



# **Harnessing the Tides: Siting and monitoring a new technology**

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***Applied Physics Lab and Civil & Environmental Engineering  
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The Water Center – 16 Feb 2010

**Oregon State**  
UNIVERSITY

**OSU**

Northwest National Marine Renewable Energy Center



UNIVERSITY OF  
WASHINGTON

# Approaches to Tidal Energy

## Barrage



- Comparable to hydroelectric
- Very high cost and environmental footprint

## Hydrokinetic

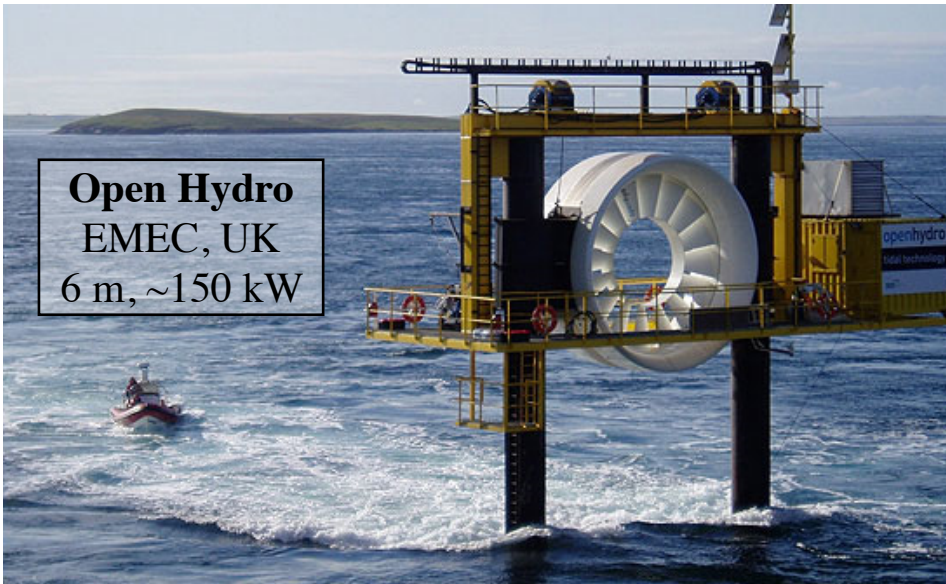


- Comparable to wind
- Potentially lower cost and environmental footprint

# Hydrokinetic Devices



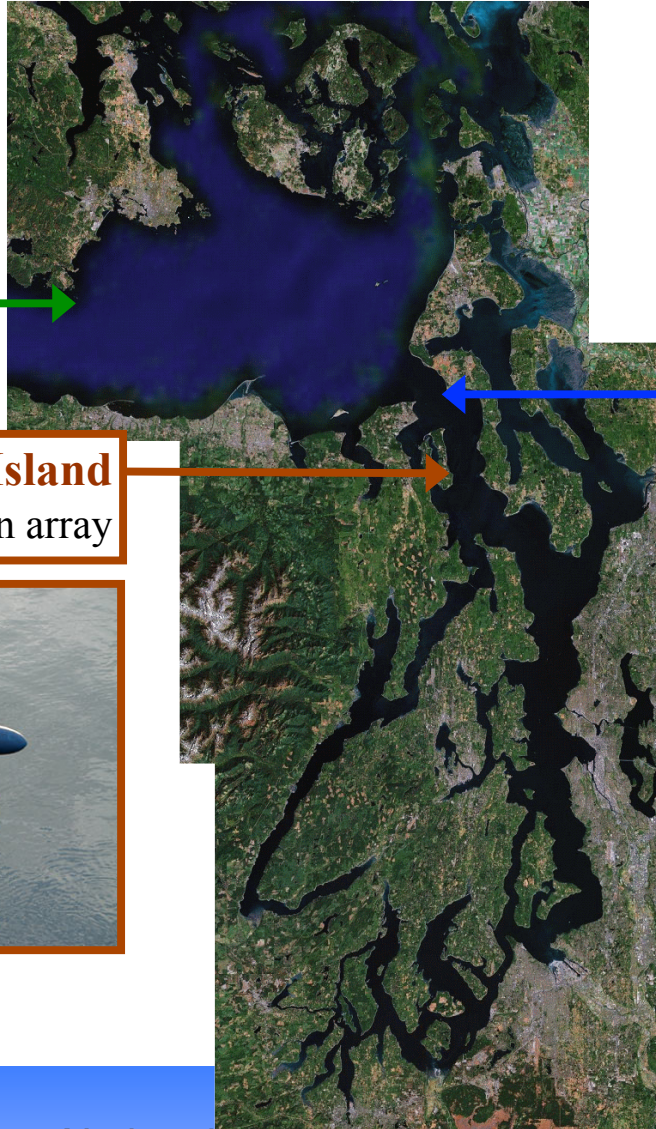
- **No dominant design**
  - Hundreds of concepts
  - Dozens of lab tests
  - Several field tests
- **No commercial projects**



# Tidal Energy Projects in Puget Sound



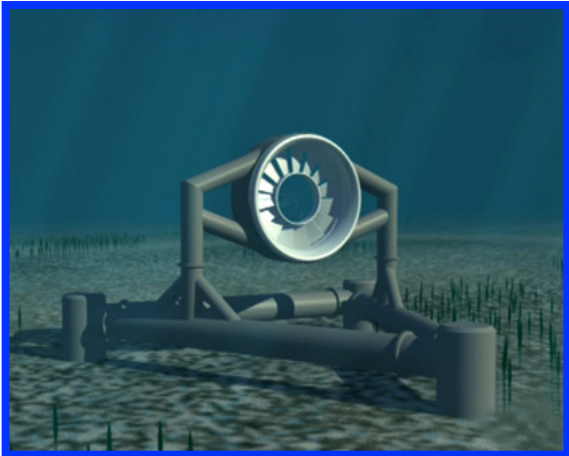
**Race Rocks**  
Demonstration turbine



~100-200 avg. MW  
practically recoverable

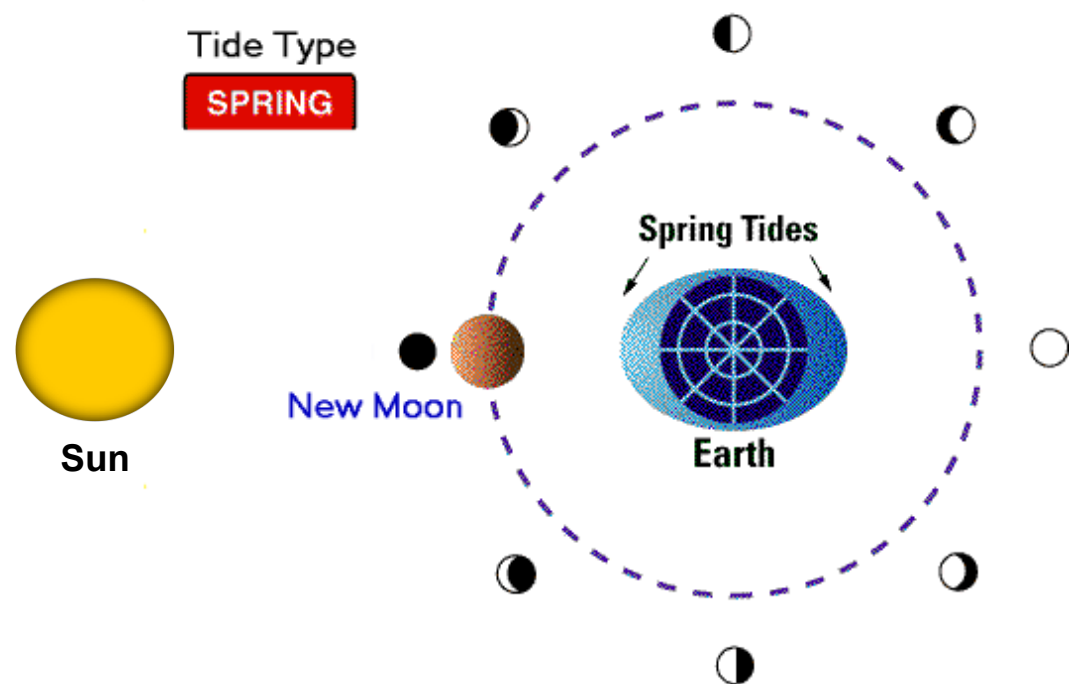
**Admiralty Inlet**  
Proposed pilot project  
10m diameter, ~500 kW rated

