Wave energy development and gray whales in Oregon: Potential risk and mitigation.

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Funding: Department of Energy
         Oregon Wave Energy Trust
         Northwest National Marine Renewable Energy Center
Eastern North Pacific gray whale

Minimum Population Estimate - 18,017 (NOAA 2010)
2007-2008 OSUMMI shore-based observational study – funded by Oregon Wave Energy Trust
(Joel Ortega-Ortiz and Bruce Mate)

Objective:
• Obtain accurate, up to date information on the distribution of gray whales migrating along the central OR coast
Locations from scan surveys

Southbound
Dec – Feb 25
Distance = 6.6 ± 2.53 km
Median Depth = 54.3 m
n = 139

Northbound Phase A
Feb 26 – Apr 9
Distance = 5.1 ± 2.13 km
Median Depth = 46.9 m
n = 230

Northbound Phase B
Apr 10 – May 27
Distance = 4.1 ± 2.62 km
Median Depth = 40.5 m
n = 91

Wave energy development and gray whales
Theodolite-tracked whale paths

Mean = 6.7 ± 1.38 km/h  
   n = 37

Mean = 6.0 ± 1.09 km/h  
   n = 47

Mean = 5.4 ± 1.53 km/h  
   n = 26

Wave energy development and gray whales
## Occurrence of gray whales within the Oregon Territorial Sea (OTS)

<table>
<thead>
<tr>
<th>Migration phase</th>
<th>Time period</th>
<th>Locations</th>
<th>Inside OTS</th>
<th>Outside OTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southbound</td>
<td>Dec - Feb 25</td>
<td>139</td>
<td>41.0%</td>
<td>59.0%</td>
</tr>
<tr>
<td>Northbound Phase A</td>
<td>Feb 26 - Apr 9</td>
<td>230</td>
<td>67.4%</td>
<td>32.6%</td>
</tr>
<tr>
<td>Northbound Phase B</td>
<td>Apr 10 - May 29</td>
<td>91</td>
<td>78.0%</td>
<td>22.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>460</strong></td>
<td><strong>61.5%</strong></td>
<td><strong>38.5%</strong></td>
</tr>
</tbody>
</table>
Ocean Power Technologies (OPT)

PowerBuoy

Wave energy development and gray whales
Acoustic Deterrent Study
- OSUMMI and Pacific Energy Ventures

**Objective**
Deflect the movement of gray whales by 500 m with the use of a low-power sound source.

**Goal**
A successful device may be useful as a mitigation tool to keep gray whales away from wave energy facilities should they prove a collision or entanglement risk.
Acoustic Deterrent Study - Approach

- Moor acoustic device off Yaquina Head, in part of gray whale migratory path (Jan-Apr 2012).

- Transmit sound during experimental period each day during daylight hours.

- Conduct concurrent shore-based observations of gray whales using theodolite to accurately track position, trajectory, and speed.

- Compare results between experimental and control (no sound) periods, as well as 2008 data.
**Intensity: an example**

**Gray whale sounds: 142-185 dB re 1 µPa @ 1 m**

→ In air: 80.5 - 123.5 dB re 20 µPa @ 1 m

**In comparison:**  
- Lawn mower: ~90 dB re 20 µPa @ 1 m  
- Car horn: ~110 dB re 20 µPa @ 1 m

The logarithmic nature of the dB scale means that each 10 dB increase in intensity is a ten-fold increase in acoustic power. A 20-dB increase is then a 100-fold increase in power, and a 30-dB increase is a 1000-fold increase in power.

A ten-fold increase in acoustic power does not mean, however, that the sound is *perceived* as being ten times louder. Humans perceive a 10 dB increase in sound intensity as only a doubling of sound loudness.
What we know

Malme et al.¹: 50% of migrating gray whales showed behavioral responses to “industrial” sounds received louder than 120 dB re 1 μPa @ 1 m.

Tyack and Clark²: Migrating gray whales responded to a low frequency active military sonar with a source level of 185 dB re 1 μPa @ 1 m.


Sound propagation modeling
(Kusel et al. 2009)

December

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Deterrent Specifications

**Signal:** FM sweeps, 1-3 kHz, 1 s duration

**Source level:** 170 dB re 1 µPa @ 1 m

**Repetition rate:** 3 sweeps per minute (when on)

**Duty cycle:** on for 6 hours per day, off for 18

**Sound emission:** total of 18 minutes per day

**Ramp-up:** start at 120 dB and increase by 5 dB every minute
Deterrent Equipment

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Data Collection

Number of days of observation – 51
Number of scans – 136
Number of scan locations – 144
Number of focal follows - 57
Sponsors and Staff

Oregon Wave Energy Trust
Oregon State University Marine Mammal Institute Endowment
Department of Energy
Pacific Energy Ventures
Northwest National Marine Renewable Energy Center
Bureau of Land Management – Yaquina Head Outstanding Natural Area

Shore-based observation teams

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