Marine Mammal Behavior in Relation to Pile Driving in Puget Sound, WA, USA

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Background

- Using both vibratory and impact hammers, 23 piles were installed and removed in the Waterfront Restricted Area (WRA) adjacent to Naval Base Kitsap at Bangor (Figure 1) over a 2-month period in fall 2011
- Mitigation measures included use of an underwater bubble curtain for noise attenuation, "soft starts" prior to initiation of pile driving, and maintenance of a 50-m shutdown zone (HDR 2012)

Goals of the Test Pile Program

- Acquire accurate sound propagation data for Hood Canal, a fjord with complex bathymetry
- Monitor marine mammal (MM) occurrence and behavior before, during, and after construction
- Ground-truth sound propagation models in relation to established injury/harassment thresholds

Table 1 – In-Water Harassment and Injury Sound Thresholds for Marine Mammals

Species Group	Harassment Threshold Vibratory Hammer	Harassment Threshold Impact Hammer	Injury Threshold (Impact Hammer Only)
Cetaceans	120 dB RMS	160 dB RMS	180 dB RMS
Pinnipeds	120 dB RMS	160 dB RMS	190 dB RMS

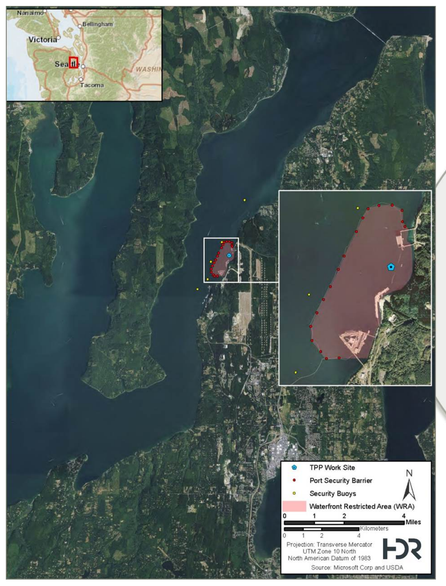


Figure 1 – Study Area

The U.S. Navy's Test Pile Program:

A large-scale 'experiment' in which construction piles were installed and removed in Hood Canal, WA, solely to characterize site-specific sound propagation characteristics and potential effects on protected species, including marine mammals

Methods

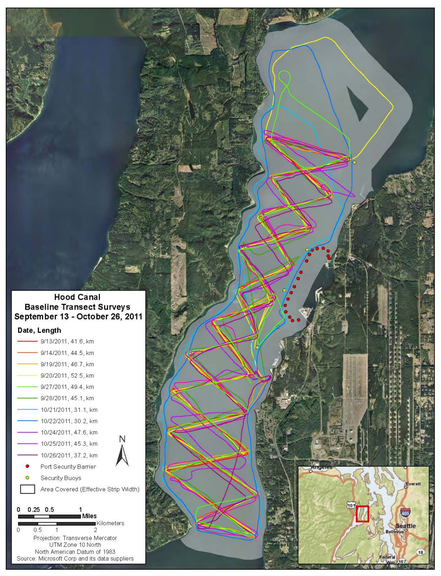
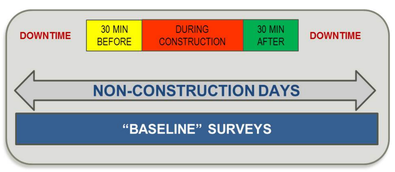


Figure 2 – Line-Transect Surveys in Hood Canal

- Vessel- and pier-based marine mammal observers (MMOs) recorded occurrence and behavior of all MM 30 min before, during, and after construction, and during construction "downtime"
- In situ acoustic measurements were used to estimate received levels (RLs) for all MM sightings
- On days when no pile driving occurred, line-transect surveys were conducted to estimate MM density, and "baseline" behavioral data was also collected



Results

Table 2 – Sighting Rates and Total Number of Sightings on Construction vs. Non-Construction Days

SPECIES	CONSTRUCTION Sightings per Observer Hour [Obs Hr] (Total Sightings)	NO CONSTRUCTION Sightings per Obs Hr (Total Sightings)
Harbor porpoise (*Phocoena phocoena*)	0.10 (66)	0.31 (34)
Harbor seal (*Phoca vitulina*)	0.76 (671)	1.80 (197)
California sea lion (*Zalophus californianus*)	0.06 (45)	0.30 (33)
Steller sea lion (*Eumetopias jubatus*)*	0 (0)	0.01 (1)
Total Number of Sightings	782	265

- Effort consisted of 321 hours of monitoring conducted over 52 days
- Harbor seals were the most frequently observed MM on both construction days (n=671 sightings) and baseline survey days (n=197 sightings, Table 2)
- The harbor porpoise was the only cetacean observed (n=66 construction, 34 baseline sightings, Table 2)
- Sighting rates for all species were lower on construction vs. non construction (baseline) days (Table 2)
- Animals showed no clear movement away from construction zone during or after pile driving (Figures 3 and 4)

Results (Cont.)