**Marrowstone Island**  
Proposed demonstration array



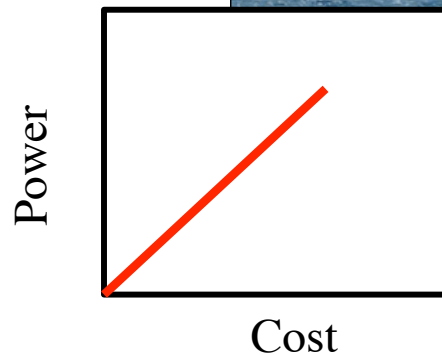
# Motivation

- I-937 obligations
- Limited transmission capacity for new wind
- Tidal energy advantages
  - **Predictable resource**
  - No CO<sub>2</sub> emissions
  - No visual impact
  - Close to load centers








# Considerations

- Existing use (fishing, shipping)
- Potential environmental effects (noise production)
- Cost (difficult environment)



# Northwest National Marine Energy Center

- **Oregon State University** 
  - Headquarters and Director (Bob Paasch)
  - Focus on **Wave Energy**
  - College of Engineering, Oceanography, Hatfield Marine Sciences Center
- **University of Washington** 
  - Co-Director (Phil Malte)
  - Focus on **Tidal Energy**
  - Mechanical Engineering, Oceanography, Applied Physics Lab
- **Partners**      
  - NREL, Snohomish PUD, BioSonics, Sound & Sea Technology, EPRI, Verdant Power, PNWER

# Northwest National Marine Energy Center

## UW Focus areas (tidal):

1. Environmental Effects
- 2. Site Characterization and Instrumentation**
3. Array Optimization
4. Materials (Survivability and Reliability)

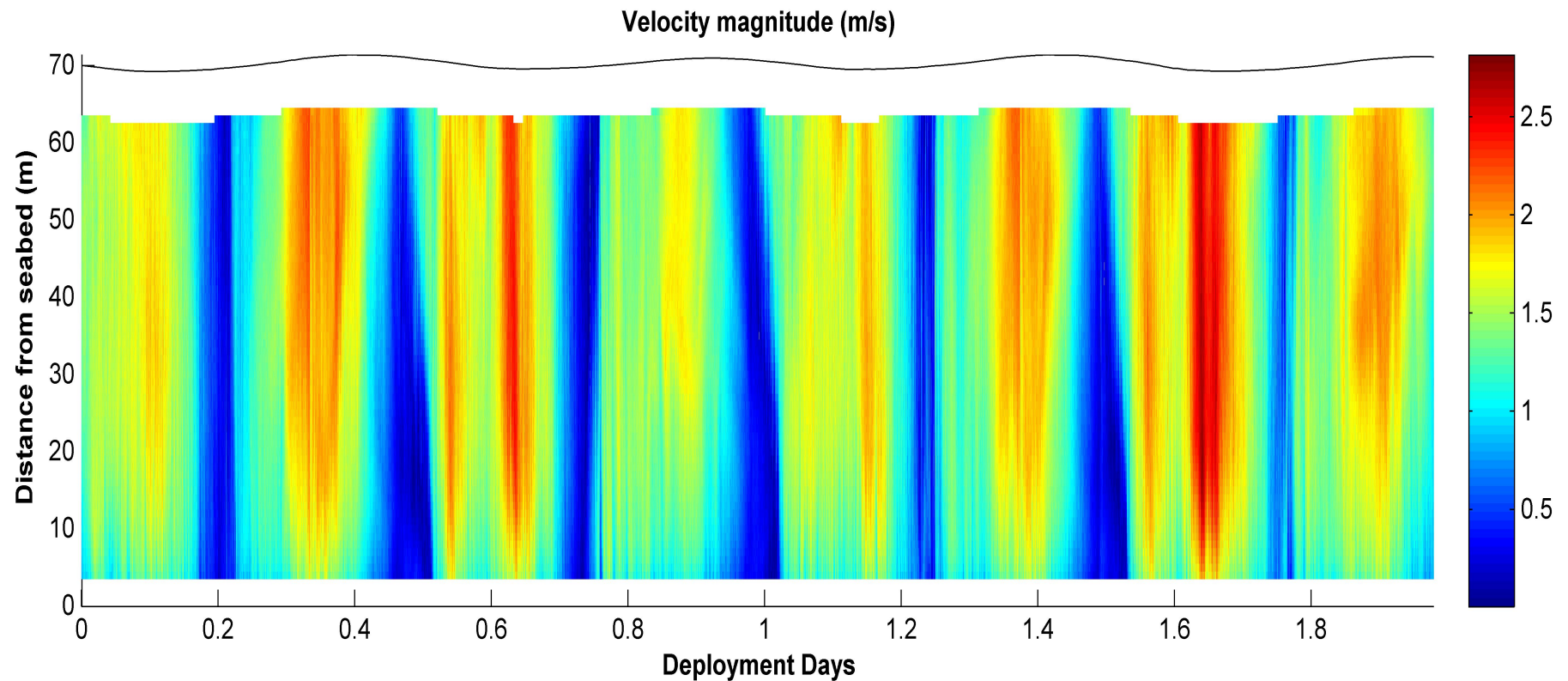


Faculty: Thomson (APL/CEE) & Polagye (ME)  
MS students: Chris Bassett, Jeff Epler, Sam Gooch  
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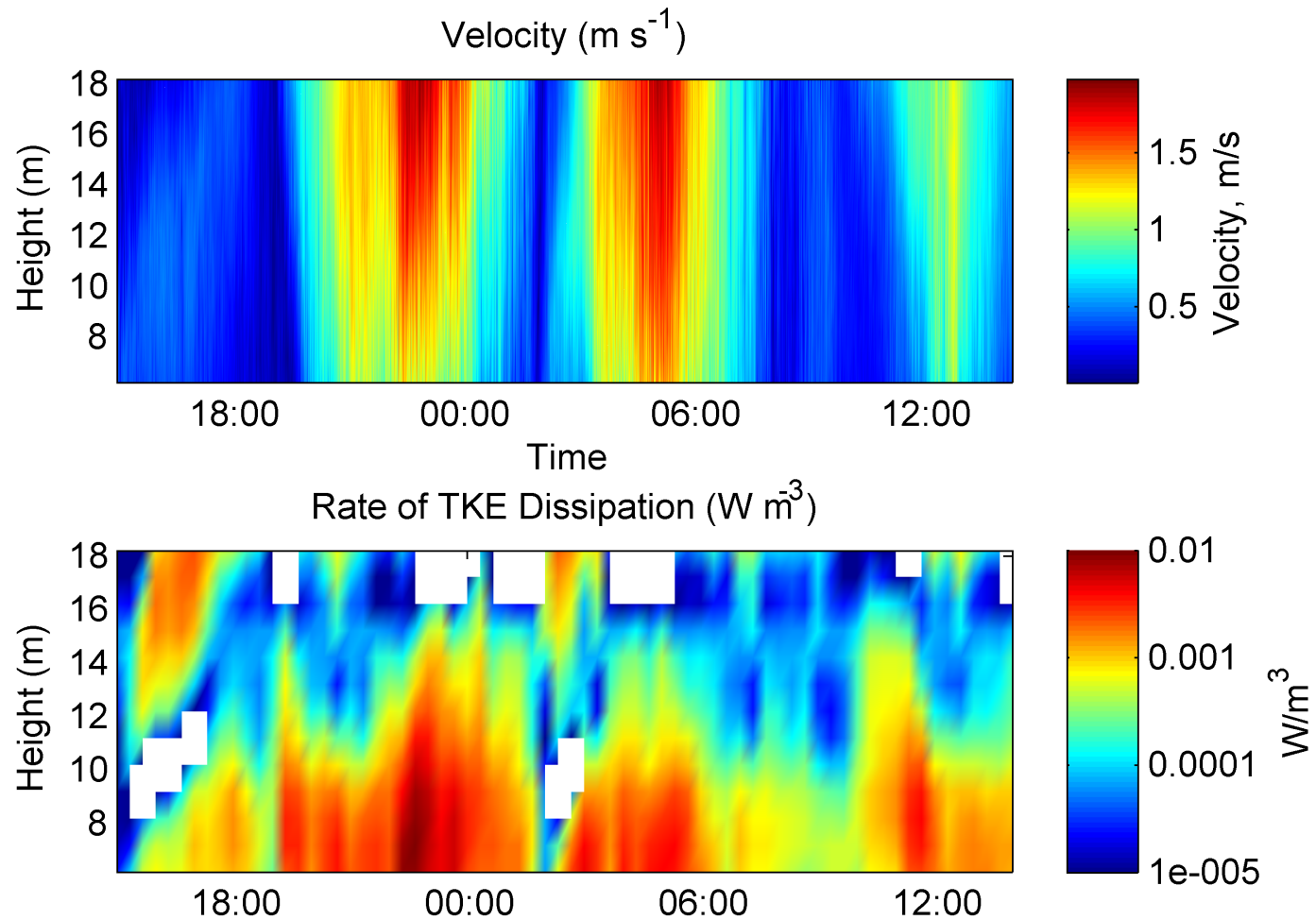
# Velocity Time Series

