Northwest
National
Marine
Renewable
Energy
Center

Riding the Tide: Tidal Power Development in Puget Sound

March 9, 2010

Brian Polagye
Research Assistant Professor
University of Washington

- **Overview**
- **Devices**
- **Admiralty Inlet Studies**

Tidal Hydrokinetic Turbines

- Superficial resemblance to wind turbines
- Key operational differences
  - Higher fluid density
  - Lower speed
  - Higher torque

Other Forms of Marine Energy

Tidal Barrage

Wave Hydrokinetic

- Ocean Current
- Ocean Thermal
- Salinity Gradient
- Offshore Wind

002,12-08-09,NWFSC.ppt

Tidal Energy Overview

Benefits

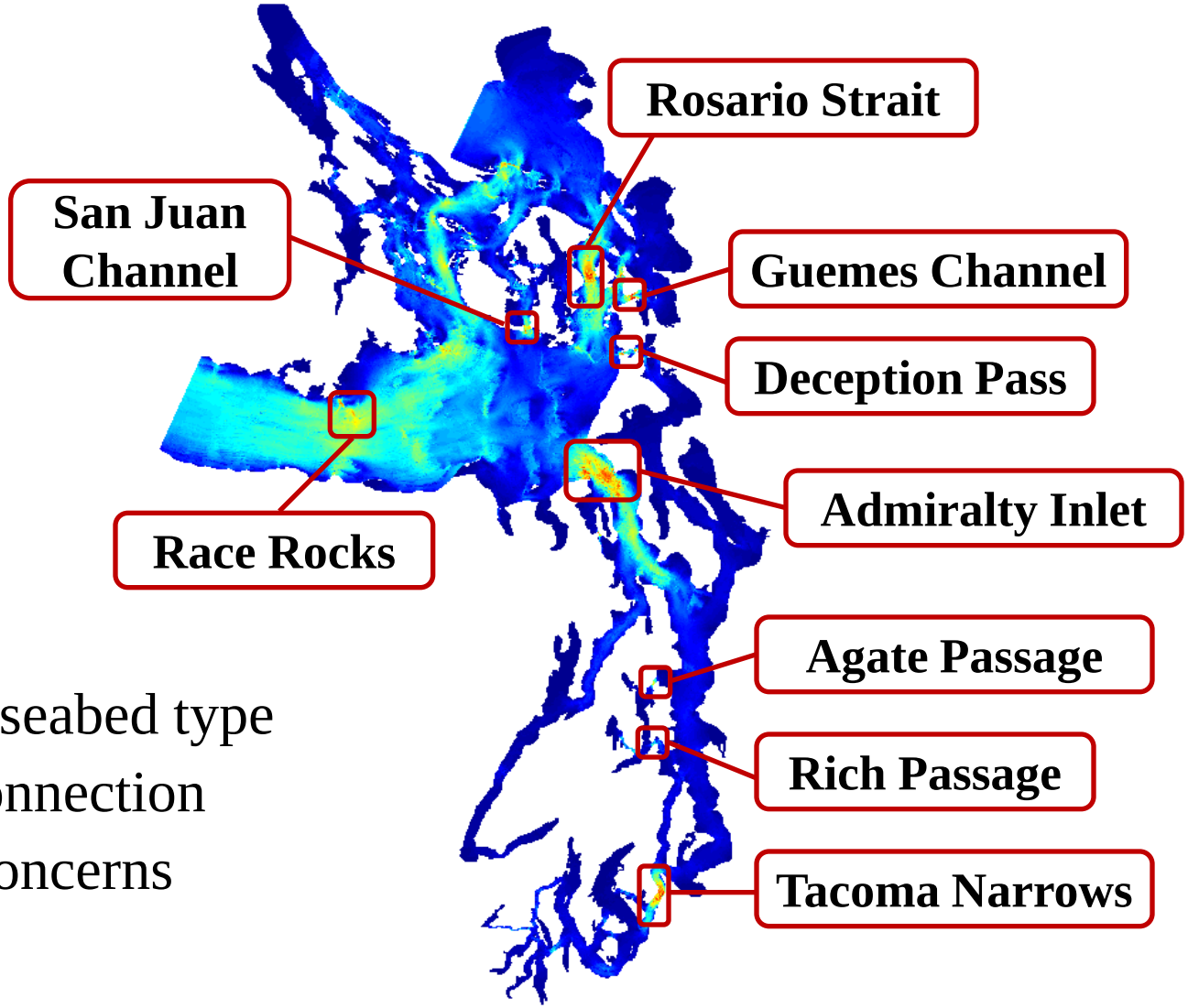
- No CO_2 emissions during operation
- Power generation is predictable
- Very high resource intensity
- No visual expression during operation
- Short transmission distances

Challenges

- Deep, fast moving water
- High cost for first-generation technology
- Limited data on environmental risks
- Existing stresses in marine environment
- Long permitting pathway with high cost

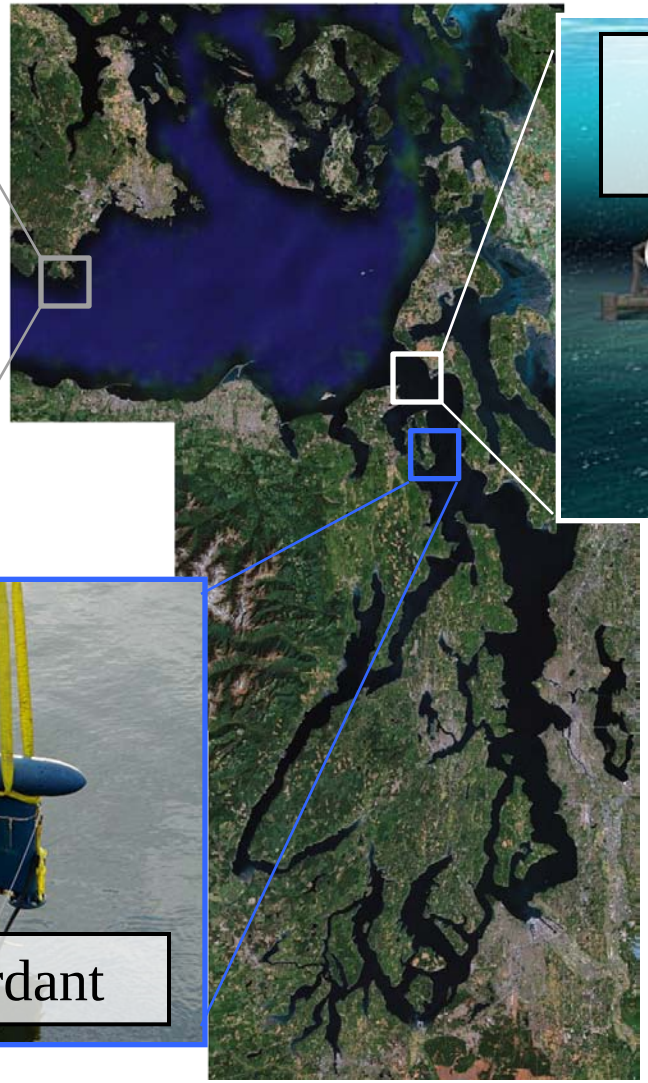
Tidal Energy Sites in Puget Sound

NNMREC-UW
Depth-averaged velocity
SUNTANS model



- **Siting Criteria**
  - Resource
  - Water depth and seabed type
  - Electrical interconnection
  - Environmental concerns
  - Existing uses

