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

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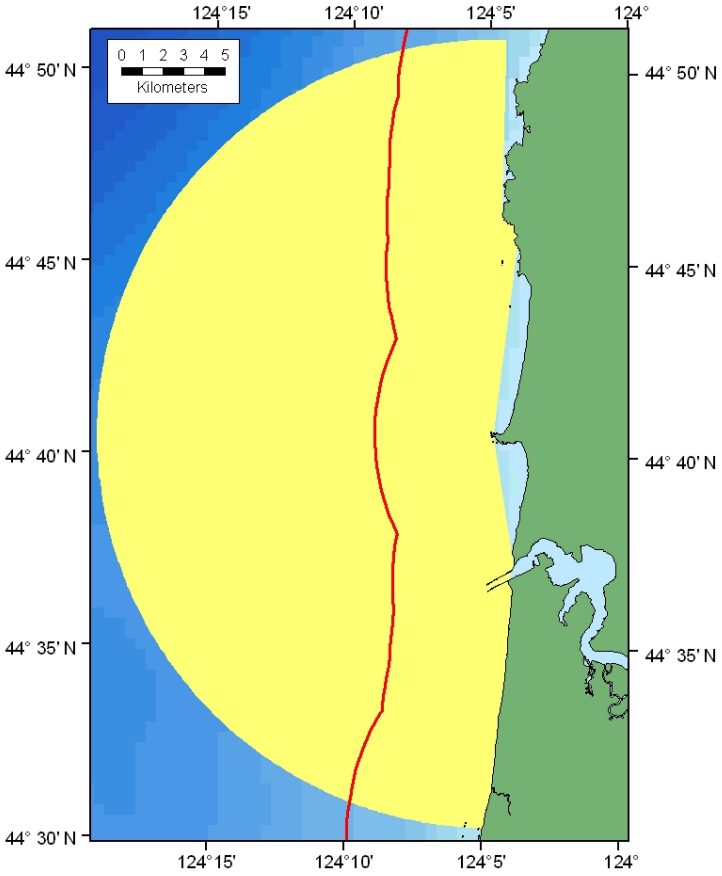
Collaborators: Pacific Energy Ventures
Dave Mellinger, Holger Klinck, Elizabeth Kusel, OSU
Funding: Department of Energy
Oregon Wave Energy Trust
Northwest National Marine Renewable Energy Center

# 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

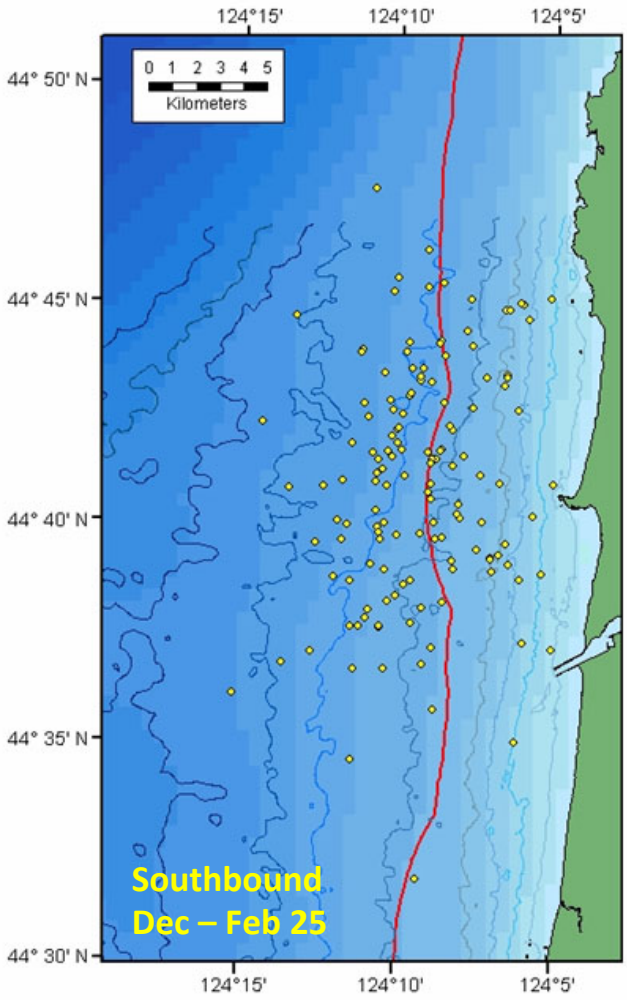
## (Joel Ortega-Ortiz and Bruce Mate)

