Temporal variation in river nutrient concentrations and the impact of storm runoff on Hood Canal nutrient loading

Nick Ward
nickward@uw.edu
School of Oceanography
Advisors: Jeff Richey and Rick Keil
• Increased frequency of low $O_2$ and fish kill events observed in recent decades
Factors affecting hypoxia

Focus of this study:
How does terrestrial input of nutrients change over time?
HCDOP Watershed Model

- Chemistry based on monthly samplings of 43 streams
- How do nutrient concentrations vary on shorter timescales?

Peter Steinberg, unpublished data
Storm Sampling Project

Goal:

Determine short term variability in river nutrient concentrations

and

Gain an understanding of the processes behind observed variability
Storm Sampling Project

**Measurements:**

- Total Dissolved Nitrogen
- Dissolved Organic Carbon
- Dissolved Silica, Phosphorous, and inorganic N concentrations
- Total Suspended Sediments
- Particulate C/N concentrations
- Particulate C/N Stable Isotopes
- Dissolved Lignin Phenols
Autumn storm sampling results

Union River [TDN] and [DOC] 10/3/08-10/6/08

River discharge (ft³/s)

Dissolved Organic Carbon Concentration (μM)

Total Dissolved Nitrogen Concentration (μM)

River Discharge (cfs)

[DOC] (μM)

[TDN] (μM)

TDN is ~66-75% NO₃ and 25-33% DON
Autumn storm sampling results

Union River C/N 10/3/08-10/6/08

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>10/3/08</th>
<th>10/4/08</th>
<th>10/5/08</th>
<th>10/6/08</th>
<th>10/7/08</th>
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</thead>
<tbody>
<tr>
<td>[DOC]/[TDN]</td>
<td>7</td>
<td>8</td>
<td>9</td>
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<tr>
<td>River Discharge (cfs)</td>
<td>20</td>
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Autumn storm sampling results

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>River Discharge (cfs)</th>
<th>[TDN]/[PO4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/3/08</td>
<td>20</td>
<td>50</td>
</tr>
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<td>22</td>
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<tr>
<td>10/6/08</td>
<td>26</td>
<td>80</td>
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<tr>
<td>10/7/08</td>
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<td>90</td>
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Union River N/P: 10/3/08-10/6/08

River Discharge (cfs)
[TDN]/[PO4]
Autumn storm sampling results

Skokomish River [Si(OH)₄] 10/2/08-10/6/08

<table>
<thead>
<tr>
<th>Time/Date</th>
<th>River Discharge (cfs)</th>
<th>[Si(OH)₄] (umol/L)</th>
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<tbody>
<tr>
<td>10/1/08</td>
<td>0</td>
<td>120</td>
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<tr>
<td>10/3/08</td>
<td>500</td>
<td>160</td>
</tr>
<tr>
<td>10/5/08</td>
<td>1000</td>
<td>200</td>
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<tr>
<td>10/7/08</td>
<td>2000</td>
<td>220</td>
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</table>

Graph showing the correlation between river discharge and [Si(OH)₄] concentration.
November: 167% increase in discharge = 167% increase in [TDN]
January: 112% increase in discharge = 30% increase in [TDN]
By March there is nearly no change in concentrations with river flow
Simple Two Pool Model

Summer/Dry period: Nutrients accumulate in surface pool

Nutrient flux        Water flux     Size of arrow reflects magnitude of flux
Simple Two Pool Model

Nutrient flux
Water flux
Size of arrow reflects magnitude of flux
Autumn storm sampling results

Rainfall not adequate enough to saturate soil and mobilize dissolved nutrients

Skokomish River [TDN] and [DOC] 9/4/09-9/8/09

<table>
<thead>
<tr>
<th>Date/time</th>
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<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
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<th>River discharge (ft³/s)</th>
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<td>100</td>
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</table>

[DOC] (µM)
[TDN] (µM)
XSmooth vs YSmooth
Discharge
Autumn storm sampling results

However, surface runoff mobilizes sediments
Autumn storm sampling results

Particulate C and N conc. increase because soils are mobilized, however soil saturation isn’t high enough to “flush” dissolved nutrients
Autumn storm sampling results

Like dissolved nutrients, particulates show largest response in early storms, then correlation diminishes.
What does this mean for modeled nutrient flux estimates?

Total N flux calculated by

“monthly average” vs.

“discharge-concentration correlation”

• My estimate is ~10% higher for October ‘07

• My estimate is ~100% higher for November ‘07
Lignin Phenol Tracer Study

Goal:

Determine variability in the source of nutrients throughout a storm

and

Gain an understanding of the processes behind observed variability, expanding on simple 2 box model

and

Enrich the virtually non-existent dissolved lignin dataset
Lignin results

Correlation between lignin and discharge indicates input of terrestrial OM
Lignin Results

Analysis of ratios of specific phenols revealed:

- During peak runoff, there is a shift toward more degraded material.
- This material is from a more woody/gymnosperm source (conifer tree) than during base flow conditions.

This suggests that the “shallow dissolved nutrient pool” is derived from degraded tree material.
Two Pool Model revisited

A nutrient enriched layer of particulates accumulates. The dissolved pool is derived from the particulate pool.

Nutrient flux  Water flux  Size of arrow reflects magnitude of flux
Two Pool Model revisited

Nutrient flux

Water flux

Size of arrow reflects magnitude of flux
Gathering monthly samples during “non-average” conditions (i.e. draught/storm) can significantly influence modeled nutrient flux estimations.

Is the magnitude and timing of storm events significant to Hood Canal hypoxia?

Results from this study can be used to increase accuracy of future modeling efforts as well as help determine the fate of riverine nutrients.

Accurate watershed models can be used to address a diverse set of issues, from water resource management to global biogeochemical cycling.
Acknowledgments

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