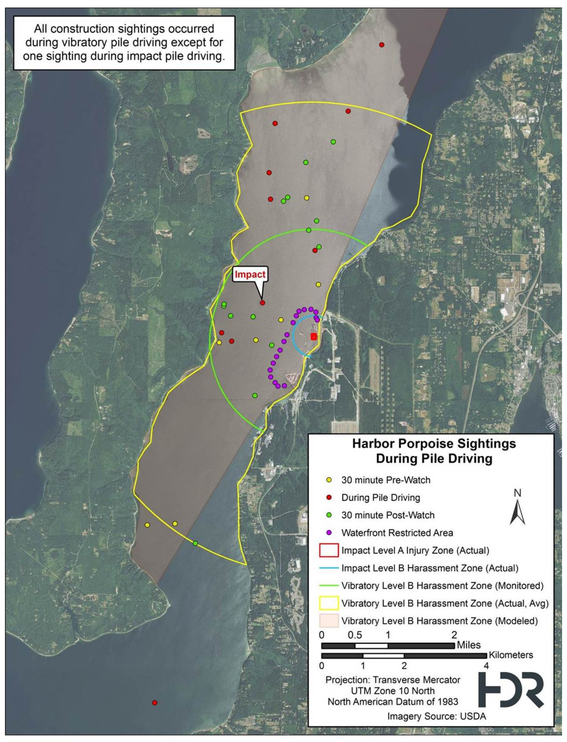


Figure 3 – Harbor Porpoise Positions Before, During, and After Pile Driving

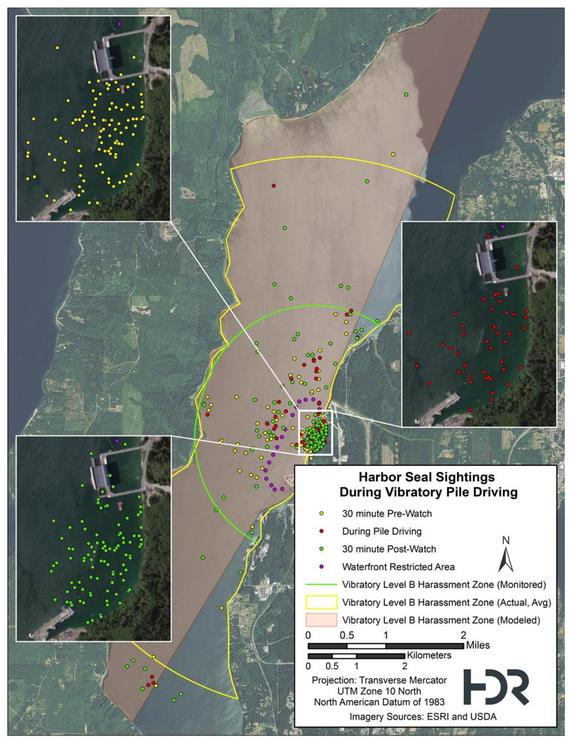


Figure 4 – Harbor Seal Positions Before, During, and After Pile Driving

- Construction appeared to coincide with a decrease in certain pinniped activities, compared with "before" and "after" construction periods, and an increase in the number of animals observed vocalizing (Figure 5)
- Harbor porpoise were most often observed "traveling," and fewer animals were observed traveling during construction vs. before and after construction periods (Figure 6)

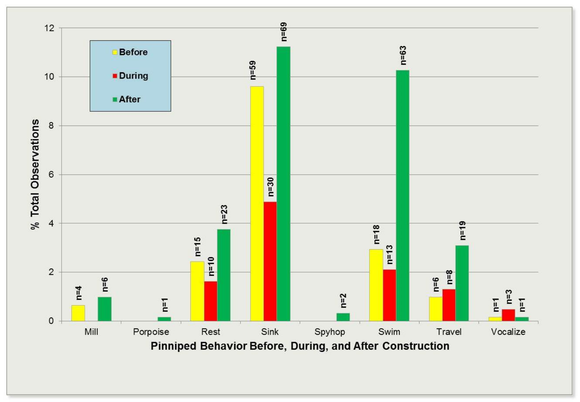


Figure 5 – Pinniped Behavior During Construction Monitoring

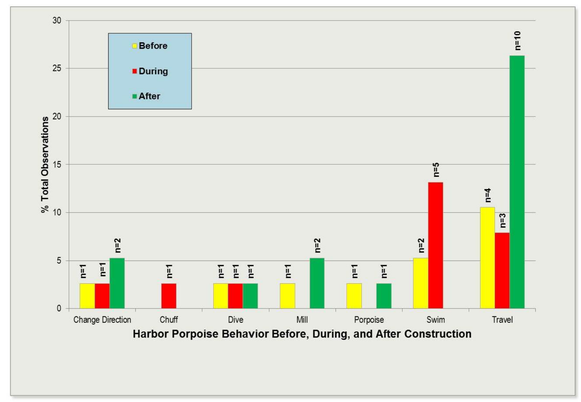


Figure 6 – Harbor Porpoise Behavior During Construction Monitoring

Conclusions

- Overall, minor behavioral disruptions were observed in relation to pile driving
- No consistent behavioral patterns observed relative to 120, 160, 180 or 190 dB root mean square (RMS) thresholds
- Animal tagging/telemetry would permit finer-scale, longitudinal behavioral observations, but was not attempted here
- Harbor seals (particularly juveniles) appeared to be attracted to pile driving, and often moved towards the shut-down zone during construction to investigate pile driving activity (HDR 2012)
- Cetaceans and pinnipeds reacted differently to construction noise
- Species and individuals likely vary in their reactions to anthropogenic noise, and a context-based approach to noise impact assessment could be more useful than analyses based solely on noise thresholds/RLs (Ellison et al. 2012)

Acknowledgements

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Literature Cited

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- HDR. 2012. Naval Base Kitsap at Bangor Test Pile Program, Bangor, Washington. Final Marine Mammal Monitoring Report. Prepared for Naval Facilities Engineering Northwest, Silverdale, WA. April 2012. (http://www.nmfs.noaa.gov/pr/pdfs/permits/navy_kitsap_monitoring_report2012.pdf)