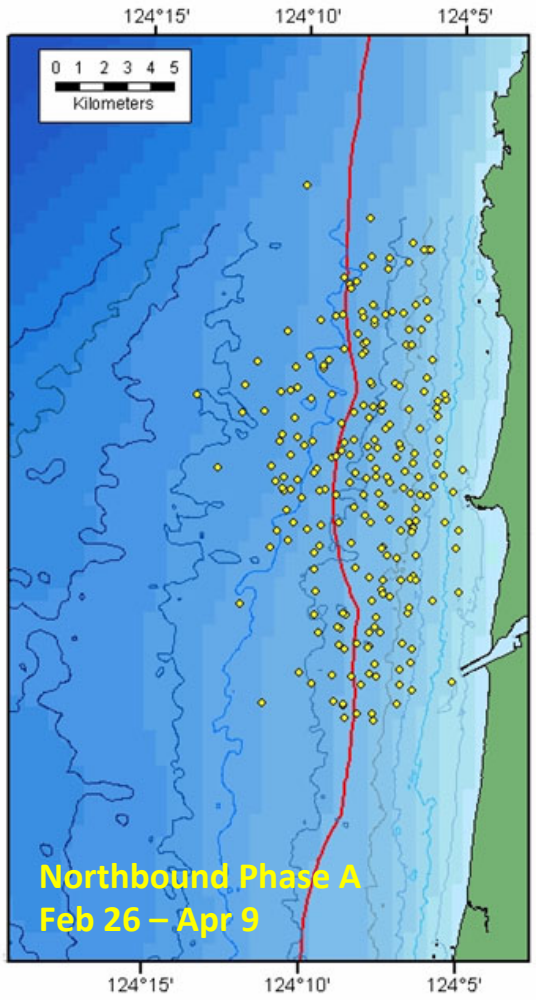


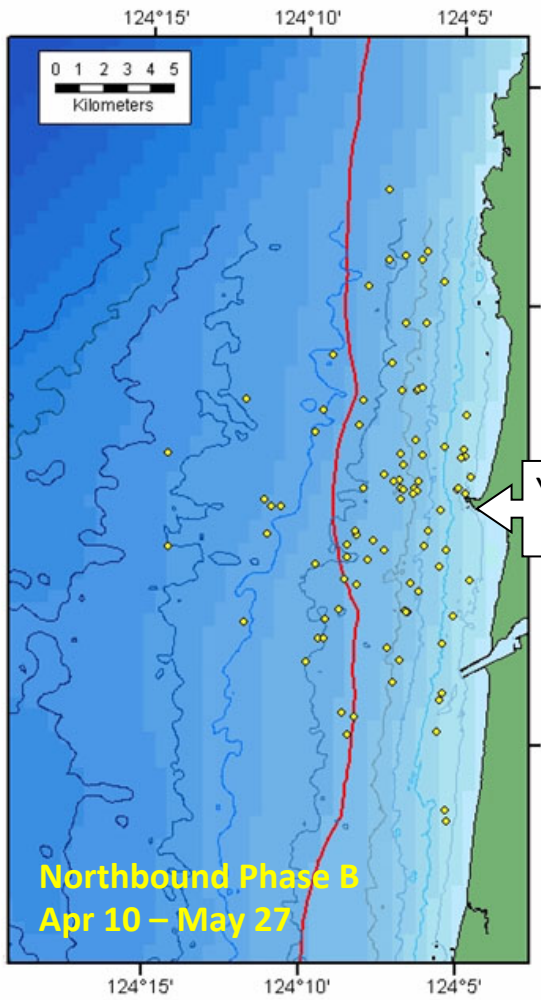

Objective:

- Obtain accurate, up to date information on the distribution of gray whales migrating along the central OR coast