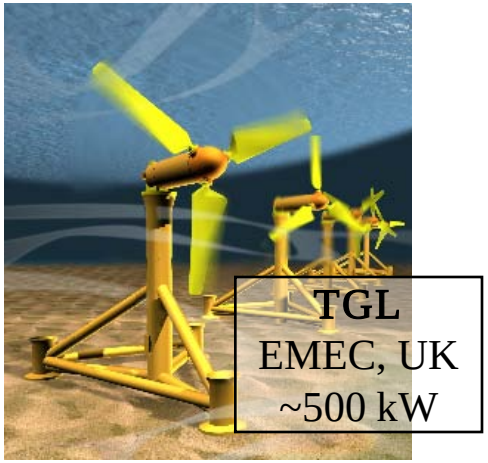
Puget Sound Demonstration Projects



- **Technology**
- **Economics**
- **Environmental risks**

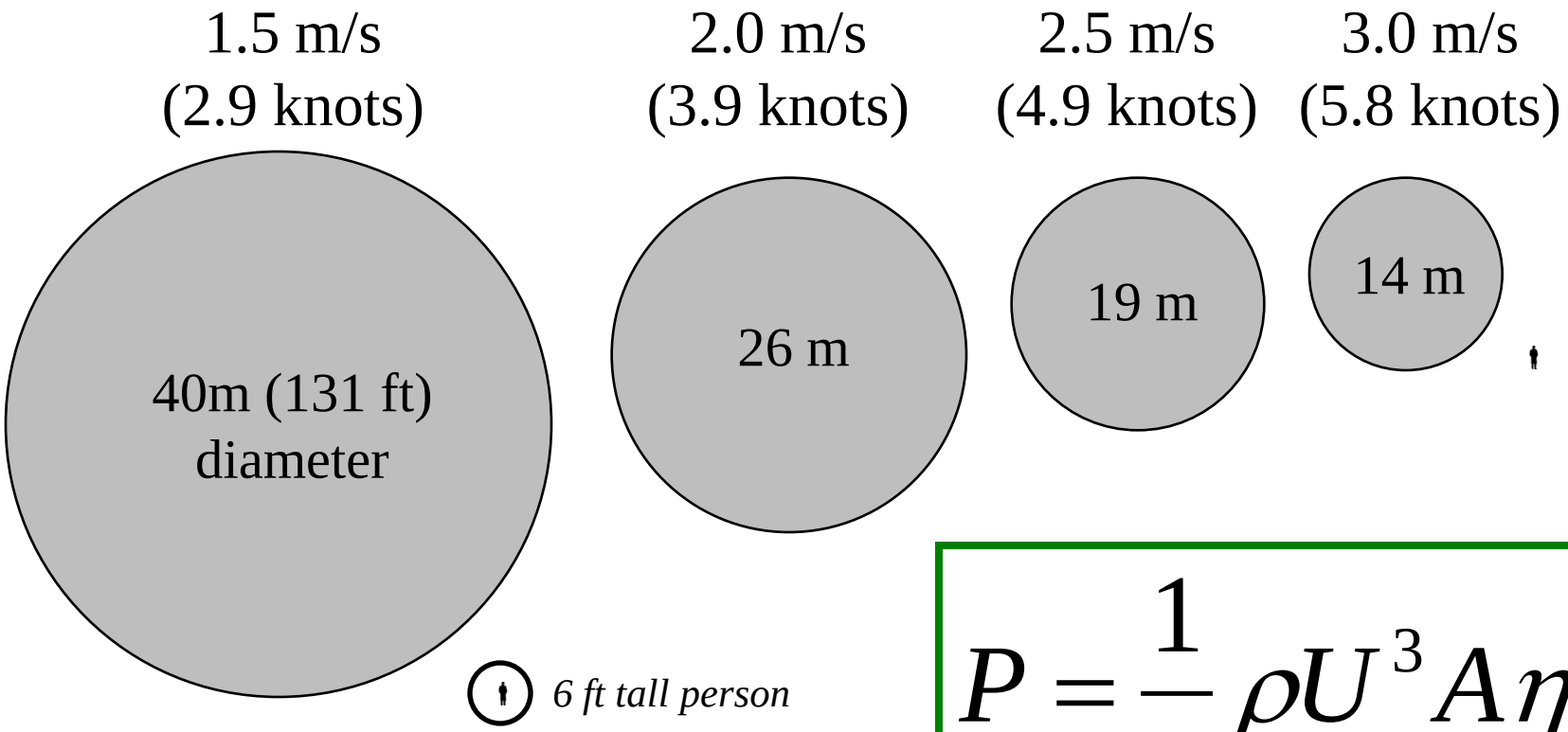
- **Overview**
- **Devices**
- **Admiralty Inlet Studies**

