Use of real-time data to monitor the biogeochemistry and plankton ecology of the lower Columbia River

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NWQMC 2012 Session C3: Emerging Technologies and Techniques in Real Time Monitoring
• 2 years (2009-2011) of high resolution biogeochemical data from the lower Columbia River

• What we’ve learned from the real-time data

• How we use the real-time data to target sampling efforts to study plankton ecology
Background: Columbia River Basin

http://en.wikipedia.org/wiki/Columbia_River
Historical Changes to the Columbia River

Sullivan et al., 2001
Historical River Flow

Regulated and Natural Flows at The Dalles Dam

Independent Scientific Advisory Board for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and NOAA Fisheries 2011
“Greening” of the River

Sullivan et al., 2001
Motivation for high resolution data

• Historical change in dominant primary producers from vascular plants to fluvial phytoplankton (‘greening’ effect)
• Track drivers of chlorophyll production and plankton assemblages
• Monitor water quality and influence of Willamette River discharge
Columbia River Biogeochemical Sensors

Beaver Army Terminal
River mile 53
Astoria, OR
Longview, WA
Columbia River
Vancouver, WA
Portland, OR

Willamette River
Land/Ocean Biogeochemical Observatory (LOBO) Sensor Platform

Sensors deployed June 23, 2009

- Water Quality Monitor (WETlabs, Inc.)
  - Chlorophyll
  - Turbidity
  - Dissolved oxygen
  - Temperature
- SUNA nitrate sensor (Satlantic)
  - UV-Nitrate sensor
- CDOM Fluorometer (WETlabs, Inc.)
  - Colored Dissolved Organic Matter

http://columbia.loboviz.com

<table>
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<th>Latest</th>
<th>Lower Columbia River 2012-04-06 12:00:00 PST</th>
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<tbody>
<tr>
<td>CDOM</td>
<td>24.66</td>
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<tr>
<td>Chlorophyll</td>
<td>2.61 μg/L</td>
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<tr>
<td>Conductivity</td>
<td>0.0084 S/m</td>
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<tr>
<td>Depth</td>
<td>4.317 m</td>
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<tr>
<td>Dissolved O₂</td>
<td>9.23 ml/l</td>
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<tr>
<td>Nitrate</td>
<td>29.6 μM</td>
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<tr>
<td>O₂ Saturation</td>
<td>8.39 ml/l</td>
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<td>O₂ % Saturation</td>
<td>110.0 %</td>
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<tr>
<td>Salinity</td>
<td>0.06 PSU</td>
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<tr>
<td>Temperature</td>
<td>7.44 °C</td>
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<tr>
<td>Turbidity</td>
<td>10.57 NTU</td>
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<td>Battery Voltage</td>
<td>14.2 V</td>
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River Discharge at Beaver Army Terminal
Hourly Data: Oxygen Saturation (%) & Chlorophyll

[Graph showing oxygen saturation and chlorophyll levels over time.]
Chlorophyll Fluorometer Quality Control

Fluorometer #1: 2009-2010

\[ y = 2.9486x + 0.2696 \]
\[ r^2 = 0.8813 \]

Fluorometer #2: 2011

\[ y = 4.1662x + 0.7233 \]
\[ r^2 = 0.9103 \]
What we’ve learned from high resolution data in the Columbia River
Results #1: Increased nitrate in winter storm run-off
Results #2: Relationship of river discharge & chlorophyll

The graph illustrates the relationship between river discharge (blue dots) and turbidity (gray dots) over time. The y-axis on the left represents turbidity (NTU) and chlorophyll (µg L⁻¹), while the y-axis on the right indicates daily discharge (m³ s⁻¹). The data is plotted from 6/1/09 to 9/1/11, with highlighted periods showing significant spikes in discharge with corresponding changes in turbidity and chlorophyll levels.
Results #3: Track seasonal phytoplankton composition

Phytoplankton Dominant Species Composition

- Chlorophyll
- Asterionella formosa
- Aulacoseira sp.

Chlorophyll (μg L⁻¹)

Chlorophyll (cells ml⁻¹)

Graph showing seasonal changes in phytoplankton composition with peaks in concentrations from June to September.
Results #4 Calculate phytoplankton POC from discrete sampling

Cell Particulate Carbon: pg carbon/cell = $0.288 \times \text{biovolume}^{0.811}$  

Menden-Deuer & Lessard, 2000
Case Study: Using the real time data to target studies of plankton ecology

• Identification of phytoplankton parasites (‘chytrid’ fungi) during spring blooms
  
  • Most prevalent on dominant species (40% infected)
    – i.e. *Asterionella formosa*

• Dynamics of infections controlled by river discharge
Conclusions & Future Work

• What we know now from sensors that we didn’t know before
  – High resolution seasonal trends in biogeochemical parameters
  – Control of river discharge on timing, magnitude, & number of spring bloom events

• How we use sensors to advance science
  – Adaptive sampling from real-time data to analyze phytoplankton seasonal dynamics and plankton ecology

• Future work
  – LOBO installment before influence of Willamette River (planned for spring 2012)
Acknowledgments

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  – Kevin Knutson
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  – Greg Fuhrer
  – Michael Sarantou

• NSF Graduate Research Fellowship Program
Willamette River Chlorophyll & Turbidity
Willamette River Chlorophyll Contribution

Columbia River

Willamette River
Willamette River Turbidity Contribution

Columbia River

Willamette River
Colored Dissolved Organic Matter

![Graph showing CDOM (QSDE) over time from 6/1/09 to 6/1/11](image-url)
Temperature
Oxygen Saturation (%)

Date

Oxygen Saturation (%)