# Locations from scan surveys



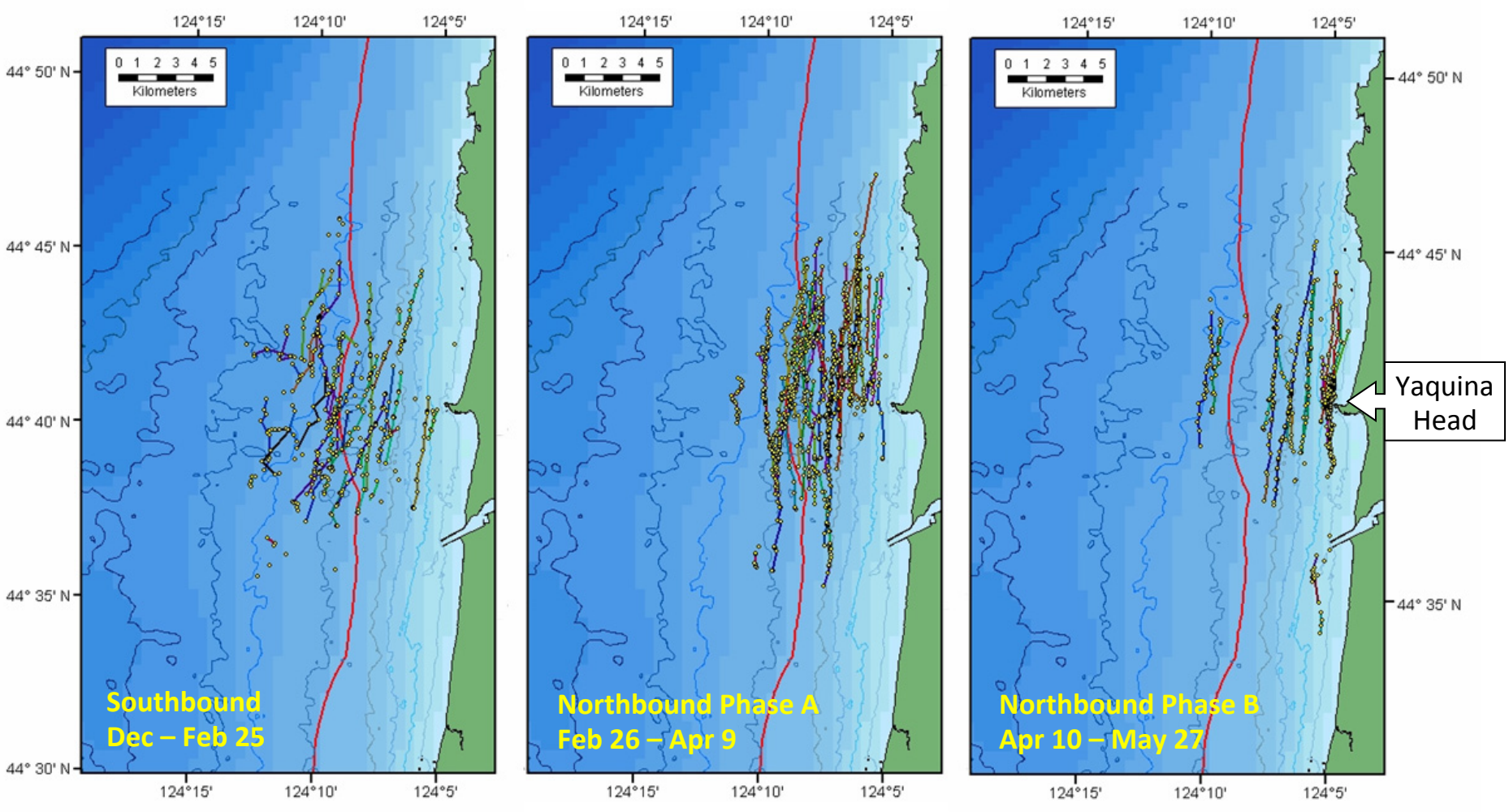




**Distance = 6.6 ± 2.53 km**
**Median Depth = 54.3 m**
**n = 139**

**Distance = 5.1 ± 2.13 km**
**Median Depth = 46.9 m**
**n = 230**

**Distance = 4.1 ± 2.62 km**
**Median Depth = 40.5 m**
**n = 91**

# Theodolite-tracked whale paths




**Mean = 6.7 ± 1.38 km/h**
**n = 37**

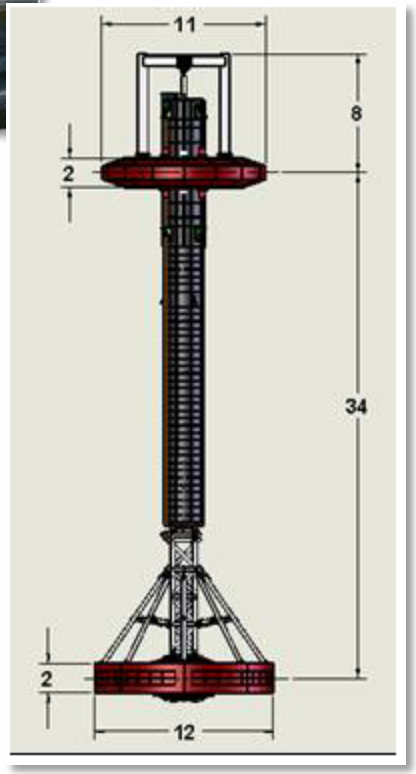
