



WASHINGTON STATE  
DEPARTMENT OF TRANSPORTATION (WSDOT)

# BREAKTHROUGH IN MITIGATING MARINE PILE DRIVING NOISE

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## ENVIRONMENTAL IMPLICATIONS



# REQUIREMENTS

## MEASUREMENTS

Peak vs. RMS vs. Cumulative SEL (cSEL)

## ADDITIONAL PERMIT PROCESS

Cannot exceed thresholds or 'take' (ESA) without permits

Must maximize noise mitigation with available technology

Required to monitor amount of 'take'

## MONITOR 'TAKE' OF CONSTRUCTION

Avoid 'take' by shutting down



# MONITORING

## EXAMPLE PLAN

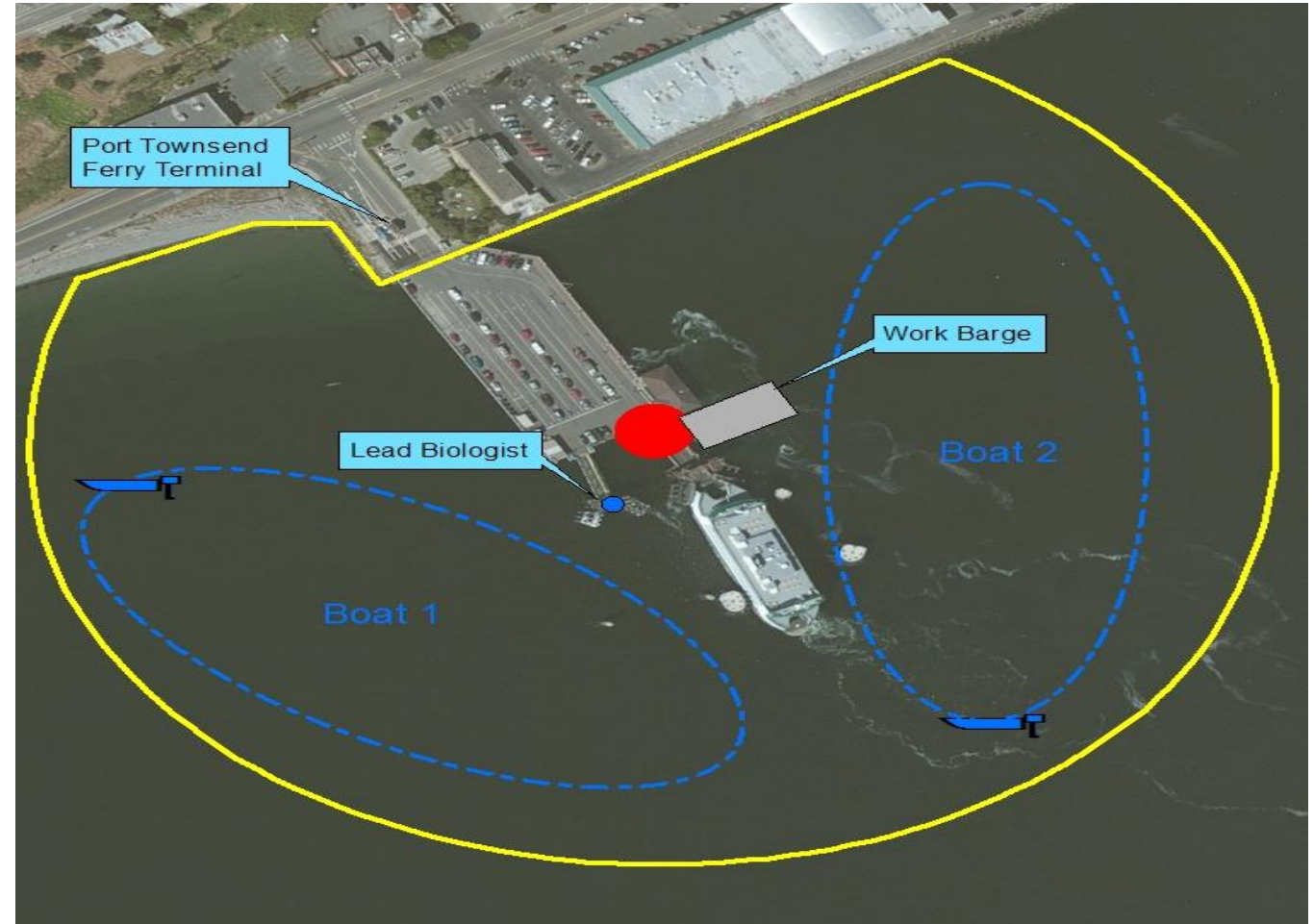
Monitor Zone: 201 meter

Monitoring Boats: 2

Boat Drivers: 2

Biologists: 5

- 1 lead biologist
- 2 biologists per boat



# CURRENT THRESHOLDS

	Injury Threshold	Non-Auditory Injury Threshold	Disturbance Threshold
<b>MARBLED MURRELETS</b> (Diving Birds)	202 dB cSEL	208 dB cSEL	N/A
<b>CETACEANS</b> (whales, porpoises)	180 dB RMS	N/A	160 dB RMS