Admiralty Inlet, April 2009



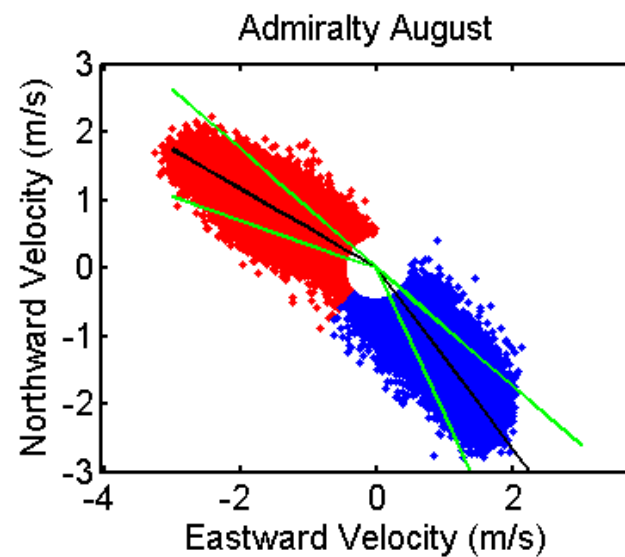
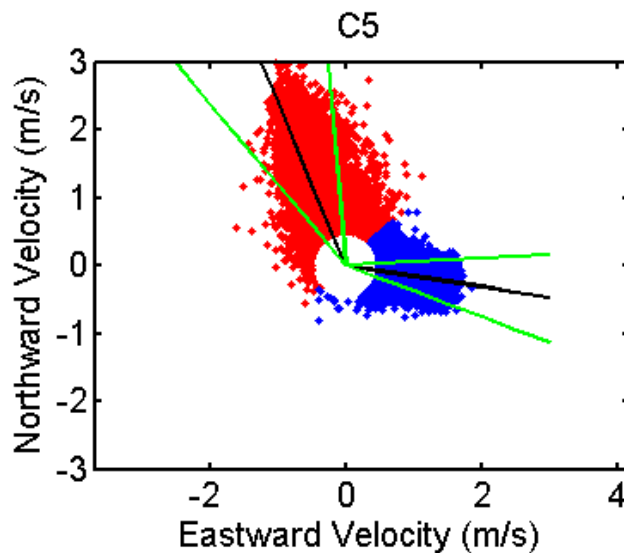
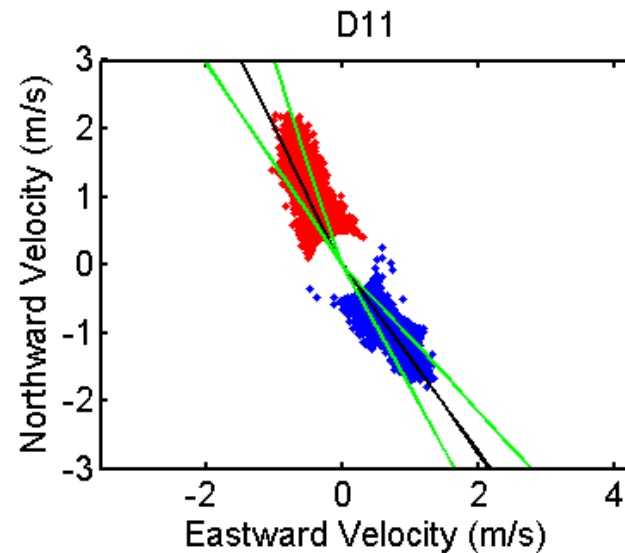
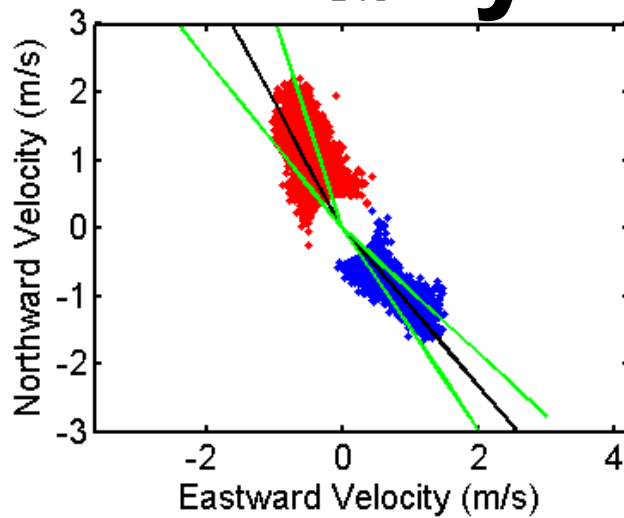
Power density is cube of velocity,  $P = \frac{1}{2} \rho v^3$

# Turbulence



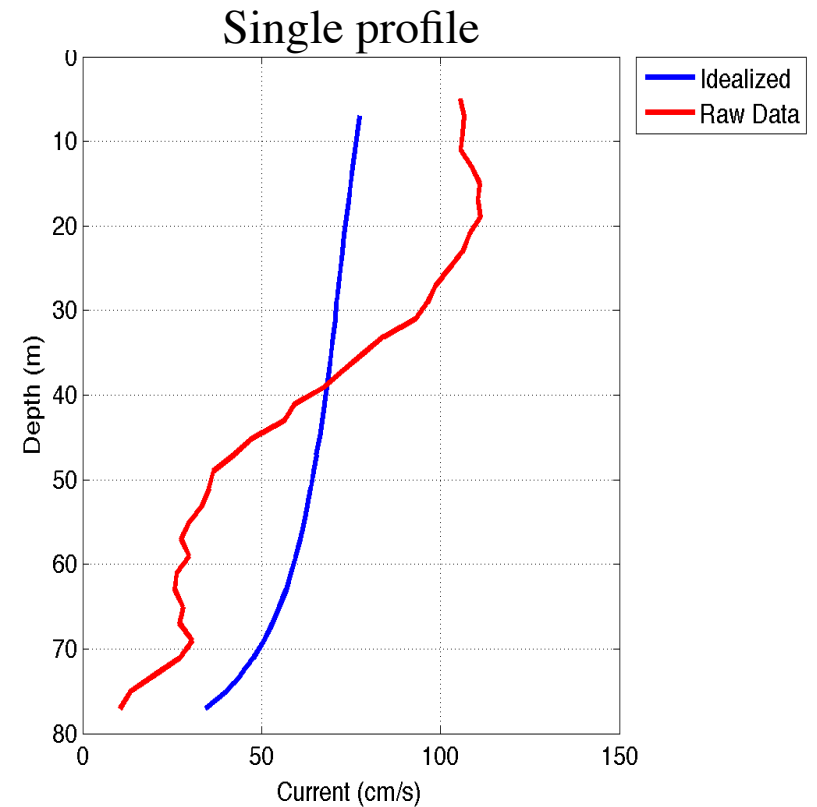
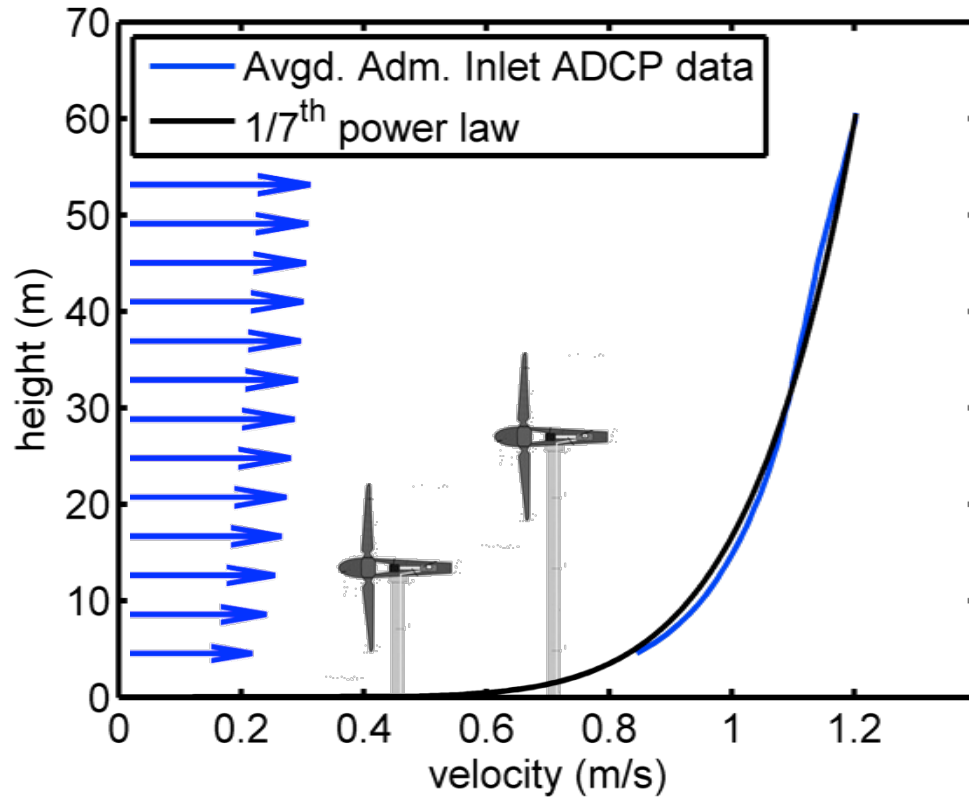
Gooch et al, 2009