**Mean = 6.0 ± 1.09 km/h**
**n = 47**

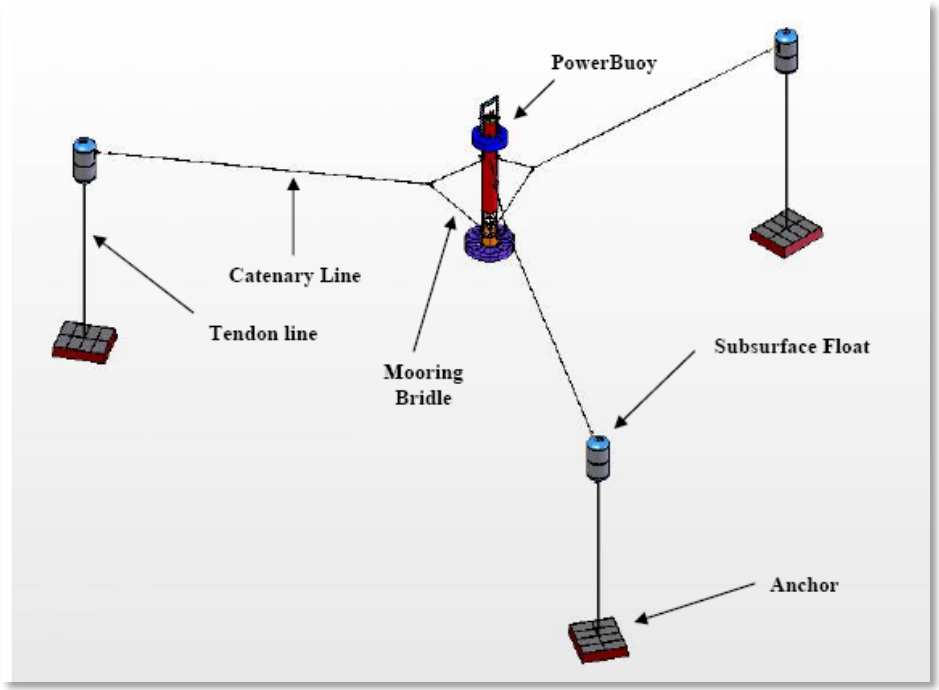
**Mean = 5.4 ± 1.53 km/h**
**n = 26**

# Occurrence of gray whales within the Oregon Territorial Sea (OTS)

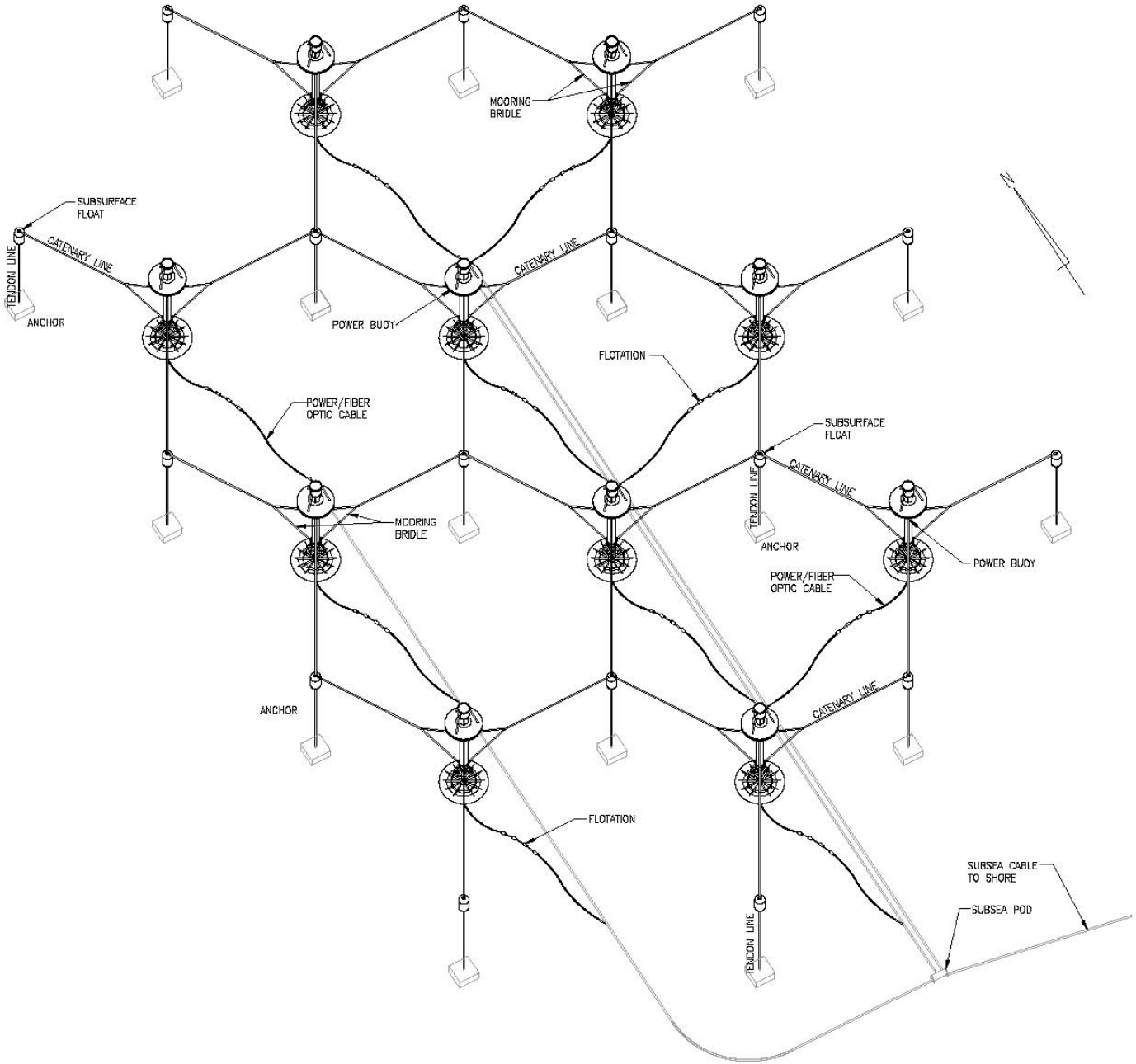
| Migration phase | Time period | Locations | Inside OTS | Outside OTS |
|---|---|---|---|---|
| Southbound | Dec - Feb 25 | 139 | 41.0% | 59.0% |
| Northbound Phase A | Feb 26 - Apr 9 | 230 | 67.4% | 32.6% |
| Northbound Phase B | Apr 10 - May 29 | 91 | 78.0% | 22.0% |
| Total | | 460 | 61.5% | 38.5% |

# Ocean Power Technologies (OPT) PowerBuoy


(FERC 2007)


MOORING BRIDLE
SUBSURFACE FLOAT
CATENARY LINE
TENDON LINE
ANCHOR
POWER BUOY
CATENARY LINE
FLOTATION
POWER/FIBER OPTIC CABLE
SUBSURFACE FLOAT
CATENARY LINE
TENDON LINE
ANCHOR
MOORING BRIDLE
POWER BUOY
POWER/FIBER OPTIC CABLE
ANCHOR
CATENARY LINE
FLOTATION
SUBSEA CABLE TO SHORE
SUBSEA POD
TENDON LINE