Hydrokinetic Turbines



017,09-24-09,AWRA.ppt

Device Size to Generate 1 MW

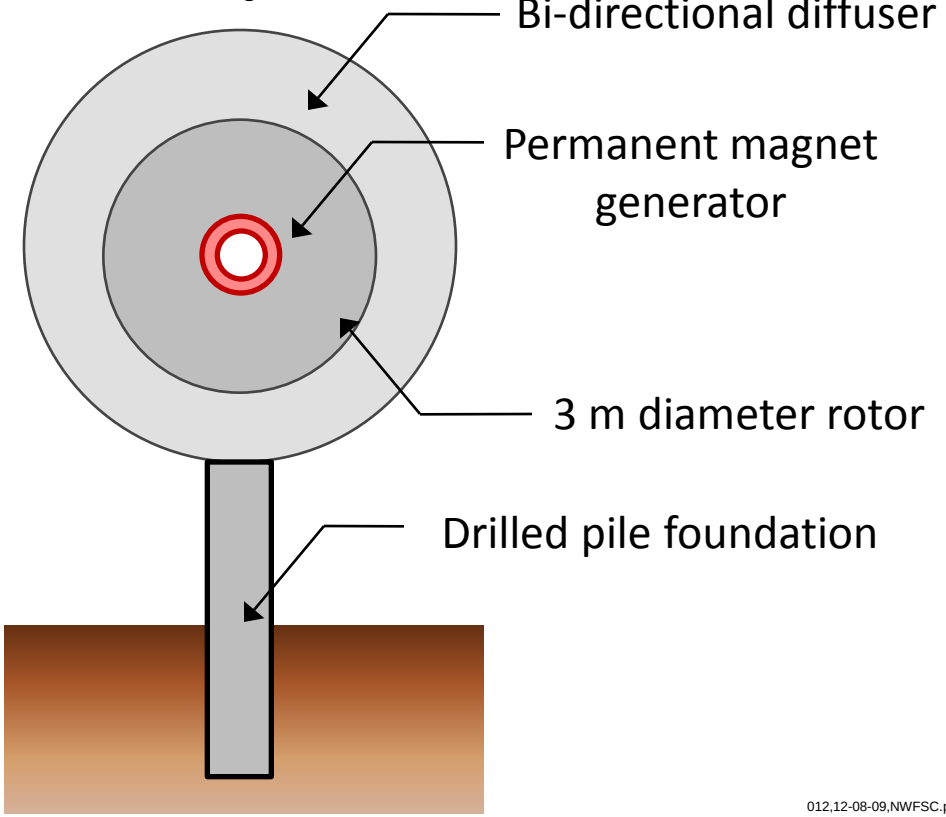


$$P = \frac{1}{2}\rho U^3 A \eta$$

Clean Current

Race Rocks demonstration project

- Offsets diesel load at lighthouse and marine science facility



012,12-08-09,NWFSC.ppt

Clean Current - Biofouling

Before

After

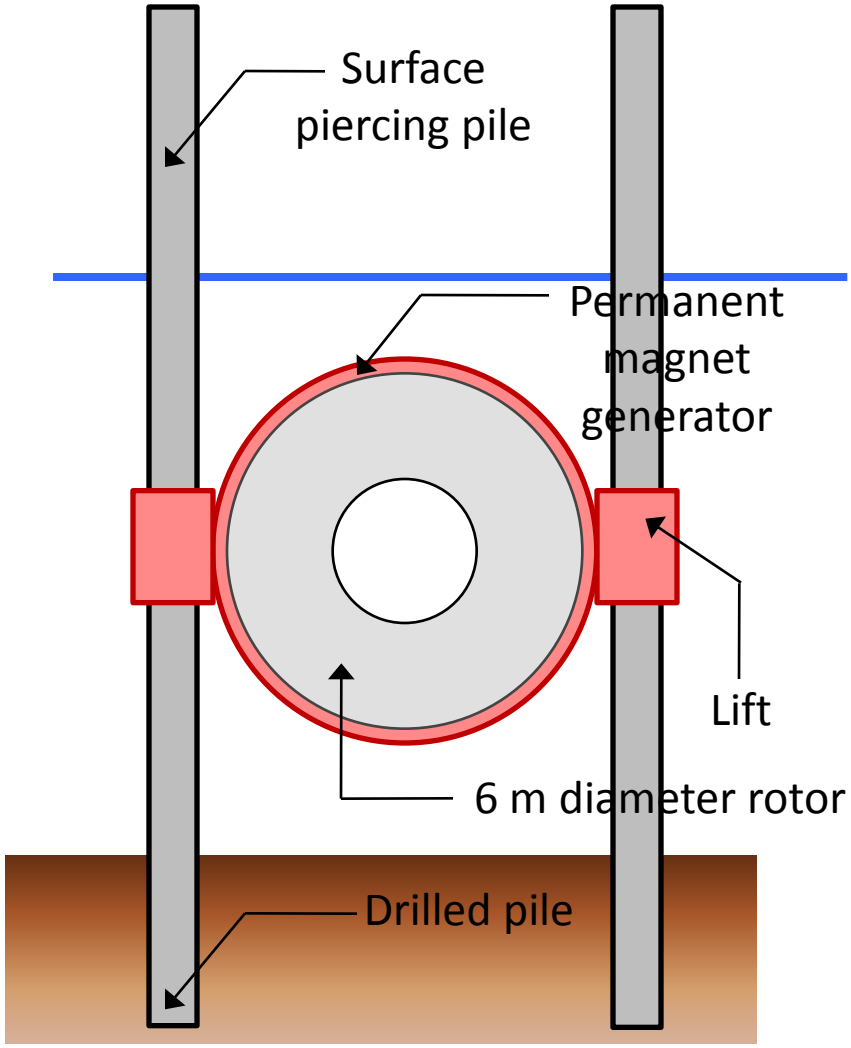
6 *months* deployment

013,12-08-09,NWFSC.ppt

Open Hydro

European Marine Energy Center

- First device tested at EMEC

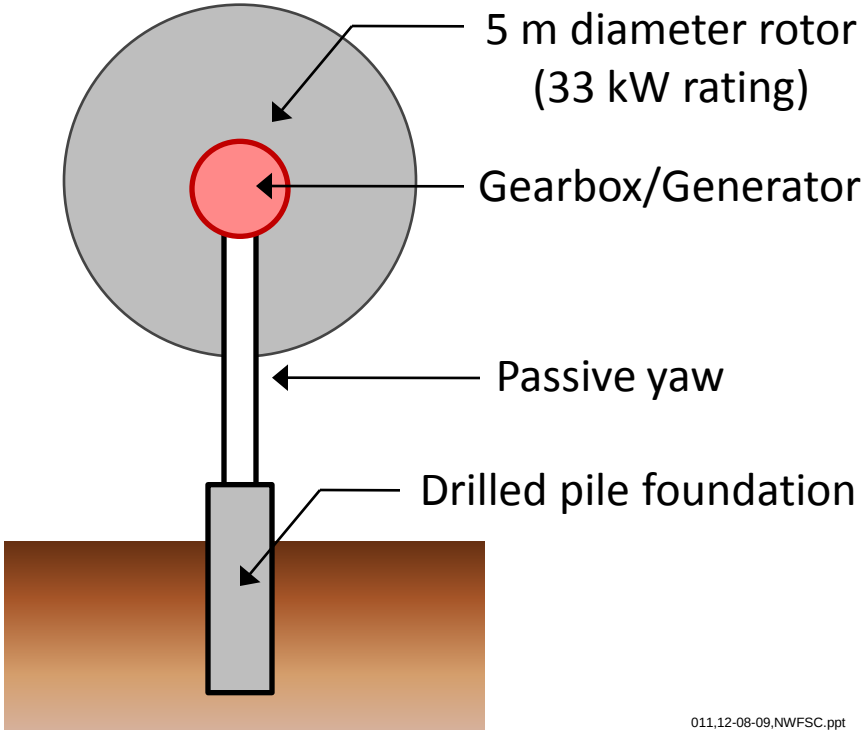


014,12-08-09,NWFSC.ppt

Verdant Power

Roosevelt Island Tidal Energy project

- Only US demonstration to date
- Only array demonstration in the world

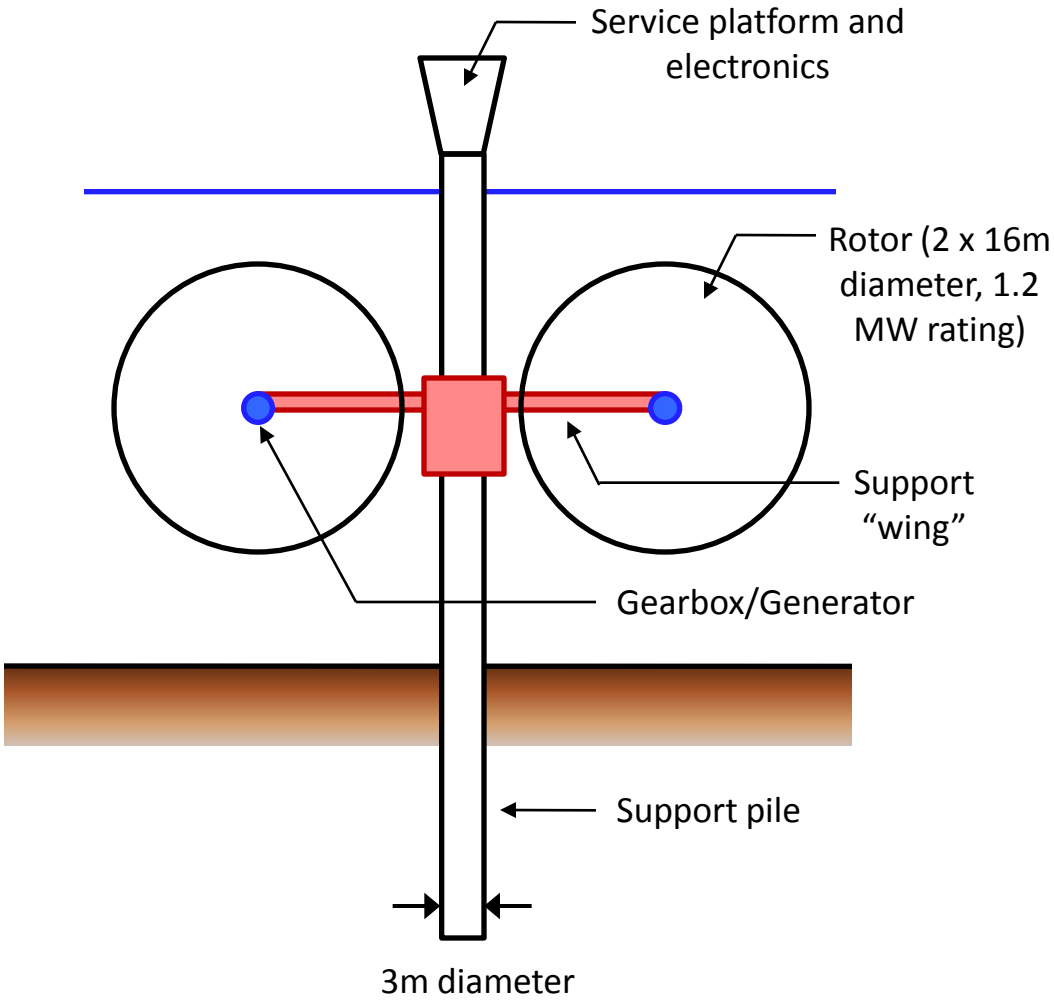


011,12-08-09,NWFSC.ppt

Marine Current Turbines