# Directionality



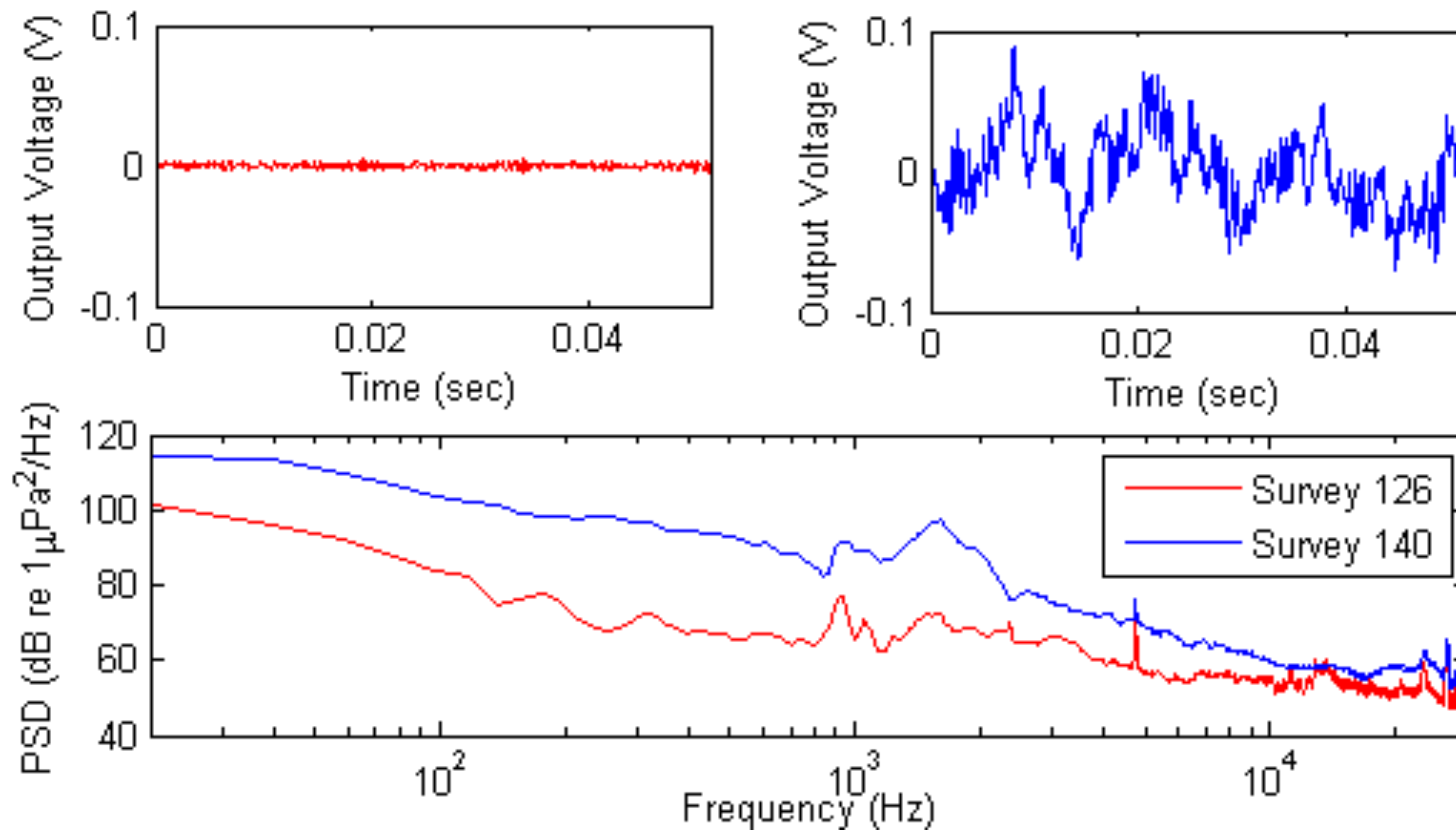
Gooch et al, 2009

# Boundary Layer Effects $V = V_0 \left(\frac{z}{d}\right)^{\frac{1}{\alpha}}$



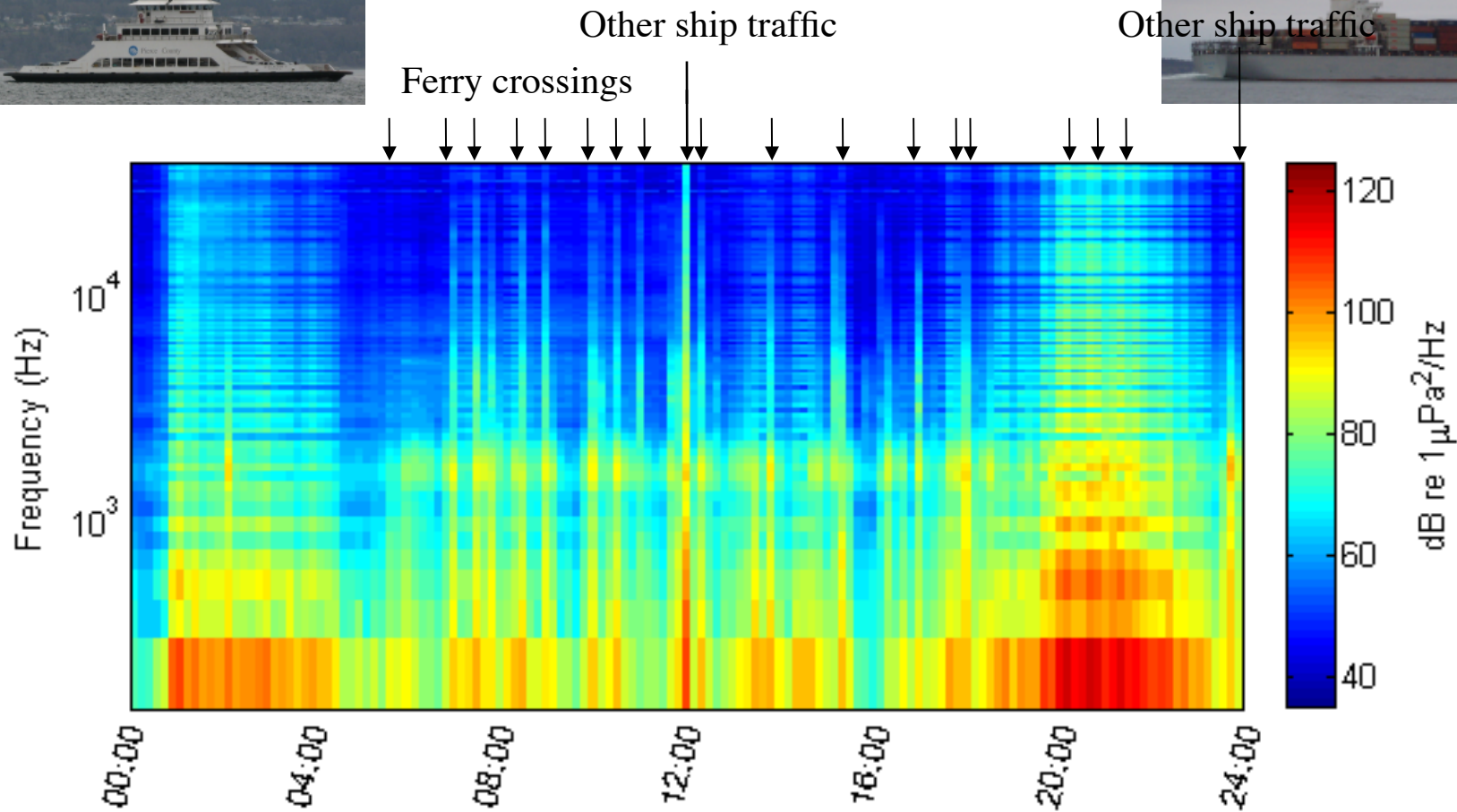
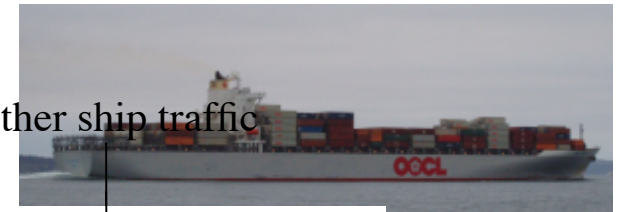
Gooch et al, 2009

# Underwater Noise: spectra



Bassett, in progress