# Acoustic Deterrent Study

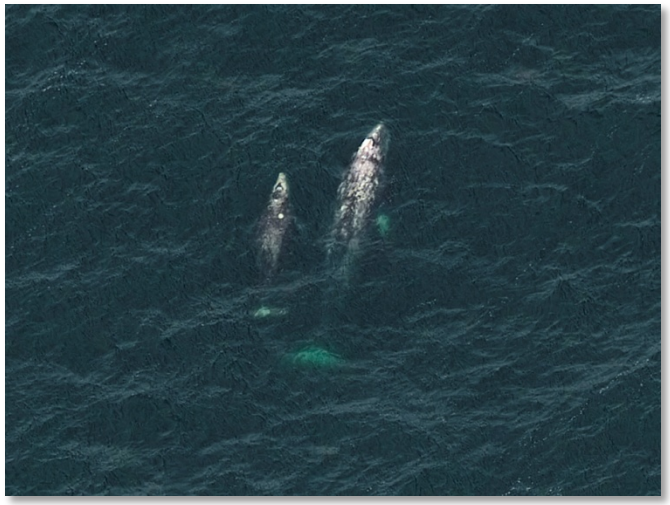
- OSUMMI and Pacific Energy Ventures

## Objective

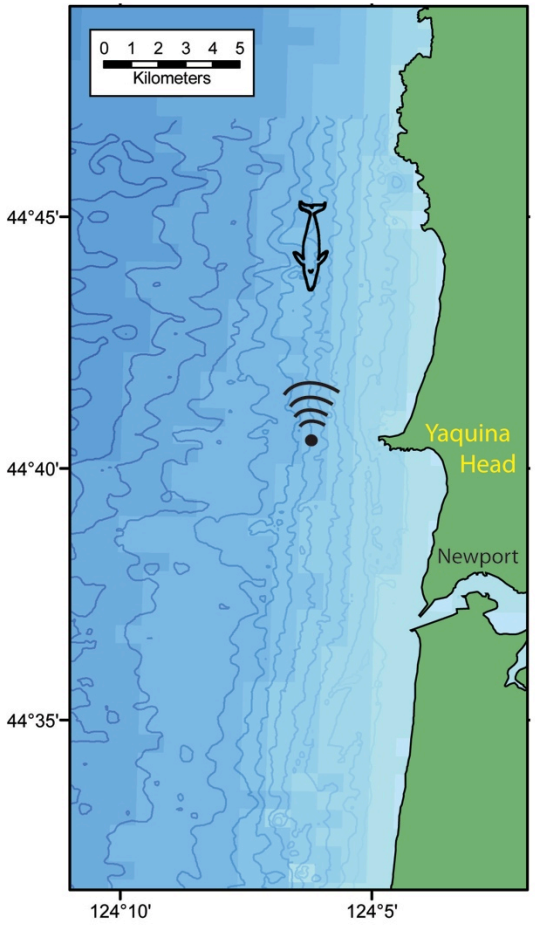
**Deflect the movement of gray whales by 500 m with the use of a low-power sound source.**

## 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

sound: Scripps Inst. Oceanogr.

## 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

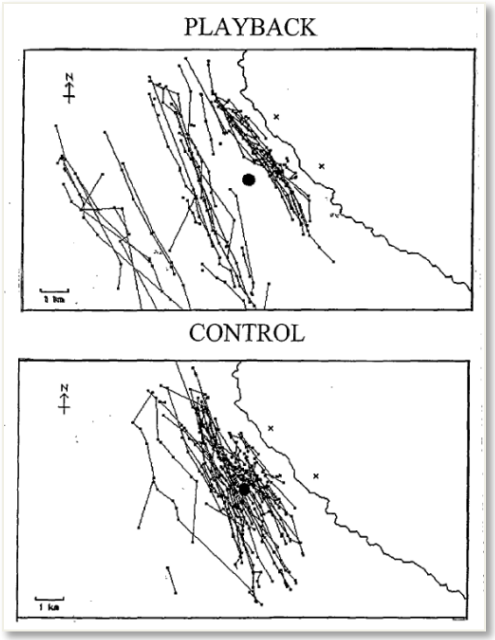
The logarithmic nature of the dB scale means that each 10 dB increase in intensity is a ten-fold increase in acoustic power. A 20-dB increase is then a 100-fold increase in power, and a 30-dB increase is a 1000-fold increase in power.