Strangford Lough demonstration

- First grid connected, utility-scale device



016,12-08-09,NWFSC.ppt

Marine Current Turbines

- Inspection boat running against current as support wing is raised

- Inspection/maintenance boarding around slack water

017,12-08-09,NWFSC.ppt

- **Overview**
- **Devices**
- **Admiralty Inlet Studies**

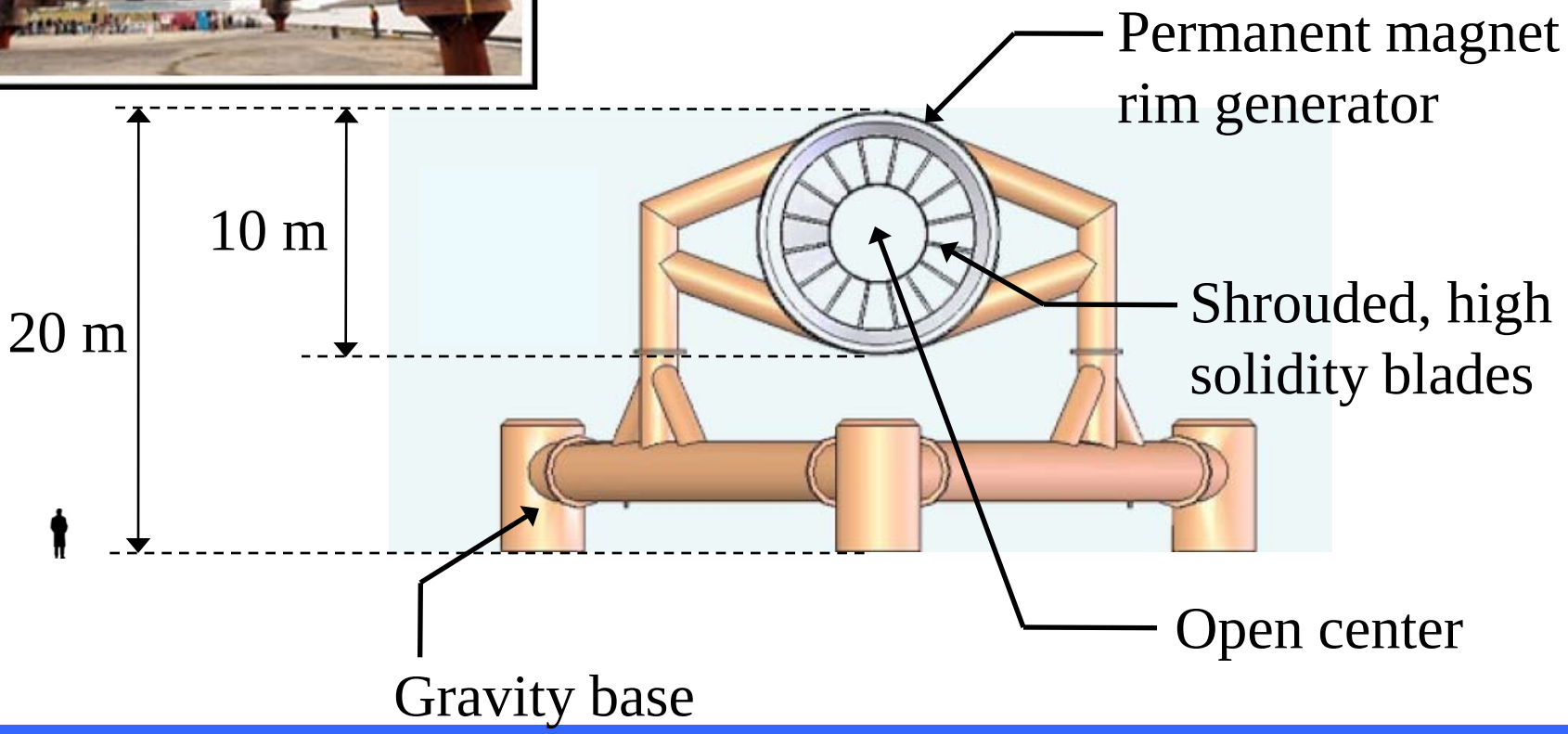
NNMREC Overview

- Department of Energy funded partnership between Oregon State University (wave) and the University of Washington (tidal)
- **Objectives**
  - Facilitate responsible device commercialization
  - Inform regulatory and policy decisions
  - Close key gaps in understanding
- **Partners on Tidal Energy**
  - Snohomish Public Utility District
  - BioSonics
  - Pacific Northwest National Lab
  - Sound and Sea Technology