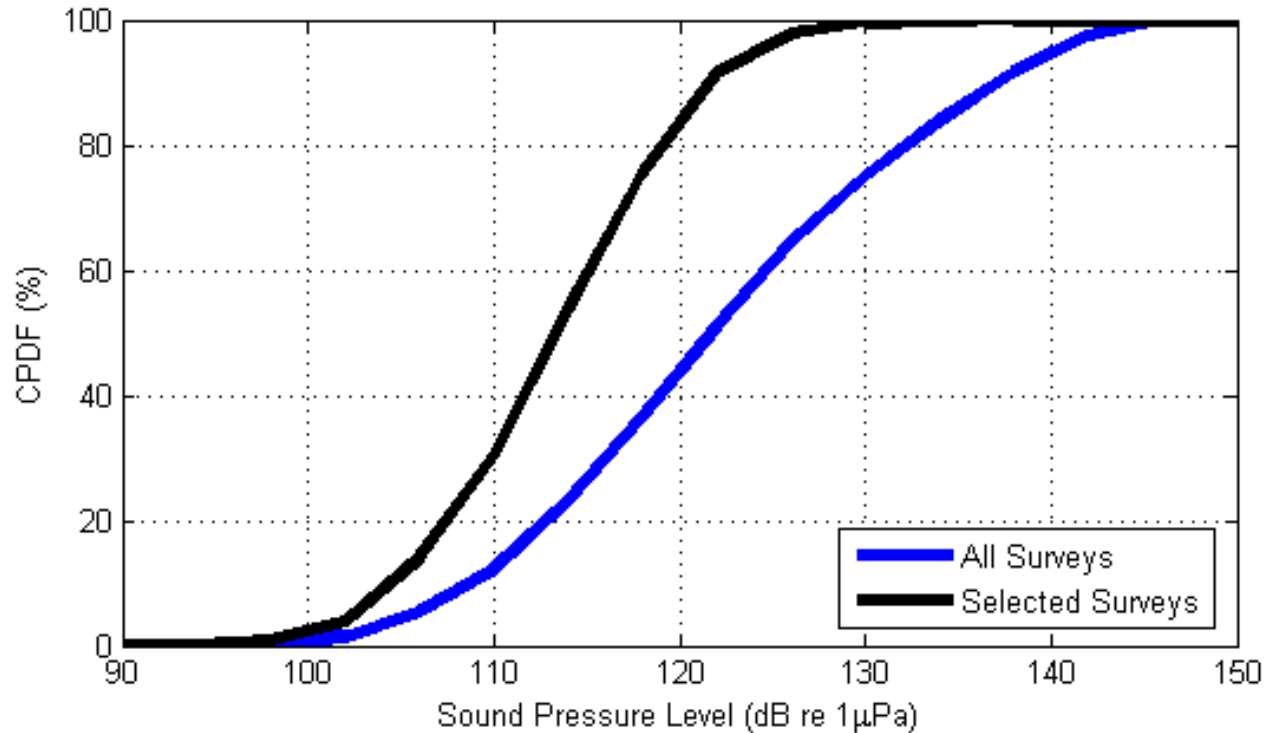
# Underwater Noise: sources



June 15th, 2009 Spectrogram

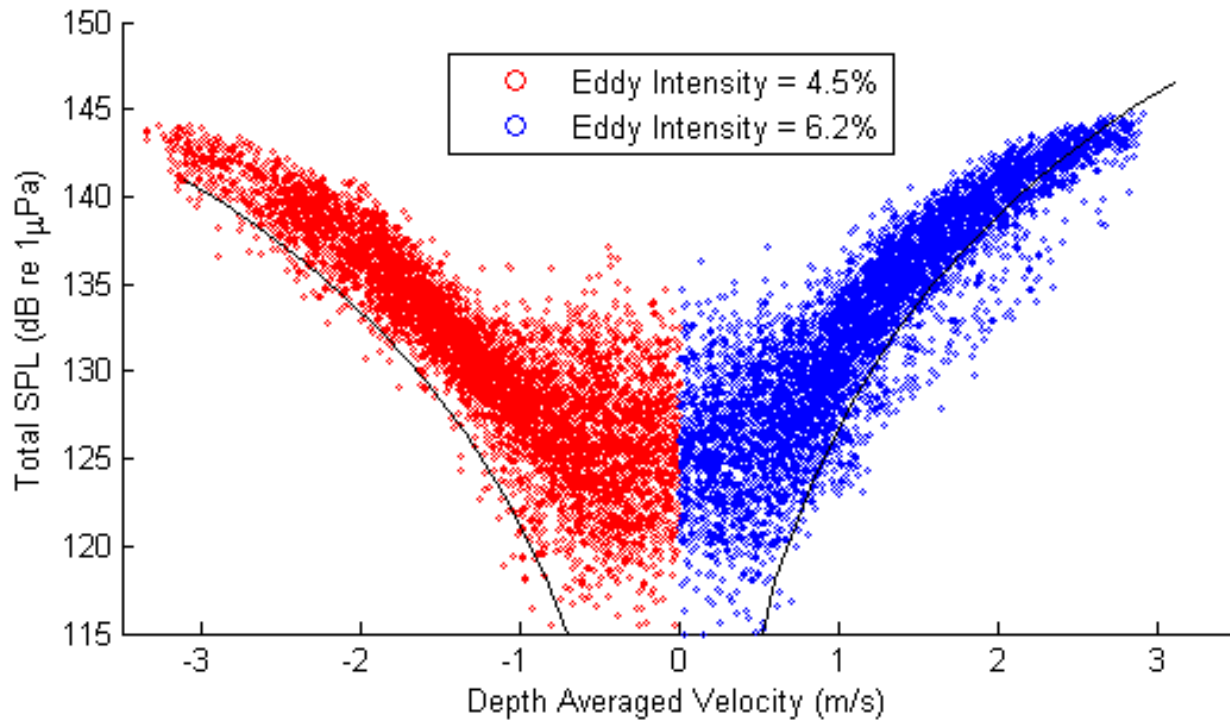
Bassett, in progress

# Underwater noise – cumulative



Bassett, in progress

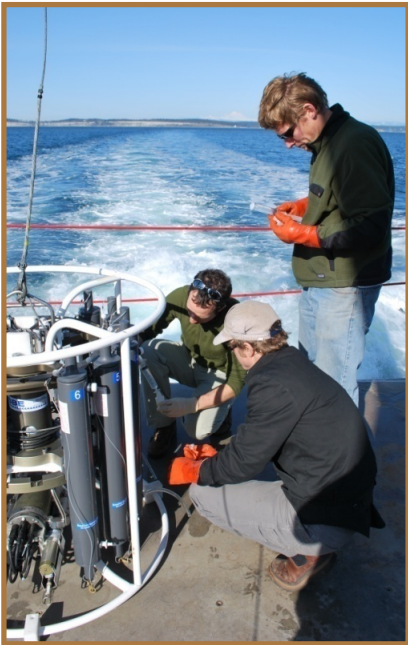
# Underwater *pseudo*-noise: pressure fluctuations at hydrophone