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 Clark[2]: Migrating gray whales responded to a low frequency active military sonar with a source level of 185 dB re 1 µPa @ 1 m.



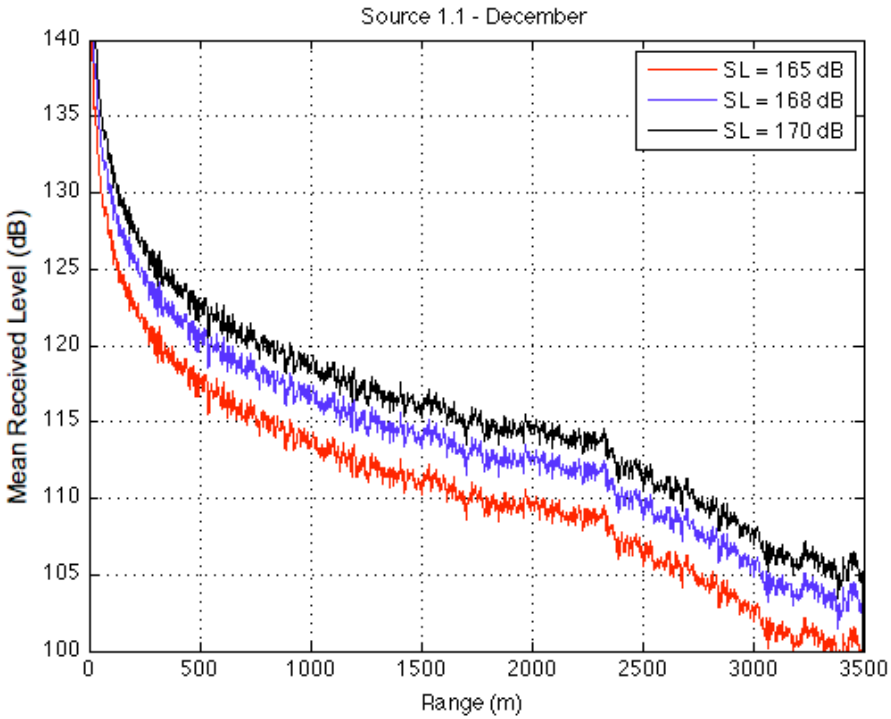

Tyack and Clark (1998)

[1]Malme, C. I., P. R. Miles, C. W. Clark, P. L. Tyack, and J. E. Bird. 1983. Investigations on the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. BBN Rep. 5366. Rep. From Bolt Beranek and Newman, Inc., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. Var. pag. NTIS PB86-174174.

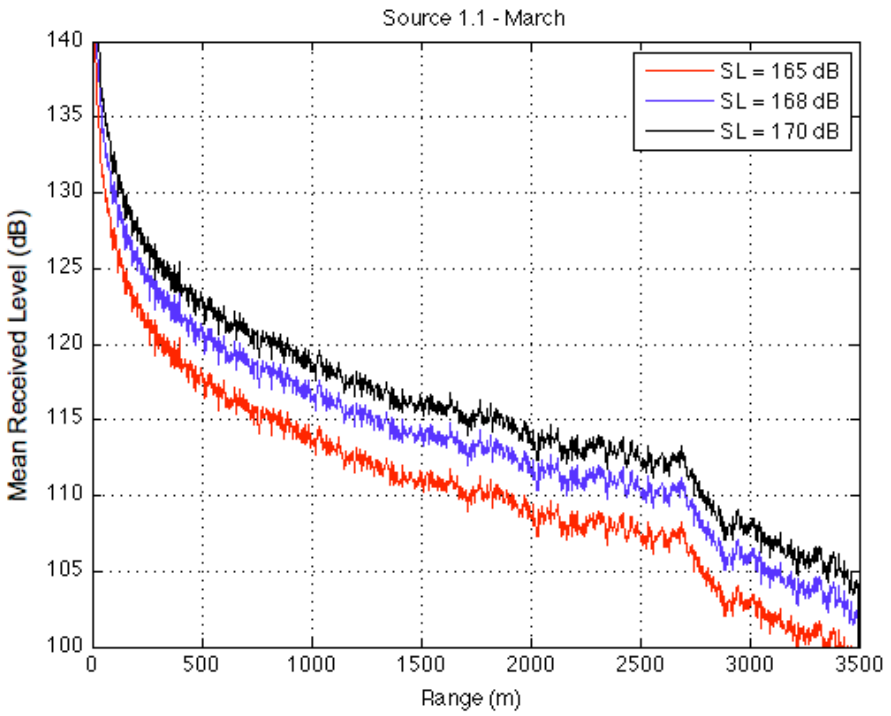
[2]Tyack, P. L., and C. W. Clark. 1998. Playback of low frequency sound to gray whales migrating past the Central California coast – January, 1998. Quick Look report LFA phase II playbacks to migrating gray whales. Unpublished Report. Available from the National Marine Mammal Laboratory.