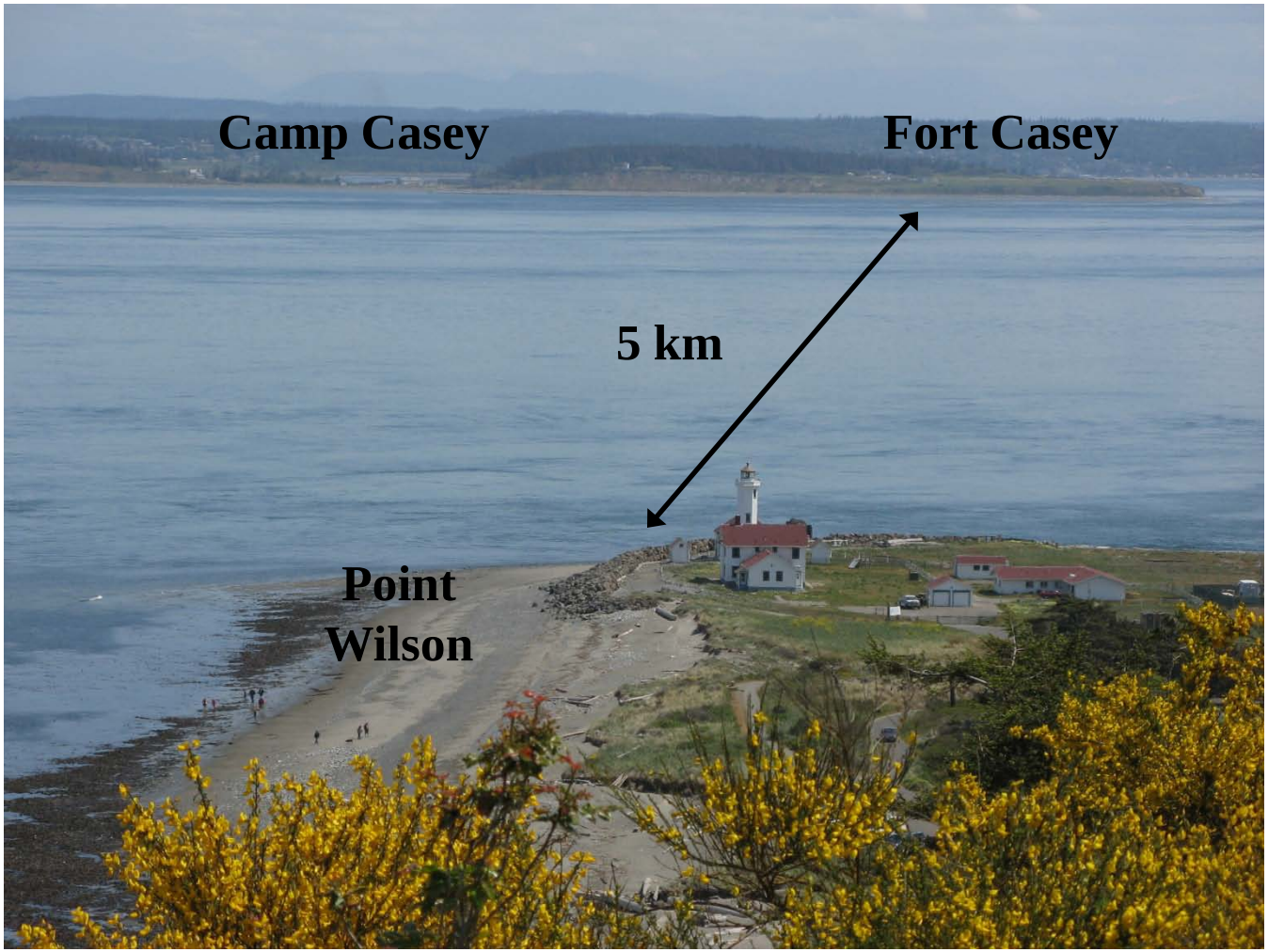
015,09-24-09,AWRA.ppt

Device Selection

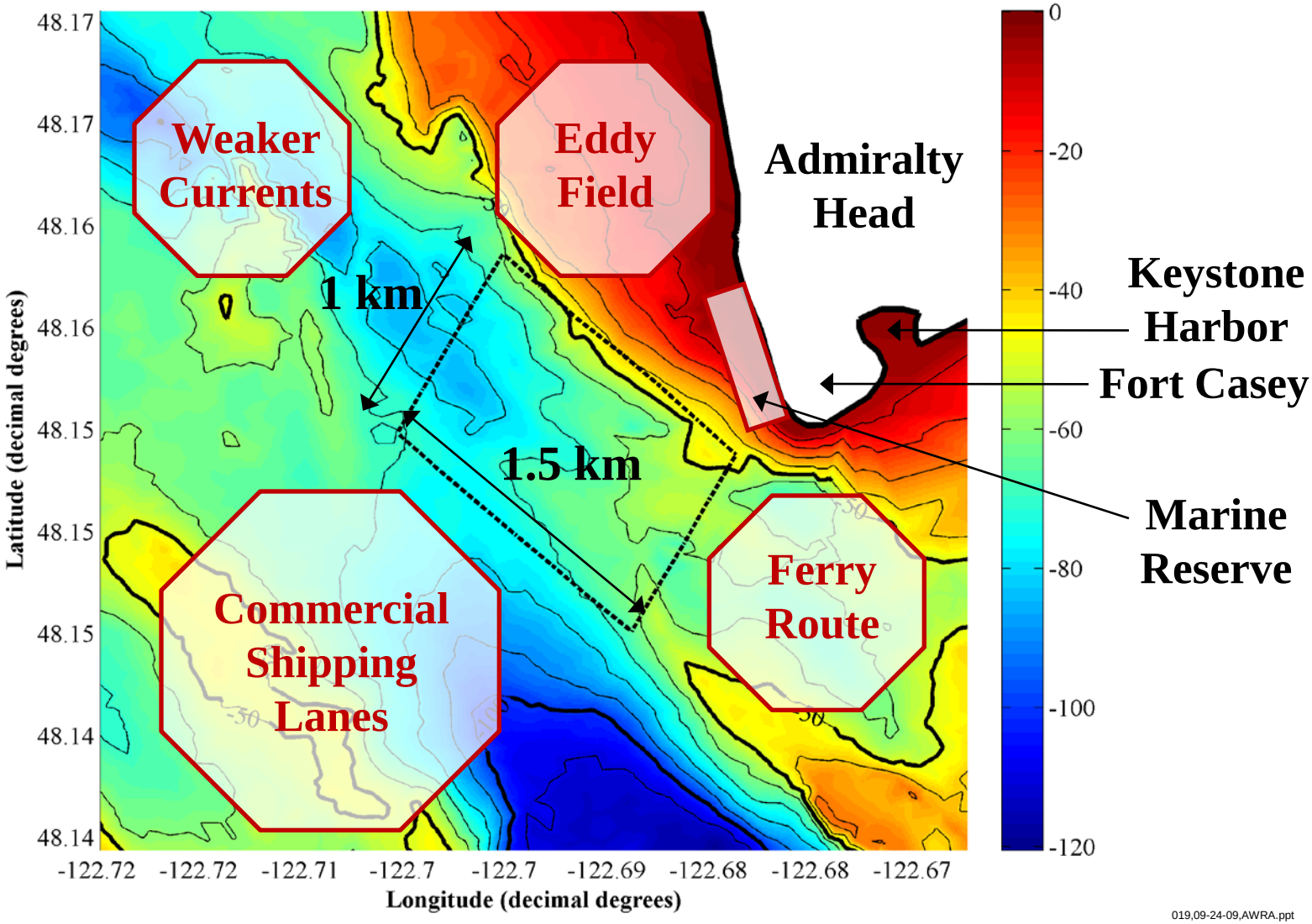
openhydro
tidal technology



Device Siting



Device Siting



019,09-24-09,AWRA.ppt

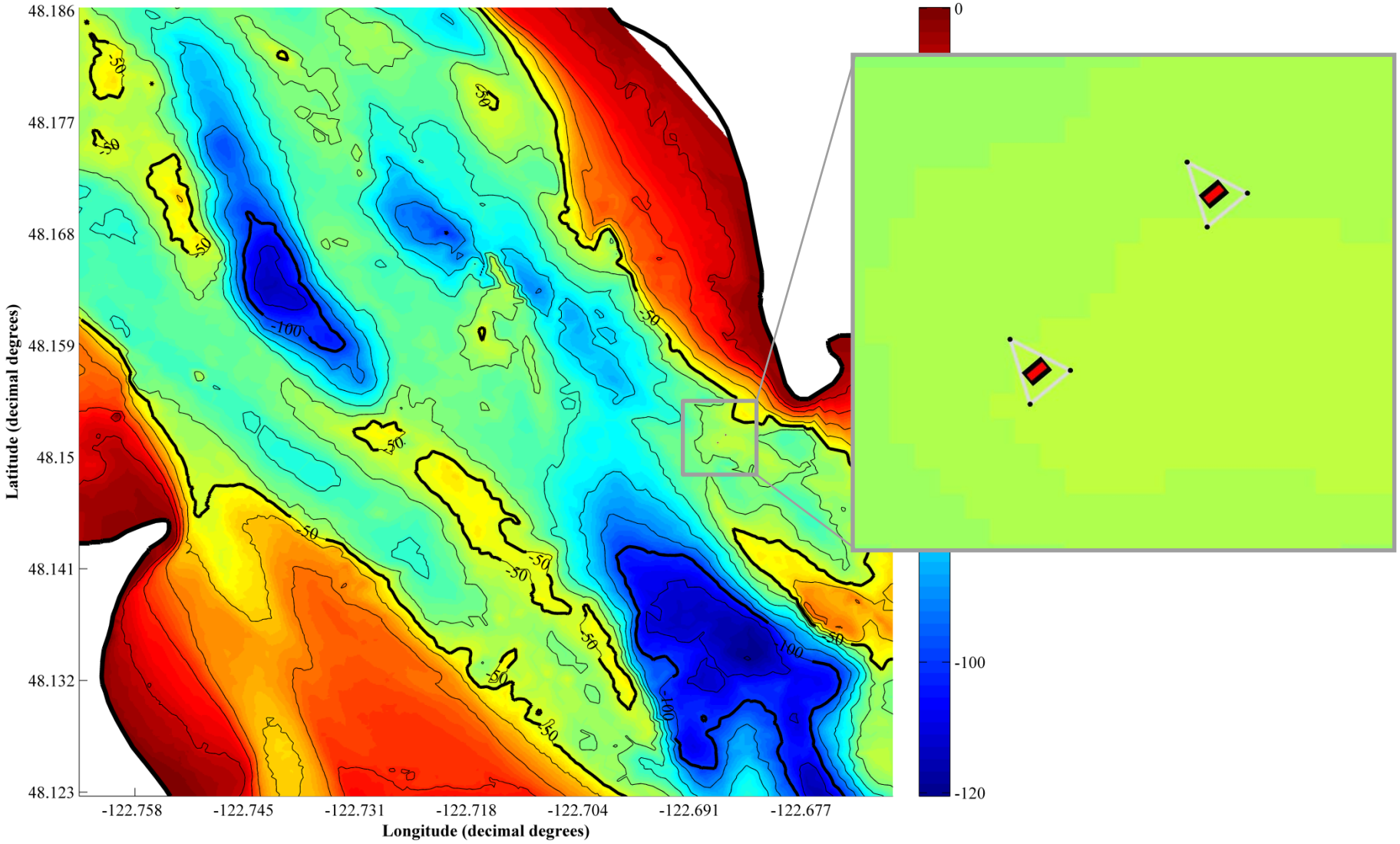
Environmental Considerations

- **Effects on aquatic species**
  - Avoidance
  - Aggregation
  - Strike

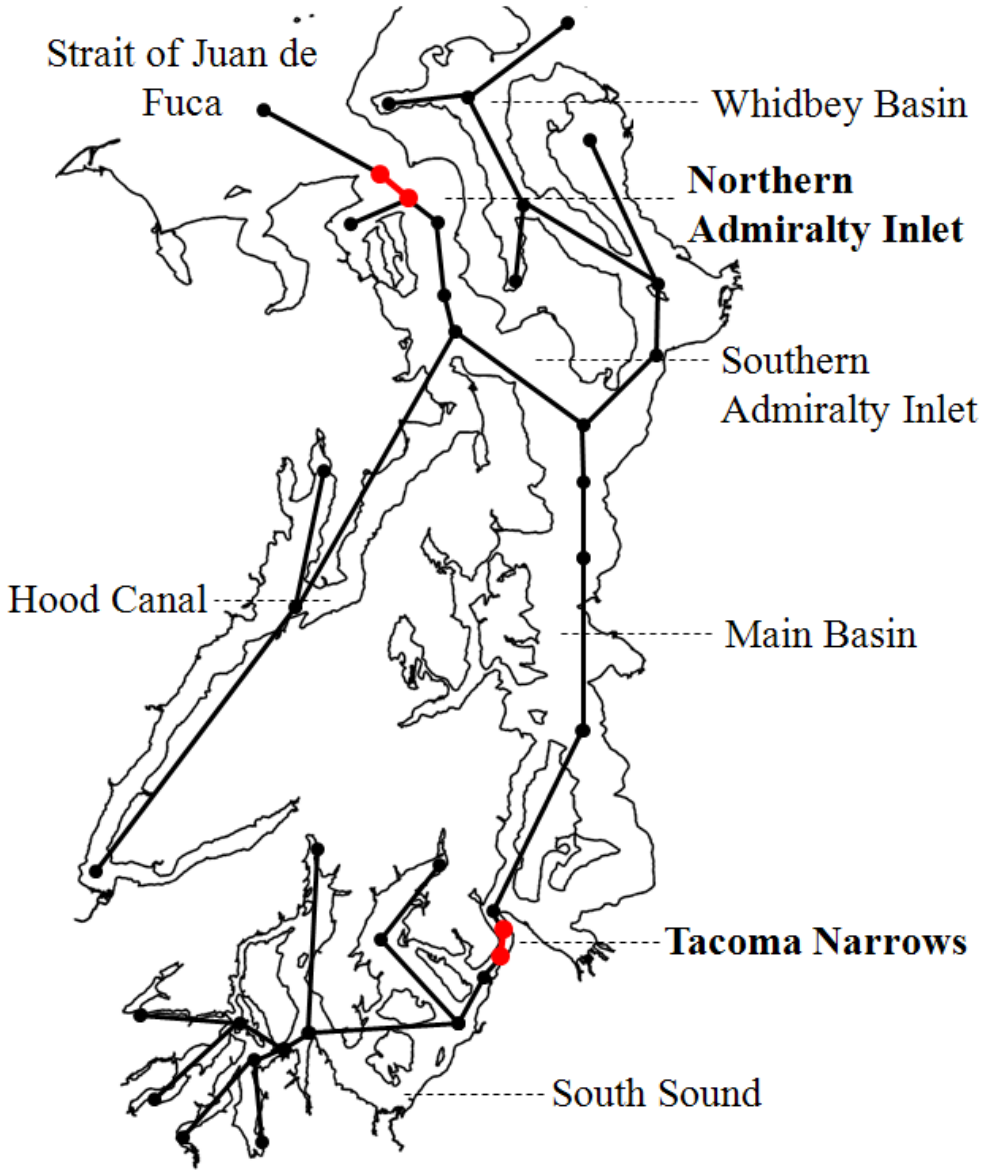
- **Far-field environment**
  - Circulation
  - Nearshore environment
  - Water quality

