployed in 18-25 m water depth.
- Each sensor measures acoustic pressure and 3D particle motion, 50 Hz-3 kHz
- Sensor spacing:
  - Vertical: 35 cm, 50 cm, 70 cm above sea bed.
  - Horizontal: 1 m separation
- Sensors enclosed in flow noise-removal shields
Acoustic pressure versus particle motion

Human Ear - Evolved to sense pressure

Fish Ear - Evolved to sense particle motion

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### November 2021 Deployment

<table>
<thead>
<tr>
<th>Date</th>
<th>Objective</th>
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</thead>
<tbody>
<tr>
<td>November 13</td>
<td>Mobilization</td>
</tr>
<tr>
<td>November 14</td>
<td>NoiseSpotter® as drifting system, along with DAISY</td>
</tr>
<tr>
<td>November 15-16</td>
<td>Real-time NoiseSpotter®</td>
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<tr>
<td>November 17-18</td>
<td>Non-real time NoiseSpotter®, 100 m and 200 m from WEC along four cardinal directions</td>
</tr>
<tr>
<td>November 19-22</td>
<td>Multi-day non-real time NoiseSpotter®</td>
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<tr>
<td>November 22</td>
<td>Demobilization</td>
</tr>
</tbody>
</table>
WEC v/s Boat Sounds
CalWave Deployment: Azimuthal Anisotropy

The diagram shows the power spectra for different directions and frequency bands. The legend indicates the frequency bands (0-3 kHz, 0-500 Hz, 500-1000 Hz, 1-3 kHz) and the orientation of the axes (N, E, W, S). The graphs present the power in dB relative to 1 μPa²/Hz⁻¹ as a function of frequency (0 Hz to 3000 Hz) for different directions (E, N, W, S).
CalWave: WEC Sounds

[Images of acoustic data with frequency, pressure, and time axes]

- Z-velocity
- WEC Boat
CalWave: Helicopter Sounds

[Graphs showing acoustic data with frequency, time, and intensity levels]
CalWave: Boat
CalWave: Whale

### Source

<table>
<thead>
<tr>
<th>Source</th>
<th>$L_{E,60,s}$ (dB re 1 $\mu$Pa$^2$ s)</th>
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</thead>
<tbody>
<tr>
<td>WEC</td>
<td>139 dB re 1 $\mu$PA</td>
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<tr>
<td>Boat</td>
<td>147</td>
</tr>
<tr>
<td>Helicopter</td>
<td>140</td>
</tr>
<tr>
<td>Gray Whale</td>
<td>138 dB</td>
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</tbody>
</table>
Conclusions

- WEC sounds at considerably lower levels than ambient sounds such as boats
- Directional processing helps isolate WEC sounds from background
- Some directional anisotropy, likely due to bathymetric variability around WEC
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› Garrett Staines, Joe Haxel (PNNL)
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› Aaron Thode (SIO)