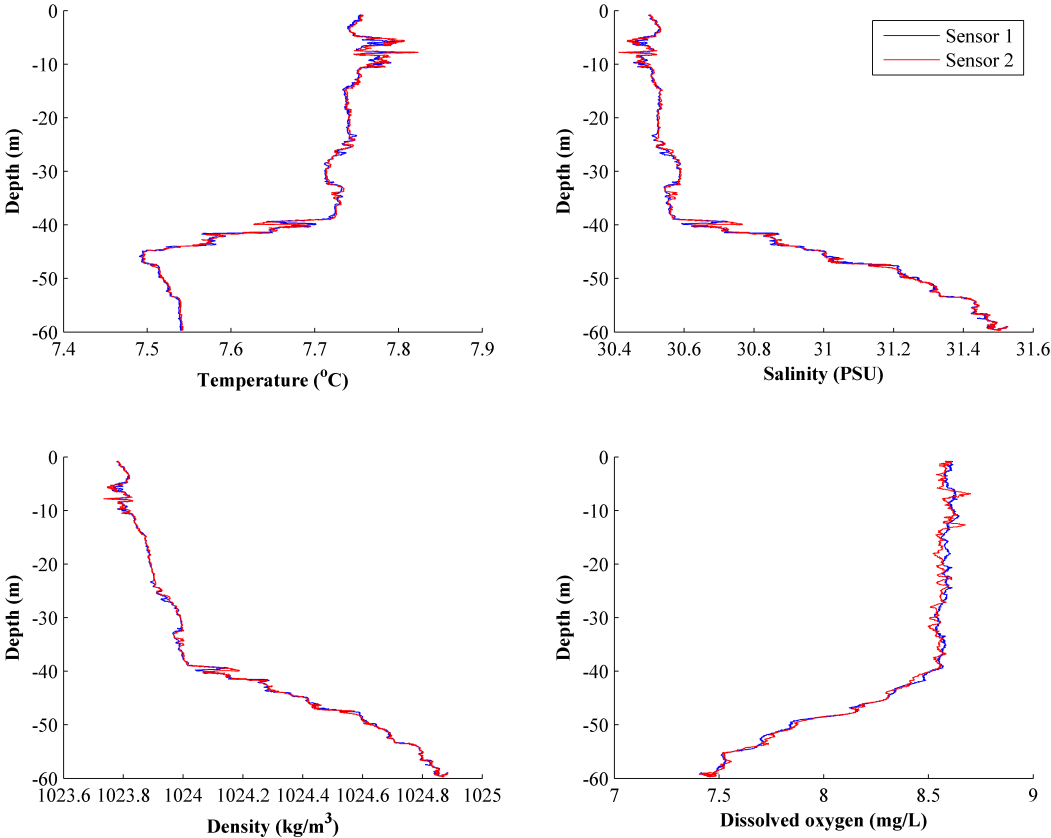
Bassett, in progress



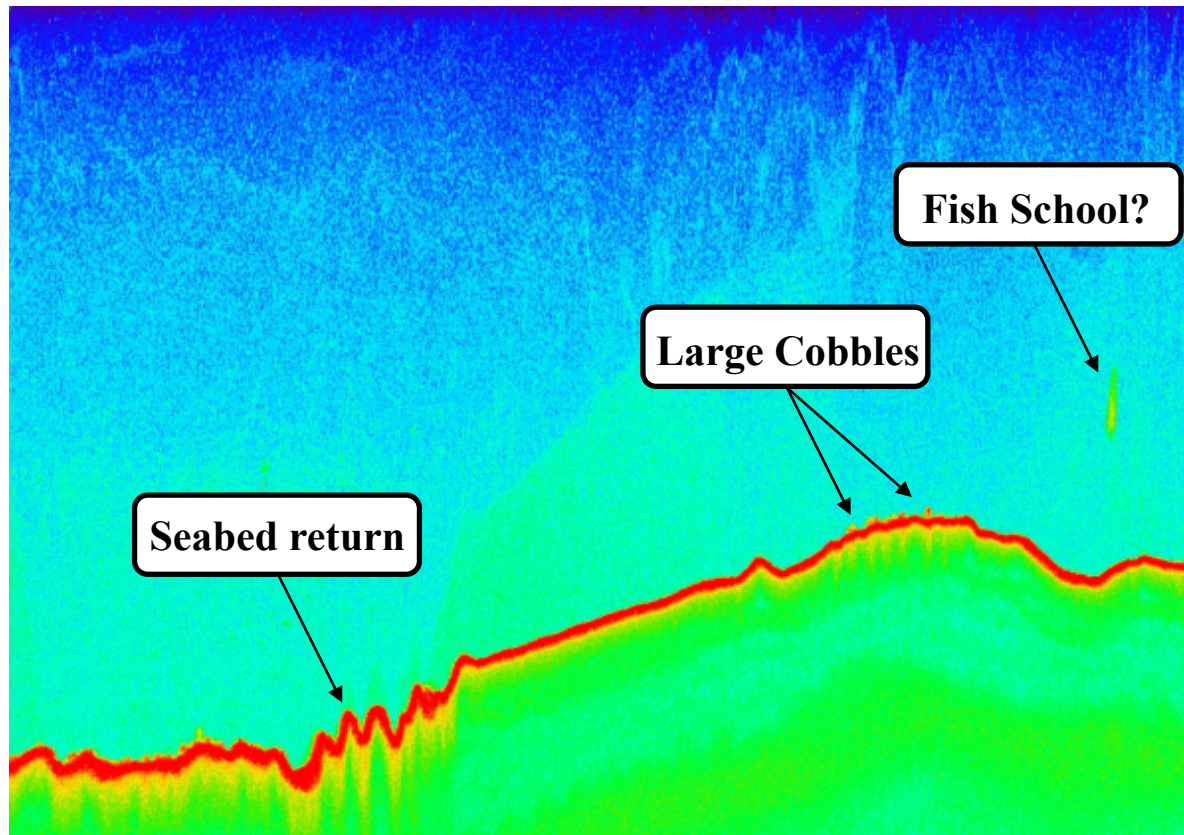
# Water quality: salinity, temperature, turbidity, oxygen, fluorescence, pH



April 7, 2009: CTD Cast #2 (downcast)



# Fish abundance

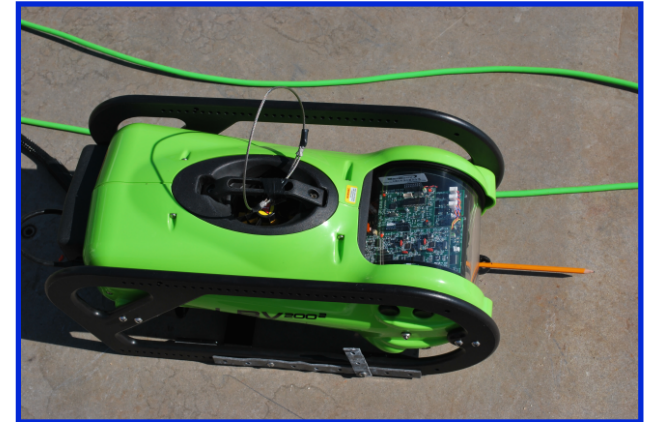


- BioSonics echosounder (Center partner)
- Significant cross-talk between echosounder, ADCP, and depth finder

