River and wastewater effluent nutrient inputs into the Salish Sea model

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River & Wastewater nutrient loading into the Salish Sea Model

Salish Sea Ecosystem Conference
April 4-6, 2018

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Acknowledgements

• Past contributors:
  • Mindy Roberts
  • Brandon Sackmann
  • Chuck Springer

• Steve Hood and John Gala: for help with R scripting

• Funding in part from the EPA National Estuary Program grant

• The rest of the Salish Sea Modeling team at Ecology and PNNL

Data sources:

• Ecology Freshwater Monitoring Unit
• South Puget Sound Dissolved Oxygen Study data
• USGS streamflow and water quality data
• King County water quality data
• Kitsap County streamflow data
• USACE for Lake Washington/Ship Canal data
• Tacoma Power/Utilities
• Wastewater treatment facilities – effluent monitoring data
• Environment Canada
Why estimate nutrient loading?

- Excess nutrients contribute to eutrophication, low oxygen levels and acidification

- Need estimates to establish boundary conditions for the **Salish Sea Model**

- Ability to quantify different sources, magnitude and timing of delivery to Salish Sea is informative

- Allows us to perturb conditions and change nutrient loading for model scenarios to evaluate effect on water quality
Pacific Ocean contributes the largest nitrogen load to the sound – driven by larger oceanic and global processes.
Nutrient Sources & Pathways

Pacific Ocean contributes the largest nitrogen load, driven by larger oceanic and global processes. Focus of this presentation is on rivers and wastewater loads – can influence through local management actions.

Focus on dissolved inorganic nitrogen (DIN), but we have estimates of:
- organic and inorganic nitrogen
- organic and inorganic carbon
- organic and inorganic phosphorus
Recent updates

- Original time series from 1999-2008, extended through mid-2017
- Expansion of model grid → needed freshwater inflows into the northern boundary (British Columbia)
- Spatial refinement of freshwater loading estimates in South & Central Puget Sound
- Updated WWTP data based on discharge monitoring reports, where available, particularly for facilities that have been upgraded since 2008
161 river and streams
- Rivers and streams entering Puget Sound, the Straits and the Pacific Ocean
- Higher spatial resolution in South & Central Puget Sound

99 point sources
- All facilities with marine outfalls
- 78 U.S. WWTPs
- 9 Canadian WWTPs
- 10 industrial facilities
Questions we can answer:

- What proportion of modeled effects are caused by human activities?
- How will conditions change in the future (climate change, population growth)?
- How much do potential nutrient reductions improve water quality?

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River & Wastewater DIN concentrations

Wastewater median concentrations: $>10 \text{ mg/L}$

River median concentrations: $<0.5 \text{ mg/L}$
**Flows**

**Wastewater:**
- Sound: 16 cms (575 cfs)
- Straits: 17 cms (700 cfs)

**Rivers:**
- Sound: 1,490 cms (52,620 cfs)
- Straits: 8,890 cms (313,950 cfs)
Dissolved Inorganic Nitrogen (DIN) concentrations in mg/L: 1999-2017 annual averages

<table>
<thead>
<tr>
<th>Wastewater</th>
<th>Concentration (mg/L)</th>
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<tbody>
<tr>
<td></td>
<td>0.0 - 1.0</td>
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<tr>
<td></td>
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<td>2.1 - 5.0</td>
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<td>25.1 - 30.0</td>
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<td>&gt; 30.0</td>
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</tbody>
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Rivers:
- Stillaguamish R
- Fraser R
- Nooksack R
- Skagit R
- Snohomish R
- Iona
- Annacis
- Nisqually R
- Green R
- Puyallup R
- West Point
- South King
Dissolved Inorganic Nitrogen (DIN) loads in kg/day: 1999-2017 annual averages
Seasonal differences

Dissolved Inorganic Nitrogen loads into Puget Sound from 2006-2016

**Annual average:**
- **WWTP:** 30,540 kg/day
- **Rivers:** 25,240 kg/day

**Annual DIN load contribution:**
- Puget Sound - WWTPs: 45%
- Puget Sound - Rivers: 55%

**Summer DIN load contribution:**
- Puget Sound - WWTPs: 21%
- Puget Sound - Rivers: 79%
2006 vs. 2014 river flows into Puget Sound

2006 Flow

2014 Flow

Streamflow (cms)
2006 vs. 2014 river flows into Puget Sound

- Spring 2014 streamflow > spring 2006 streamflow
- Spring 2014 nutrient loads > spring 2014 loads
- Flows affect residence times between these two years
- River influence on oxygen levels in Puget Sound (relative to WWTPs) was greater in 2014 than in 2006
Reference Conditions

Current loading

- **point sources** (WWTPs)
- **non-point sources** (rivers)
Reference Condition = nutrient loading in the absence of regional anthropogenic nutrient sources

- no change in ocean inputs
- no change in Canadian inputs
- U.S. WWTP effluent removed (flow on)
- U.S. river nutrient inputs reduced to estimate reference concentrations (no change in flow)

Published in Mohamedali et. al. (2011), updated in Pelletier et. al. (2017, Appendix B), estimates may be refined further in 2017-2018
An estimated 70% of the DIN load to Puget Sound is from human sources.
Future nutrient loading

Drivers:
- Population growth
- Land use change
- Changes in WWTP treatment
- Climate change
Next Steps

• **Continuous monitoring at select rivers** - to improve temporal resolution of nutrient inputs – our current statistical method may be underestimating river loading during rain events

• **Salish Sea Model runs** to evaluate high-level impacts/influences of management actions e.g. if the largest WWTPs had Biological Nutrient Removal technologies

• **Climate change and population growth scenarios** - refinement of previous estimates

• **Puget Sound Nutrient Reduction Project** – project that will be guided using the Salish Sea Model

• **Continuous technical improvement as time and resources allow**

For more information:

**Salish Sea Model:** [https://ecology.wa.gov/Research-Data/Data-resources/Models-spreadsheets/Modeling-the-environment/Salish-Sea-modeling](https://ecology.wa.gov/Research-Data/Data-resources/Models-spreadsheets/Modeling-the-environment/Salish-Sea-modeling) (includes links to all model related publications)

**Reducing nutrients in Puget Sound:** [https://ecology.wa.gov/Water-Shorelines/Puget-Sound/Helping-Puget-Sound/Reducing-Puget-Sound-nutrients](https://ecology.wa.gov/Water-Shorelines/Puget-Sound/Helping-Puget-Sound/Reducing-Puget-Sound-nutrients)

**Nitrogen in Puget Sound - A Story Map:** [https://waecy.maps.arcgis.com/apps/MapSeries/index.html?appid=907dd54271f44aa0b1f08efd7efc4e30](https://waecy.maps.arcgis.com/apps/MapSeries/index.html?appid=907dd54271f44aa0b1f08efd7efc4e30)

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