<b>PINNIPEDS</b> (seals, sea lions)	190 dB RMS	N/A	160 dB RMS
<b>FISH</b> (≥ 2 grams)	187 dB cSEL	N/A	150 dB RMS
<b>FISH</b> (all sizes)	206 dB Peak		





# RESULTS

	Control w/o BC	Control w/BC	BC $\Delta$	Double Wall	DW $\Delta$	Mandrel	MP $\Delta$
<b>PEAK</b>	211 dB	205 dB	- 6 dB	190 dB	- 21 dB	190 dB	- 21 dB
<b>RMS<sub>90%</sub></b>	198 dB	192 dB	- 6 dB	179 dB	- 19 dB	178 dB	- 20 dB
<b>cSEL</b>	198 dB	192 dB	- 6 dB	182 dB	-16 dB	182 dB	- 16 dB



# RESULTS VS. THRESHOLDS

DOUBLE WALL PILE		FISH	CETACEAN INJURY	CETACEAN / PINNIPED DISTURBANCE	PINNIPED INJURY	MURRELET INJURY	MURRELET NON-AUDITORY
PEAK	190 dB	206 dB	-	-	-	-	-
RMS <sub>90%</sub>	179 dB	-	180 dB	160 dB	190 dB	-	-
CSEL	182 dB	187/183 dB	-	-	-	202 dB	208 dB

MANDREL		FISH	CETACEAN INJURY	CETACEAN / PINNIPED DISTURBANCE	PINNIPED INJURY	MURRELET INJURY	MURRELET NON-AUDITORY
PEAK	190 dB	206 dB	-	-	-	-	-
RMS <sub>90%</sub>	178 dB	-	180 dB	160 dB	190 dB	-	-
CSEL	182 dB	187/183 dB	-	-	-	202 dB	208 dB