# Bottom characterization



- Scoured seabed
- Relatively flat
- Cobbles and gravel
- Sponges
- Barnacles
  
- Consistent with high currents and grab samples



D

V5 083HD+0 CA+05 06APR09  
H5 GR 0000.1MS 11C 10:13:58

# Northwest National Marine Energy Center

## UW Focus areas (tidal):

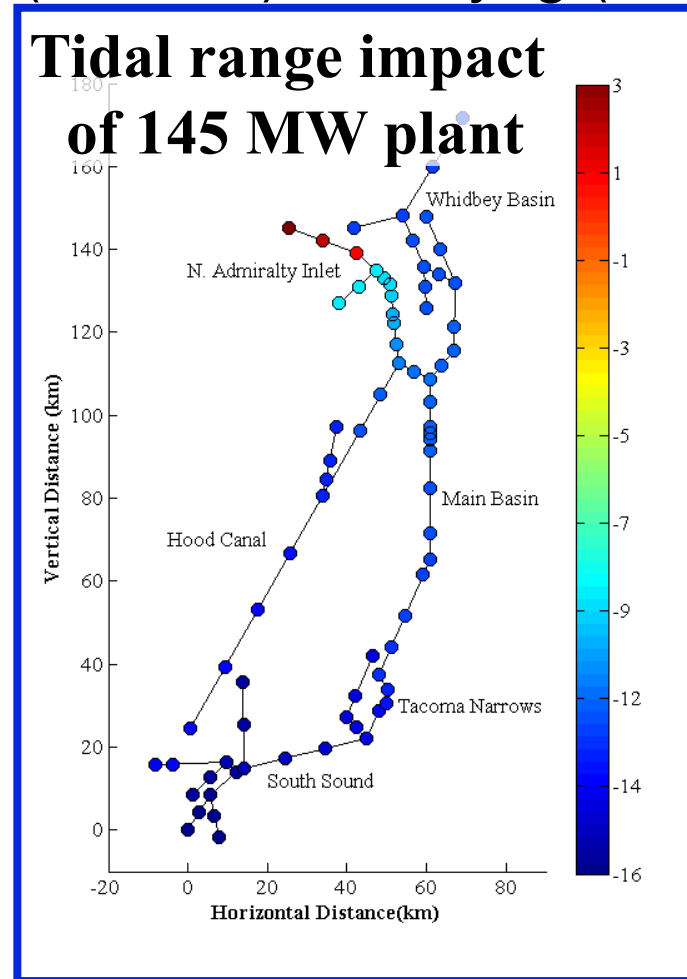
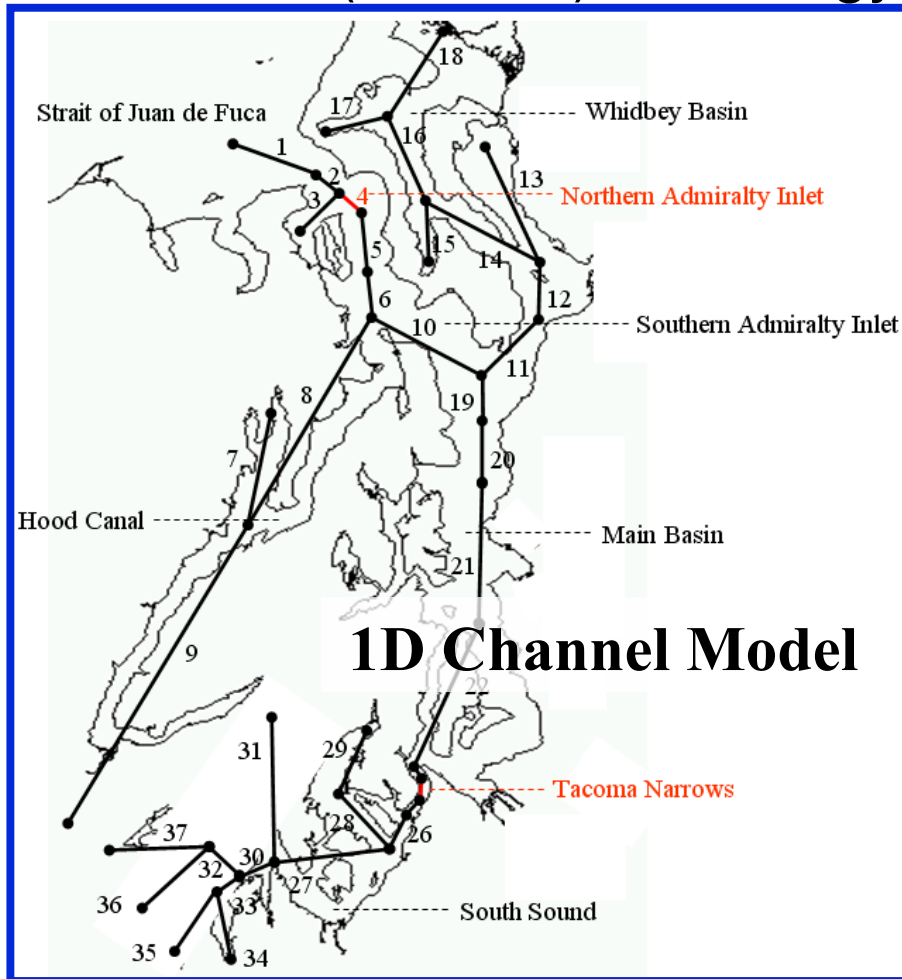
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# Area 1: Environmental Effects – tidal range

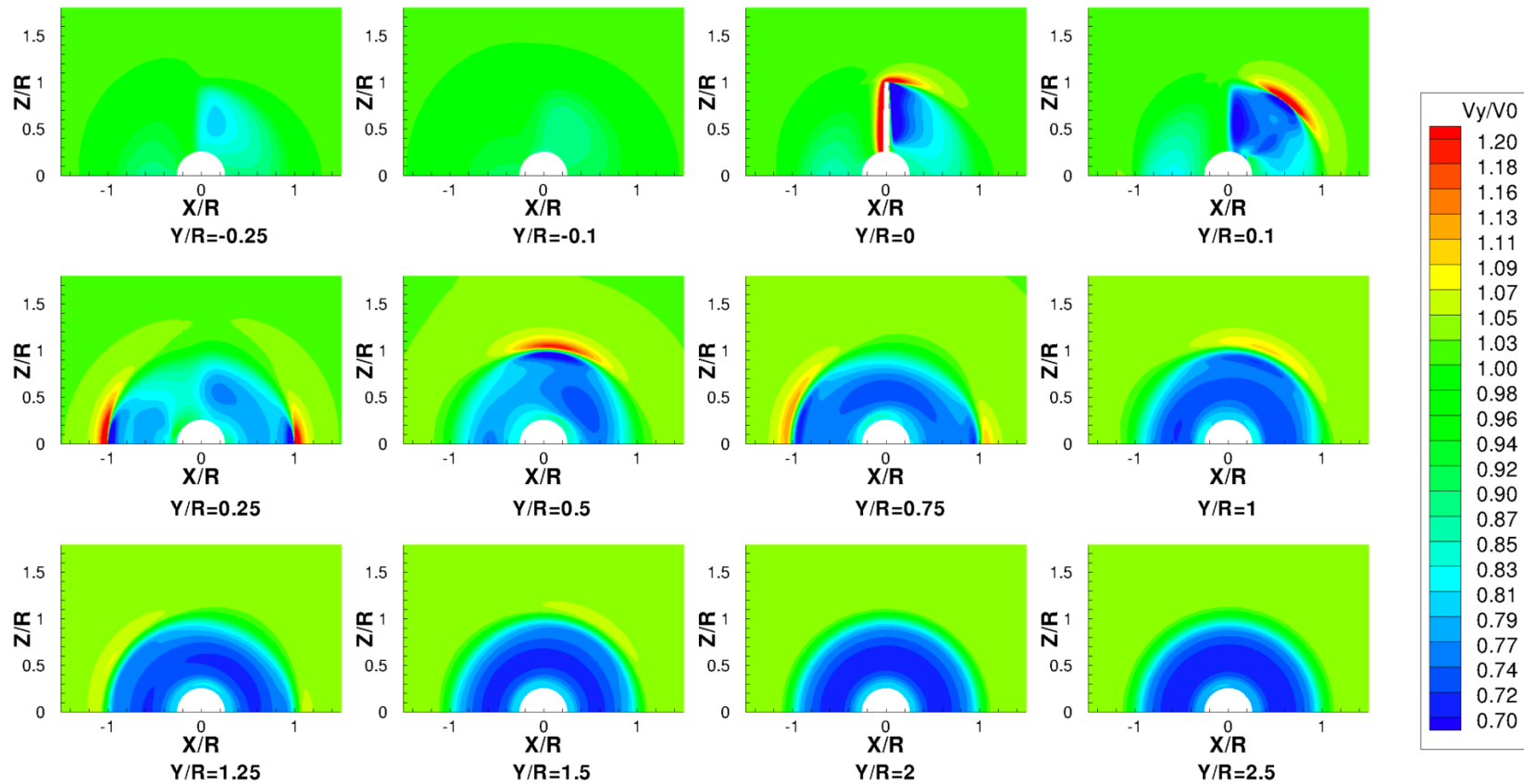
M. Kawase (UW-SO), B. Polagye (UW-ME), K. Thyng (UW-ME)