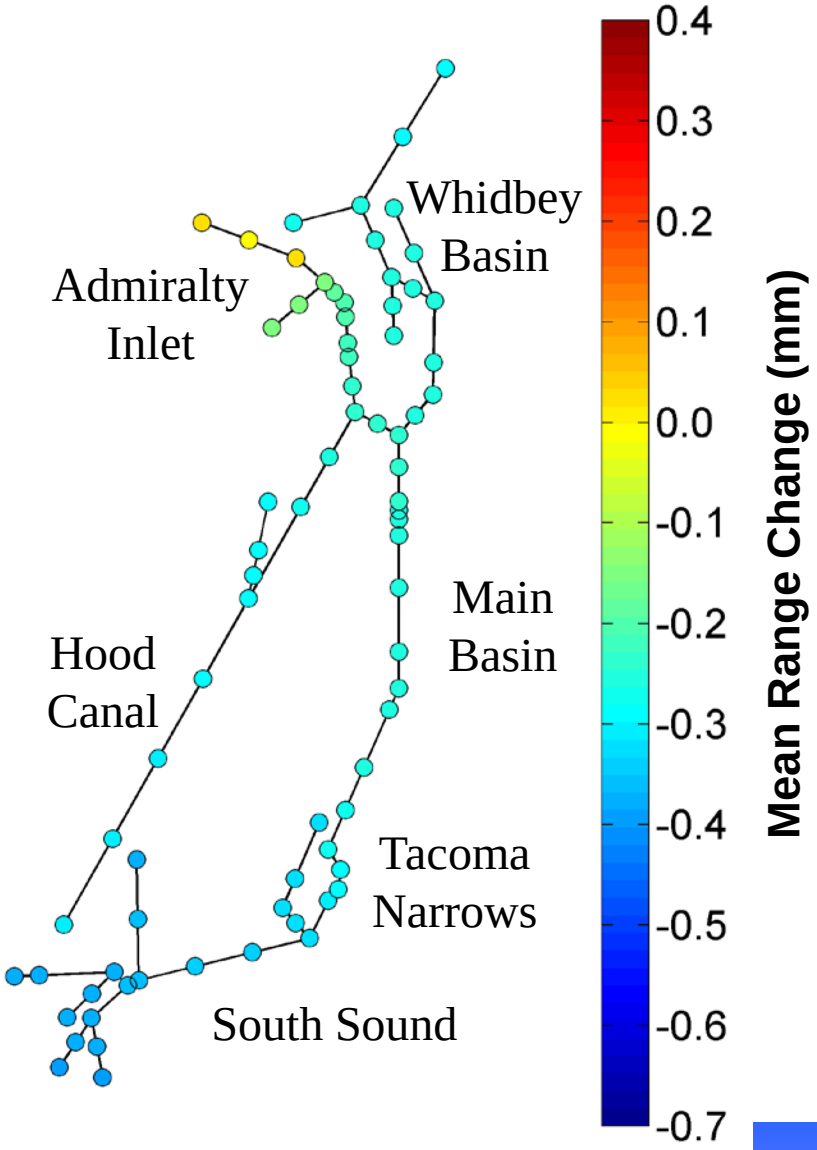
- **Near-field environment**
  - Noise (device, vessels)
  - Wake (sediment transport)
  - Hard substrate (artificial reef)
  - EMF
  - Toxicity (coatings, lubricants)

Relative Scale



Far-field Effects at Pilot Scale (0.5 MW)





Physical and Biological Site Characterization

- **Velocity**
- **Background noise**
- **Seabed characteristics**
- **Water quality**
- **Aquatic species presence and use**

Site Developer
(SnoPUD)

Device Mfg.
(OpenHydro)

Resource Agencies

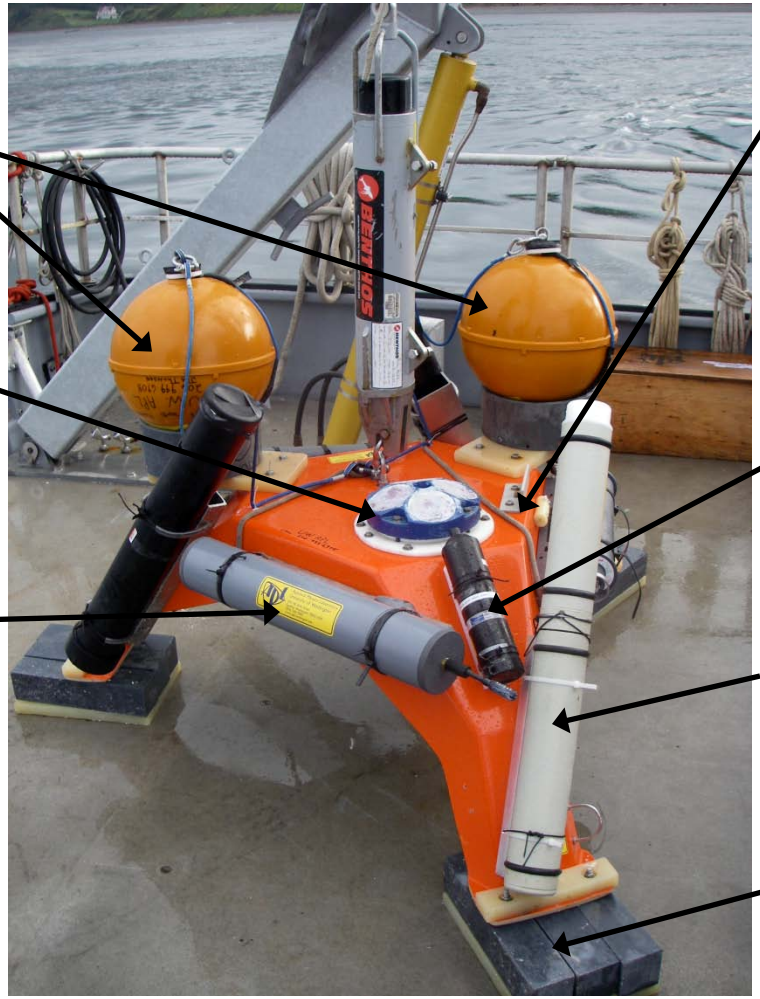
Instrumentation Package

Acoustic release
(redundant recovery)

ADCP
(Acoustic Doppler current profiler)

Hydrophone
(background noise)

Programmed for 3 month deployments



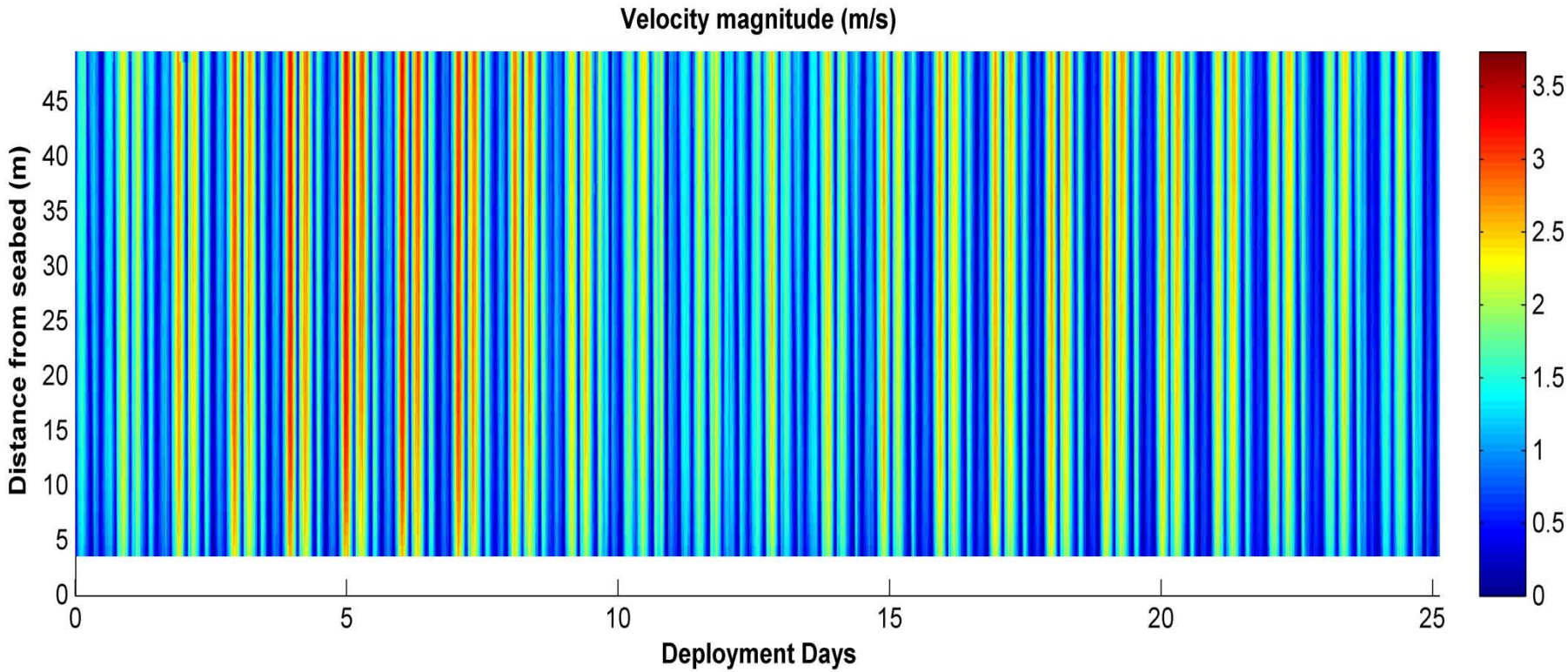
CTDO (conductivity, temperature, depth, dissolved oxygen – partnership with WA Dept of Ecology)

