Apr 30th, 1:30 PM - 3:00 PM

Relative influences of human nutrient sources, the Pacific Ocean, and climate change on Salish Sea dissolved oxygen through 2070

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Speaker
Mindy Roberts, Teizeen Mohamedali, Brandon Sackmann, Tarang Khangaonkar, Wen Long, and Alan Hamlet

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Relative influences of human nutrient sources, the Pacific Ocean, and climate change on Salish Sea dissolved oxygen through 2070

Mindy Roberts¹, Teizeen Mohamedali¹, Brandon Sackmann¹, Tarang Khangaonkar², Wen Long², and Alan Hamlet³

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² Pacific Northwest National Laboratory
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Funded by EPA – NEP
Low oxygen happens ... algae grows ... why?

Puget Sound Dissolved Oxygen
- Waters of Concern
- Impaired Waters
- Cities

Eyes Over Puget Sound
Hood Canal 2013

Pacific Ocean dissolved oxygen levels, coastal upwelling, Pacific Decadal Oscillation, other climate cycles, NE Pacific oxygen trends, ocean circulation, residence time, estuarine circulation, stratification, vertical mixing, wind, air temperature, organic matter decay, sediment burial rates, trophic-level dynamics, algae growth, water temperature, human wastewater input, river flows, river nutrient inputs, sediment-water processes, etc. ...
Relative impacts on dissolved oxygen

Pacific Ocean trends

- Increased air temperature
- Changes in circulation due to changes in freshwater inflows
- Increased wastewater from future population
- Higher river nitrogen concentrations from land cover change

... more study needed.
Local sources of nitrogen
*(US and Canada)*

- Pacific Ocean is the largest source of nitrogen
- Sediment-water exchanges highly influential

Mohamedali et al. (2011)
Current and Future Scenarios

(2020s, 2040s, 2070s)

- Population
- Climate change
- River Flows
- Estuarine Circulation
- Declining Pacific Ocean oxygen
- Land cover change
• 3D model (circ, WQ)
• 10,000s of elements
• 1,000,000,000s of outputs
• See me for modeling details...

Source: Khangaonkar et al. (2012)

Data courtesy of King County
Average DO depletion (mg/L)
- 0.00 – 0.05
- 0.05 – 0.10

Oxygen depletion – current sources (wastewater, watersheds)

- Biggest impacts in South and Central Puget Sound
- Not directly applicable to State of WA water quality standards

Average regional and seasonal oxygen deficit:
- Oxygen inventory
- Below pycnocline
- September - October
Oxygen depletion – future marine point sources and watershed inflows

<table>
<thead>
<tr>
<th>Year</th>
<th>Current Circulation, Current Ocean</th>
<th>Average DO depletion (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>2020 loads, current circ, current ocean</td>
<td>0.00 – 0.10</td>
</tr>
<tr>
<td>2040</td>
<td>2040 loads, current circ, current ocean</td>
<td>0.11 – 0.20</td>
</tr>
<tr>
<td>2070</td>
<td>2070 loads, current circ, current ocean</td>
<td>0.21 – 0.50</td>
</tr>
</tbody>
</table>

Legend:
- 0.00 – 0.10
- 0.11 – 0.20
- 0.21 – 0.50
- 0.51 – 0.80
- 0.81 – 1.10

Study Area
Oxygen depletion – future human loads and future circulation

<table>
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<tr>
<th>Year</th>
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<th>0.21 – 0.50</th>
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<td>2020</td>
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</table>
Future scenarios – Pacific Ocean trends

Oxygen declining at all isopycnals at Station P (50-year trend)

Faster decline near Strait of Juan de Fuca (Station P4)

Sources: Figs 1 and 4 from Whitney et al. / Progress in Oceanography 75 (2007) 179-199
Oxygen depletion – future human loads, circulation, and ocean

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Legend:
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-1.5 mg/L
Future population growth will increase oxygen impacts; ocean trends would make it worse.

Average depletion (mg/L of oxygen decline compared with current conditions)

- 0.00 – 0.10
- 0.11 – 0.20
- 0.21 – 0.50
- 0.51 – 0.80
- 0.81 – 1.10
Relative impacts on dissolved oxygen

Pacific Ocean trends

- Increased air temperature
- Changes in circulation due to changes in freshwater inflows
- Increased wastewater from future population
- Higher river nitrogen concentrations from land cover change

... more study needed.
Influence

Uncertainty

Future ocean conditions

Future marine community shifts
Future climate
(air temperature, precipitation, hydrology)
Future sediment-water exchanges
Future watershed concentrations
(land cover)
Future watershed inflows
Future marine point source concentrations
Future marine point source flows
Current sediment-water exchanges

Current ocean conditions

Current watershed inflows
Current marine point sources
Next steps (2015):
Pacific Ocean trends?
Sediment diagenesis
Revisit scenarios

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Report:
www.ecy.wa.gov/programs/wq/PugetSound/DOModel.html