# Area 3: Array Optimization

Profs. Aliseda (ME) & Riley (ME), MS student Teymour Javaherchi

## Single reference frame (SRF) simulations



# Area 4: Survivability and Reliability

M. Tuttle (ME), B. Polagye (ME)

**Before**



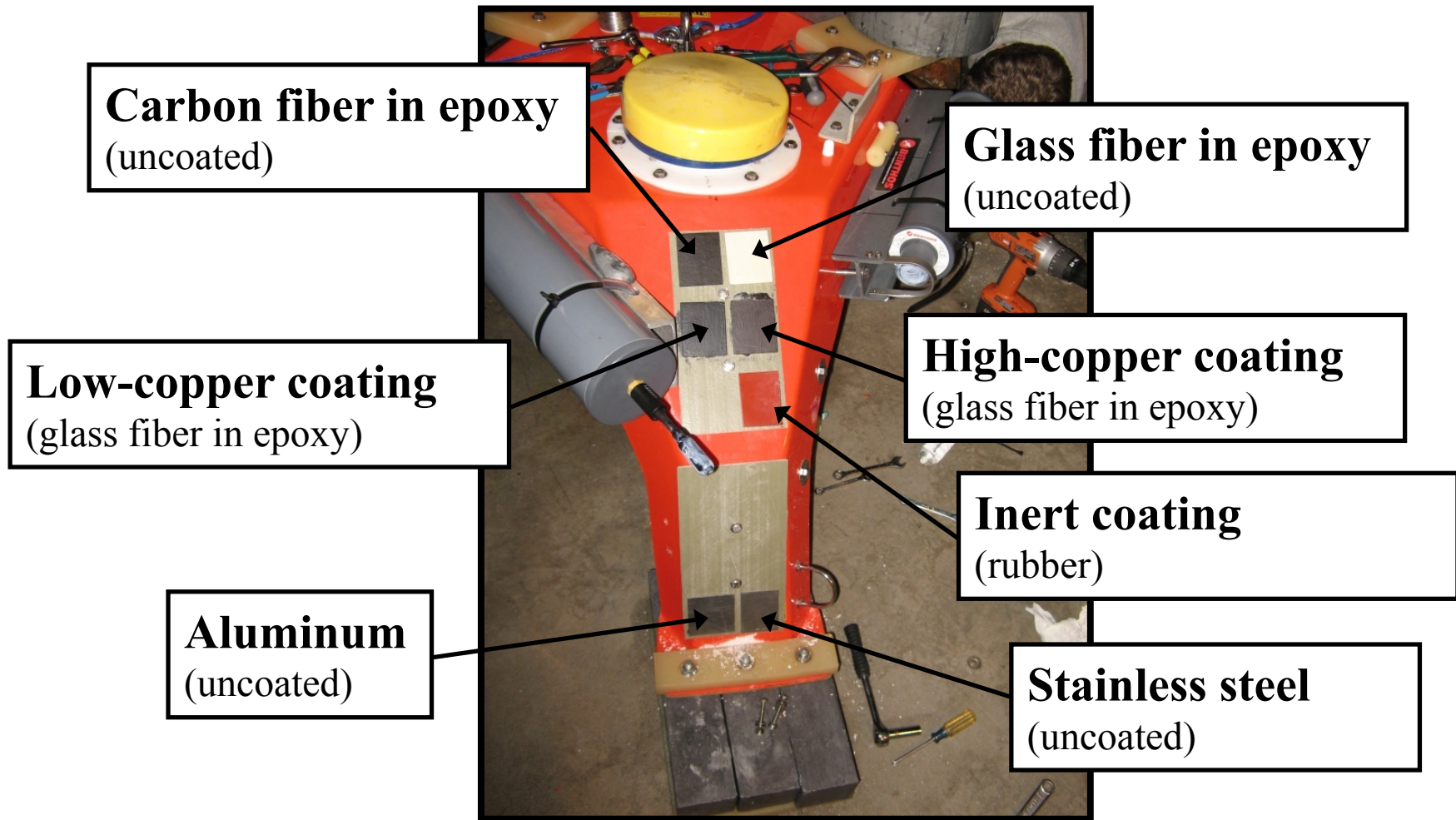
**After**



**Clean Current turbine: 6 months deployment**



# Area 4: Preliminary Materials Testing



# Questions?

Northwest National Marine Renewable Energy Center

[nnmrec.oregonstate.edu](http://nnmrec.oregonstate.edu) (OSU - Wave)

[depts.washington.edu/nnmrec](http://depts.washington.edu/nnmrec) (UW - Tidal)

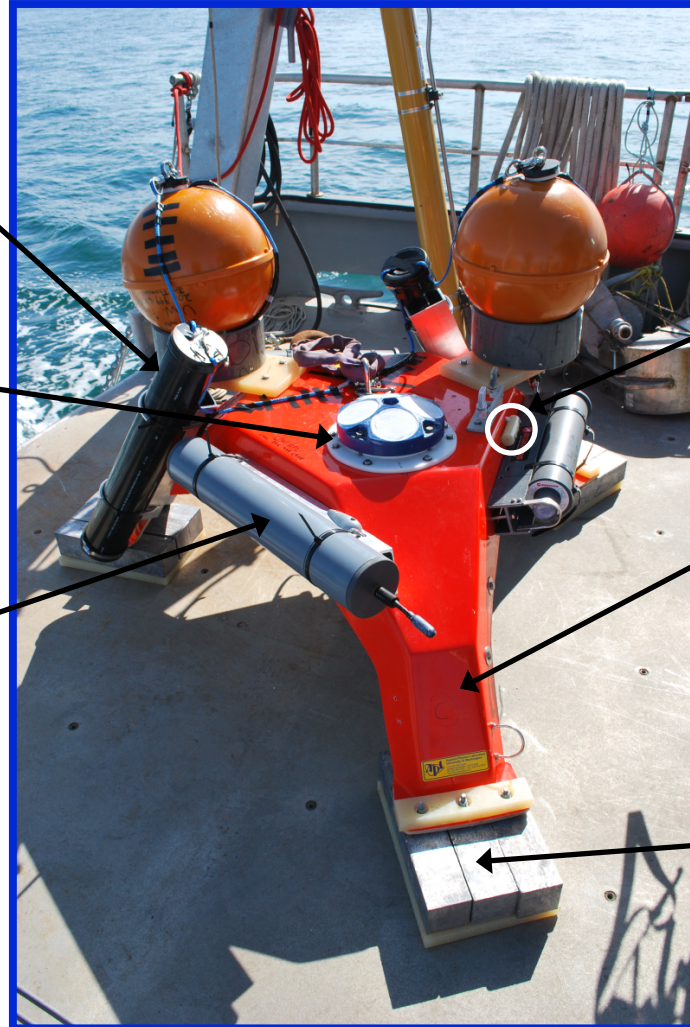
# Area 2 Detail: Stationary Surveys

**Acoustic release**  
(redundant recovery)

**300 kHz ADCP**  
(velocity)

**Hydrophone**  
(background noise)

**Programmed for 4  
month deployment**



**Mini-CTD**  
(salinity and temperature)

**Sea Spider**  
(heavy duty fiberglass frame)

**Lead Weight**  
(600 lbs)