# Sound propagation modeling
## (Kusel et al. 2009)

### December




### March



# Deterrent Specifications

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

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

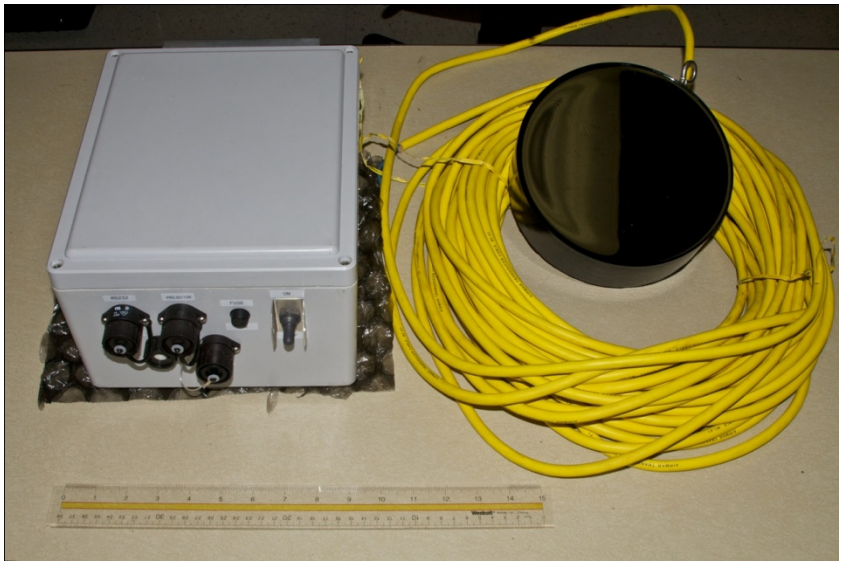
**Repetition rate:** 3 sweeps per minute (when on)

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

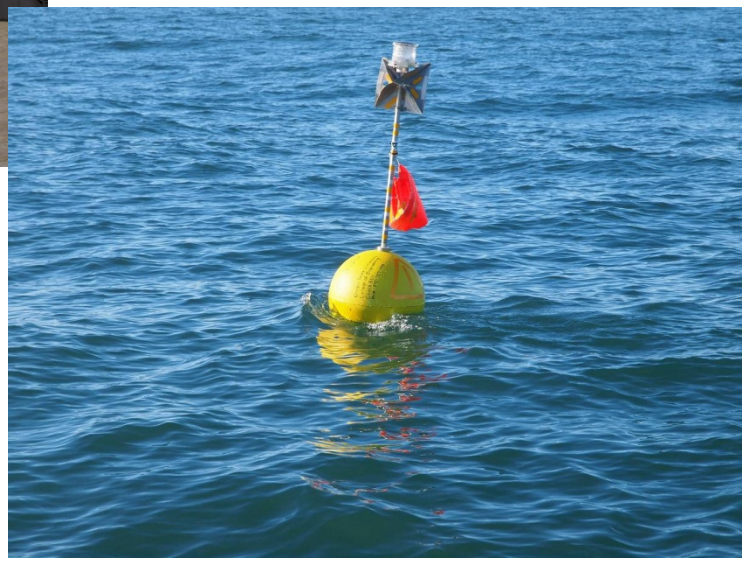
**Sound emission:** total of 18 minutes per day

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

# Deterrent Equipment



# 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
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Pacific Energy Ventures
Northwest National Marine Renewable Energy Center
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