Marine moorings in Elliott Bay:
What you didn’t know you were missing

Wendy Eash-Loucks
King County, Marine and Sediment Assessment Group
Mooring System

YSI 6600EDS V2 datasondes
- Depth
- Water Temperature
- Conductivity
- Salinity
- Dissolved Oxygen
- pH
- Chlorophyll
- Turbidity

Valsala WXT510 meteorological station
- Air Temperature
- Wind Speed
- Wind Direction
- Relative Humidity
- Rainfall
- Pressure
- Radiation

Satlantic SUNA sensor
- Nitrate-N

YSI EcoNet data acquisition system
Why Use Moorings?

• Supplements monthly/bimonthly monitoring data with near-continuous data
  – 15-minute intervals
• Records water conditions when we can’t
• Cost-effective and efficient
  – Monthly calibration
• Provide public with near-real-time water quality data
Elliott Bay Seattle Aquarium Mooring

Photo Credit: Shawn Larson
Pilot Project – November 2005
Current System Online – January 2008

Goals:

• Real-time water quality data
  – Provide Seattle Aquarium with data from intake
  – Provide public with Elliott Bay water quality data

• Observe seasonal water quality trends

• Evaluate influence of Duwamish River
Issues: Bio-fouling

- Make data un-useable
  - Turbidity
  - Chlorophyll
Fouling vs Sensors

Turbidity (NTUs)

Jan-2008  
Feb-2008  
Mar-2008  
Apr-2008  
May-2008  
Jun-2008  
Jul-2008  
Aug-2008  
Sep-2008  
Oct-2008  
Nov-2008  
Jan-2009

= ~ 1 m
Combat Fouling with Copper!

[Graph showing turbidity levels from January 2008 to July 2012 with corresponding months and turbidity values.]
Issues: pH Data

- Still having problems with drift in pH between deployment and sonde/probe specificity despite passing post-calibration QC checks.

- We can’t monitor for ocean acidification with current accuracy of probes.
The Data

• Real-time water quality data

• Seasonal/inter-annual trends

• Evaluate influence of Duwamish River
Fine-Resolution Data: What’s Going on During the Day (and Night)?

Temperature - 2013

- Jun 27th - 00:00
- Jun 27th - 04:00
- Jun 27th - 08:00
- Jun 27th - 12:00
- Jun 27th - 16:00
- Jun 27th - 20:00
- Jun 28th - 00:00

Temperature (°C)

Salinity - 2013

- Jun 27th - 00:00
- Jun 27th - 04:00
- Jun 27th - 08:00
- Jun 27th - 12:00
- Jun 27th - 16:00
- Jun 27th - 20:00
- Jun 28th - 00:00

Salinity (ppt)
The Data

- Real-time water quality data
- Seasonal/inter-annual trends
- Evaluate influence of Duwamish River
Seasonal Trends

Temperature - 2013

Salinity - 2013

Chlorophyll-a - 2013

Dissolved Oxygen - 2013

Strong Stratification

High Mixing
Seasonal Trends

Temperature - 2013

Salinity - 2013

Chlorophyll-a - 2013

Dissolved Oxygen - 2013

Less Variability at Depth

Summer = Dry

Rainfall and Snowmelt

Rainfall

Salinity - 2013

Rainfall

Salinity (ppt)

Dissolved Oxygen (mg/L)
Seasonal Trends

Chlorophyll and DO are highest in early spring through late fall

Upwelling of deep water
The Data

- Real-time water quality data
- Seasonal/inter-annual trends
- Evaluate influence of Duwamish River
Influence of the Duwamish River

“Typical” Elliott Bay

Elliott Bay after heavy rains/river discharge

Photo Credit: Wikipedia.com

Photo Credit: Seattle Times, Steve Ringman
Influence of the Duwamish River

Turbidity

Discharge (cfs)

Turbidity (NTU)

Jan-2010  
Mar-2010  
May-2010  
Jul-2010  
Sep-2010  
Nov-2010  
Jan-2011  
Mar-2011  
May-2011  
Jul-2011  
Sep-2011  
Nov-2011  
Jan-2012
Influence of the Duwamish River

Photo Credit: Seattle Times, Steve Ringman
Future Uses of Data

• What conditions are ideal for phytoplankton blooms
• Conditions that biological communities are exposed to (fish, benthos, plankton...)
• Evaluate long-term trends
  – Changes in temperature
  – Changes in timing of upwelling/de-stratification
  – Changes in timing of first bloom
• Education programs
Where are the Data?

Show me the DATA!

- King County

- NANOOS
Acknowledgements

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  – Shawn Larson

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    • Stephanie Hess
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• NANOOS

• King County’s Marine and Sediment Assessment Group
  – Kim Stark and Amelia Kolb
Questions?
# Instrument Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Resolution</th>
<th>Accuracy</th>
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</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>-5 to 50</td>
<td>0.01</td>
<td>+/- 0.15</td>
</tr>
<tr>
<td>Conductivity (mS/cm)</td>
<td>0 to 100</td>
<td>0.001 to 0.1</td>
<td>+/- 0.5% of reading</td>
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<tr>
<td>Salinity (PSS)</td>
<td>0 to 70</td>
<td>0.01</td>
<td>0.1</td>
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<tr>
<td>Depth (m)</td>
<td>0 to 61</td>
<td>0.001</td>
<td>+/- 0.12</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/L)</td>
<td>0 to 50</td>
<td>0.01</td>
<td>+/- 0.1</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>0 to 1,000</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>pH</td>
<td>0 to 14</td>
<td>0.01</td>
<td>+/- 0.2</td>
</tr>
<tr>
<td>Chlorophyll (µg/L)</td>
<td>0 to 400</td>
<td>0.1</td>
<td>Detection Limit – 0.1</td>
</tr>
</tbody>
</table>
Schematics

Seattle Aquarium YSI Buoy Design
at Low Tide
~King Co. Environmental Lab~

- Met tower
- AC in
- EcoNet box
- Fixed pulley guides
- Seattle Aquarium pump house
- Sonde cable
- Lower pulley moves up as tide goes out
- 50 lb. lead ball
- 3/8" braided Spectra strength member
- Upper YSI Sonde 1 m depth
- Lower YSI Sonde 10 m depth

Seattle Aquarium YSI Buoy Design
at High Tide
~King Co. Environmental Lab~

- Met tower
- AC in
- EcoNet box
- Fixed pulley guides
- Seattle Aquarium pump house
- Sonde cable
- Lower pulley moves down as tide comes in
- 50 lb. lead ball
- 3/8" braided Spectra strength member
- Upper YSI Sonde 1 m depth
- Lower YSI Sonde 10 m depth
- 20 lb. lead ball
- Surface float
- Seattle Aquarium pump house