# ZONE OF INJURY: FISH (CONTROL)

## INJURY LEVEL:



187 dB cSEL  
206 dB Peak



### NO BUBBLE CURTAIN

-  206 dB Peak  
21 meters
-  187 dB cSEL  
46 meters

### BUBBLE CURTAIN

-  206 dB Peak  
7 meters
-  187 dB cSEL  
18 meters

 PILE



# ZONE OF INJURY: FISH

**INJURY LEVEL:**  
187 dB cSEL

- CONTROL PILE**  
46 meters
  
- DOUBLE WALL & MANDREL PILE**  
4 meters
  
- PILE**






# ZONE OF INJURY: PINNIPEDS

**INJURY LEVEL:**  
190 dB RMS

 **CONTROL PILE**  
28 meters

 **DOUBLE WALL & MANDREL PILE**  
1.5 meters

 **PILE**

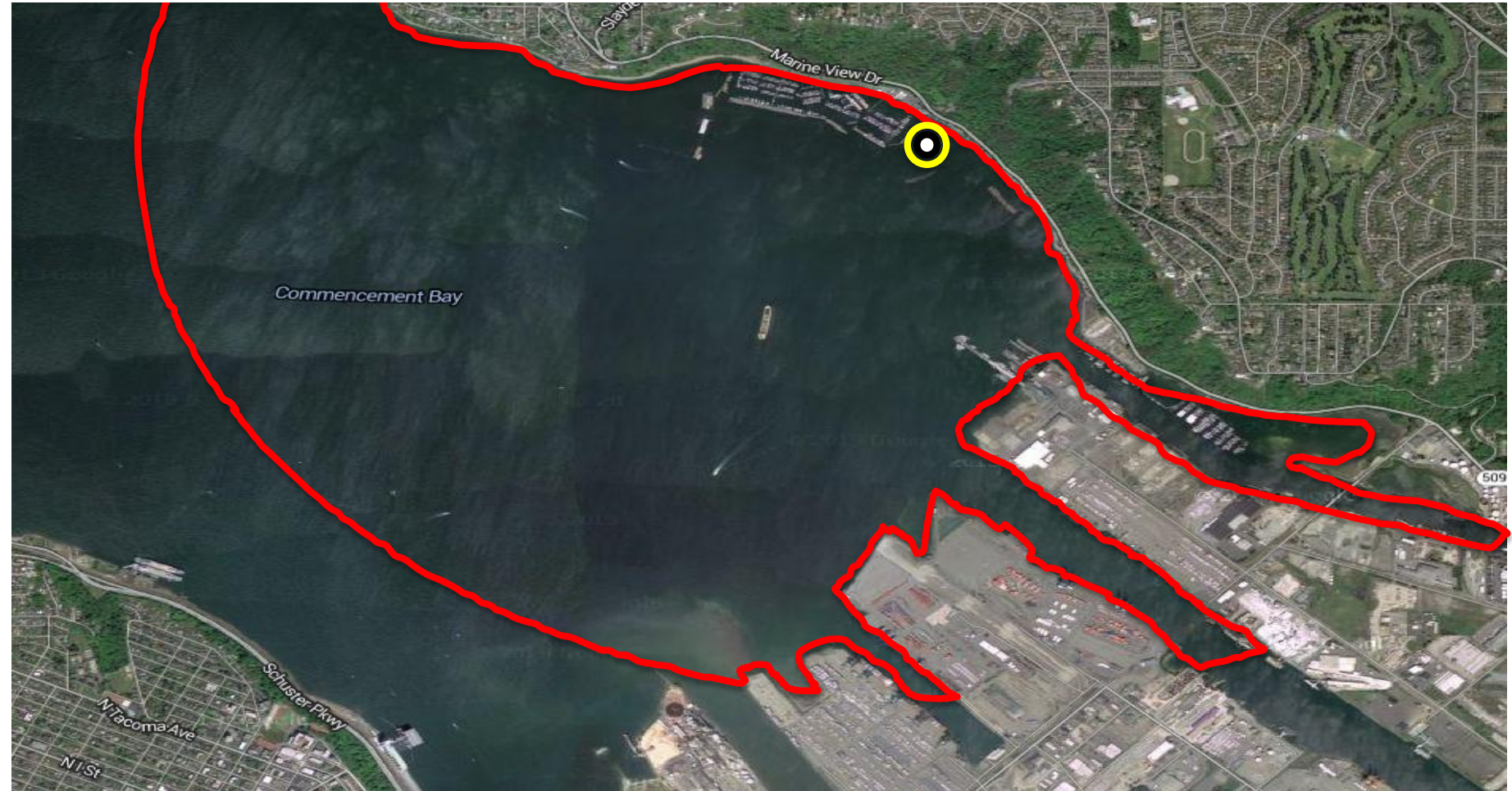




# ZONE OF DISTURBANCE: CETACEAN/PINNIPED

**INJURY LEVEL:**  
160 dB RMS

- **CONTROL PILE**  
2,800 meters
- **DOUBLE WALL & MANDREL PILE**  
150 meters
- PILE**






# ZONE OF INJURY: MARBLED MURRELETS

## INJURY LEVEL:

202 dB cSEL

208 dB cSEL

 **CONTROL PILE**  
2 – 5 meters

 **DOUBLE WALL &  
MANDREL PILE**  
0.4 - 0.02 meters

 **PILE**





# USLM RESULTS

	Control w/o BC	Double Wall	DW $\Delta$	Mandrel	MP $\Delta$
<b>PEAK</b>	200 dB	173 dB	- 27 dB	177 dB	- 23 dB
<b>RMS<sub>90%</sub></b>	187 dB	161 dB	- 26 dB	166 dB	- 21 dB
<b>cSEL</b>	173 dB	151 dB	- 22 dB	155 dB	- 18 dB



# IMPLICATIONS

## REDUCED 'TAKE'

Fewer environmental impacts

Fewer animals harmed

## REDUCED BIOLOGICAL MONITORING

## INSTALLATION EFFICIENCIES

No air compressors/hoses

Eliminate vibratory driving/changing hammers?

Consistent results

## REDUCED RISK OF STOP WORK



# W MECHANICAL ENGINEERING

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UNIVERSITY of WASHINGTON



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