VEMCO recorder
(tagged fish species – partnership with NMFS)

T-POD recorder
(porpoise clicks)

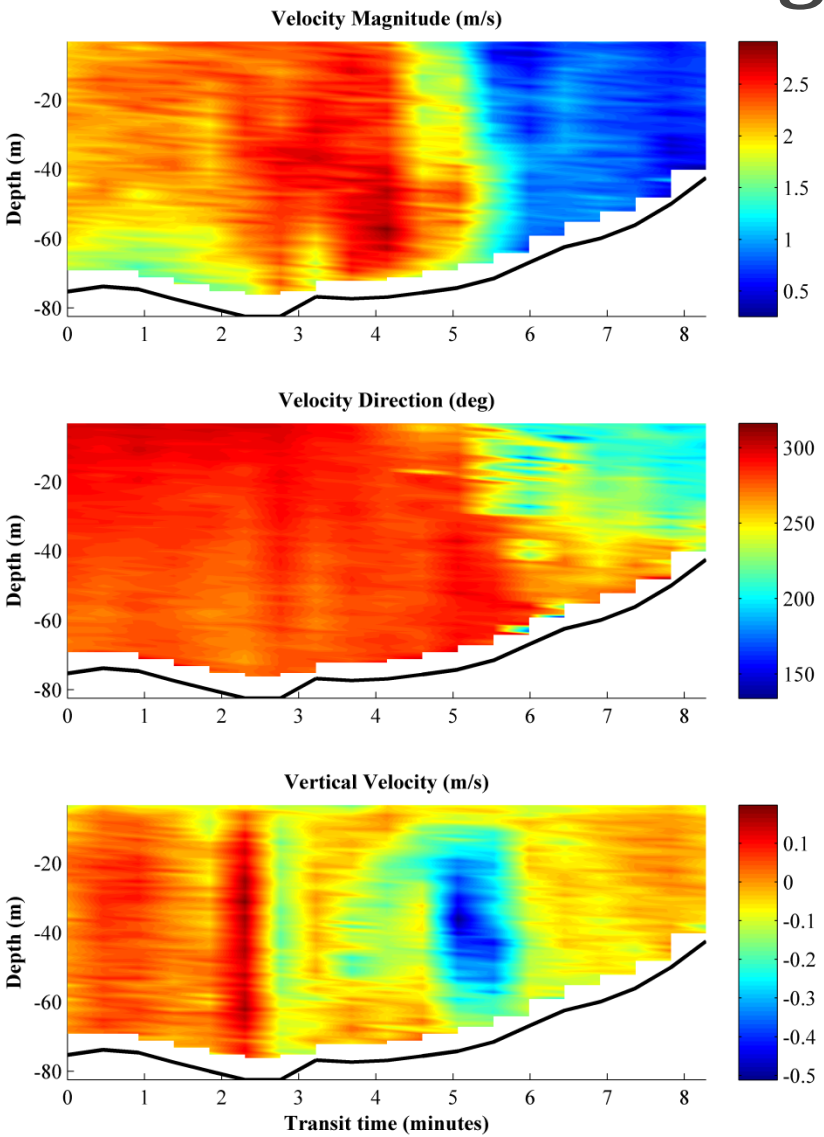
Lead Weight
(600 lbs)

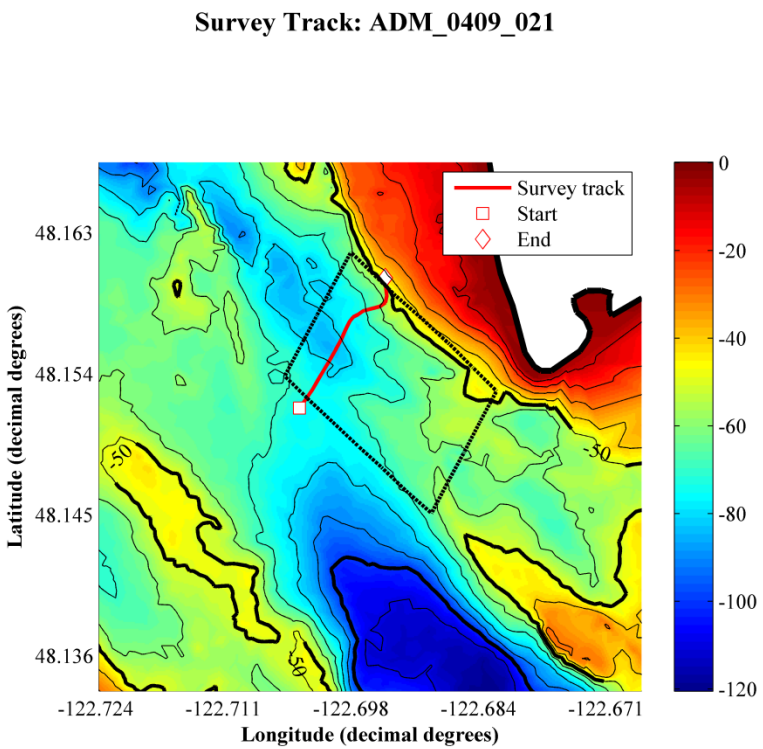
Findings: Current Velocity



Velocity > 1m/s generally required to produce power

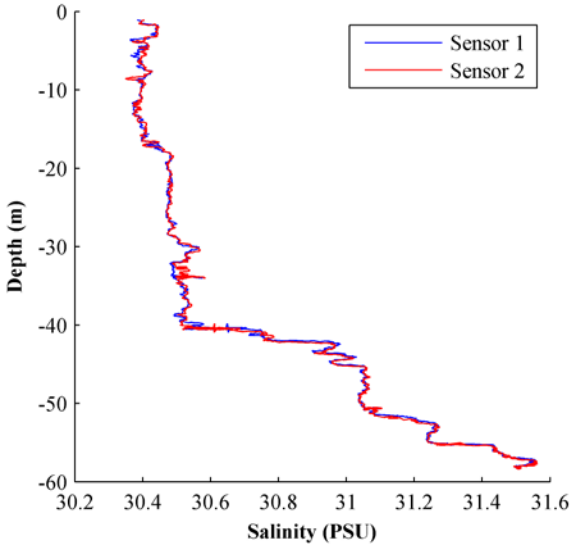
Findings: Velocity



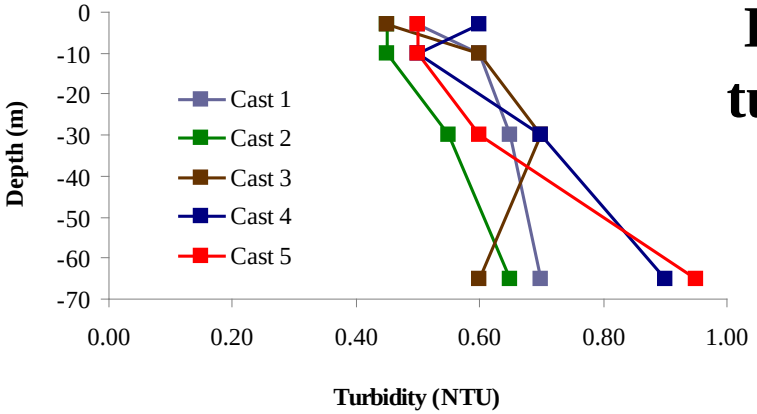


Survey Start: 07-Apr-2009 07:03:20

Findings: Water Quality

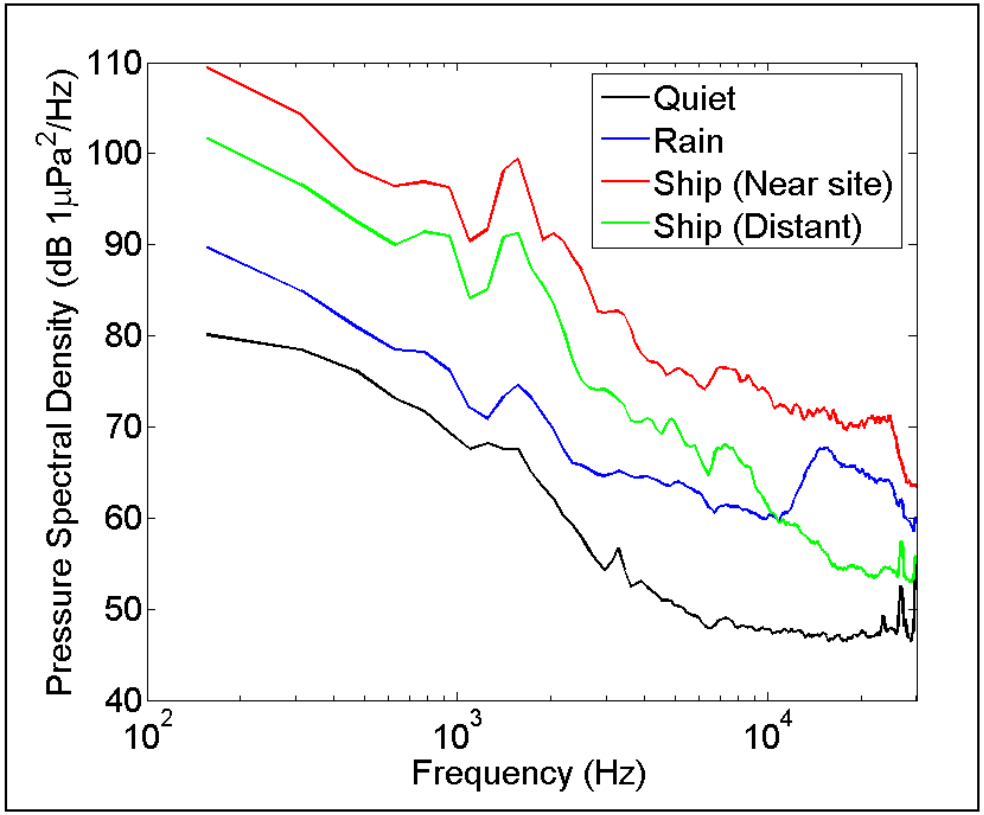


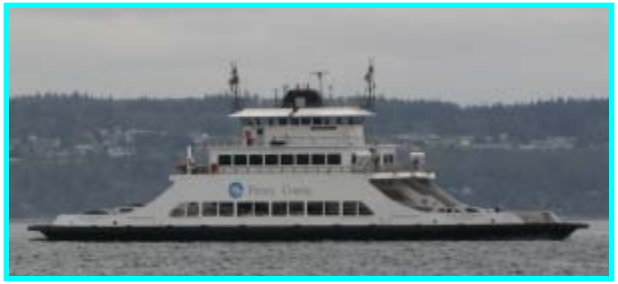
***In-situ* measurements show slight halocline and thermocline (*for this cast*)**



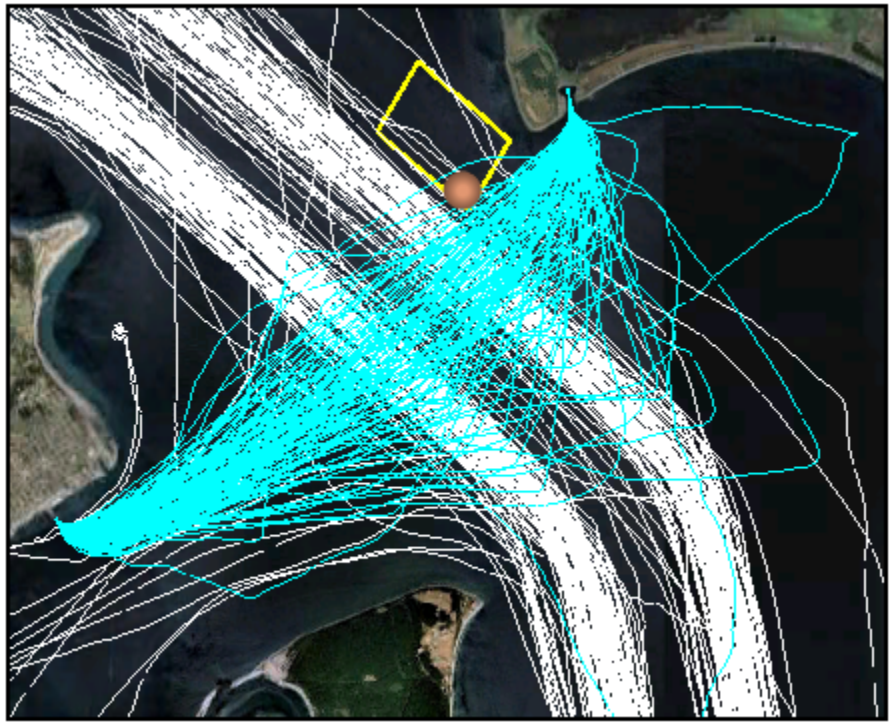
Lab results indicate low turbidity (*for this season*) (WHO drinking water guidelines: < 1 NTU)

Findings: Noise



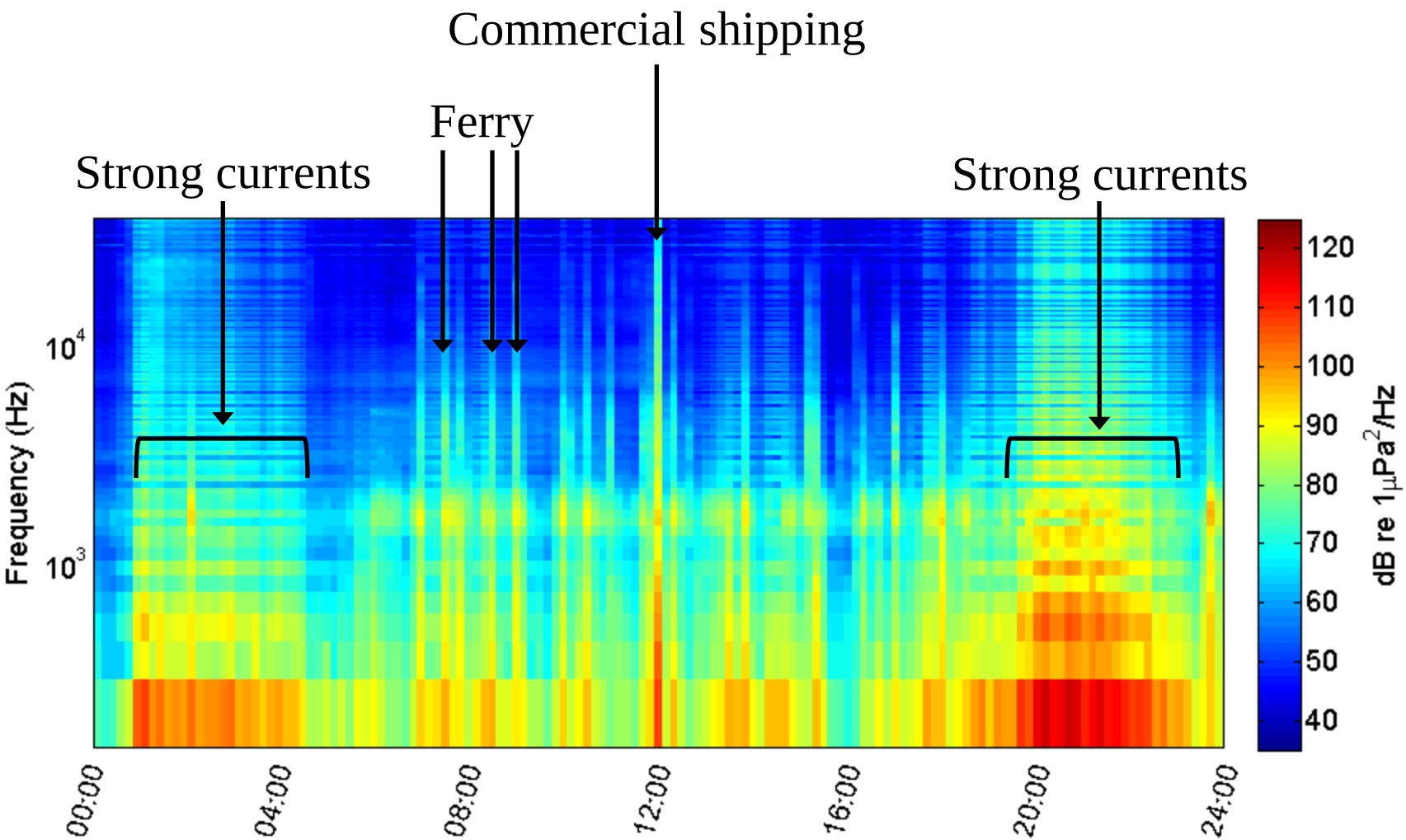


Passenger and Car Ferry



Container Ships

Findings: Noise



Questions?

http://depts.washington.edu/nnmrec