

Modeling Dissolved Oxygen in Budd Inlet and Capitol Lake

Mindy Roberts, Anise Ahmed, and Greg Pelletier

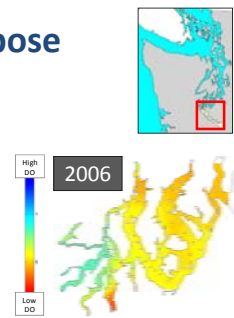
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Project purpose

The purpose of this study is to quantify whether humans have impacted dissolved oxygen (DO) levels in Budd Inlet and Capitol Lake, and if so, by how much.

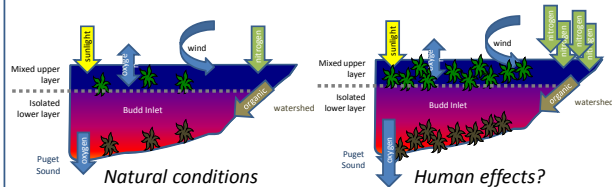
Budd Inlet has the lowest levels of DO in South Puget Sound, and some years are worse than others.

The project included data collection and computer models of Budd Inlet, Capitol Lake, and the Deschutes River.

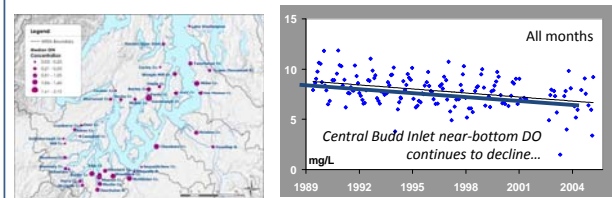


Budd Inlet DO is particularly complicated

- The natural shape of Budd Inlet reduces circulation in the southern end because of shallow depths.
- Humans have reduced Budd Inlet's volume even more by filling in the near-shore areas and creating Capitol Lake.
- Dissolved oxygen represents the interactions of physical, chemical, biological, and human systems. Humans have contributed additional sources of nitrogen from wastewater treatment plants and enhanced river loads.



- The Lacey, Olympia, Tumwater, and Thurston County (LOTT) wastewater treatment plant implemented an advanced treatment process in 1994, decreasing nitrogen loads from the plant, but central Budd Inlet DO continues to decline.

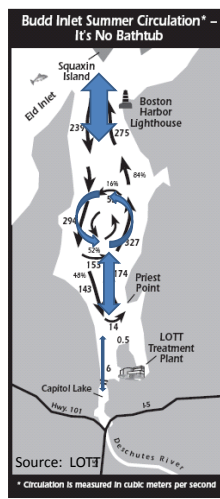


- Deschutes River nitrate concentrations are rising.
- Rivers and streams around Budd Inlet have some of the highest nitrogen concentrations of tributaries to South Puget Sound.

Contact Information

Mindy Roberts, Ph.D., P.E. mrob461@ecy.wa.gov 360-407-6804
 Anise Ahmed, Ph.D., P.E. aahm461@ecy.wa.gov 360-407-6767
 Greg Pelletier, P.E. gpel461@ecy.wa.gov 360-407-6485

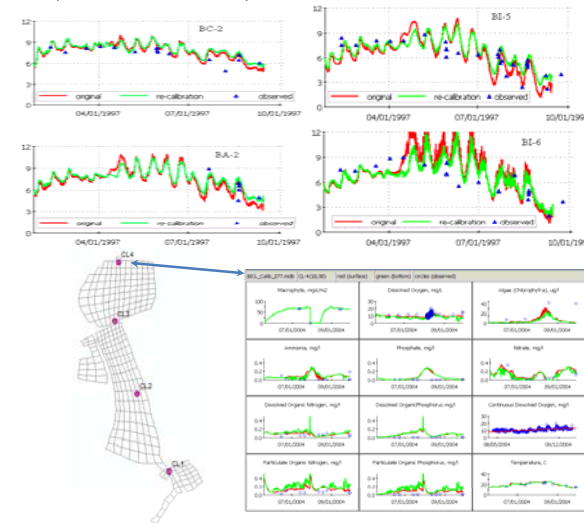
Limited circulation strongly influences Budd Inlet water quality



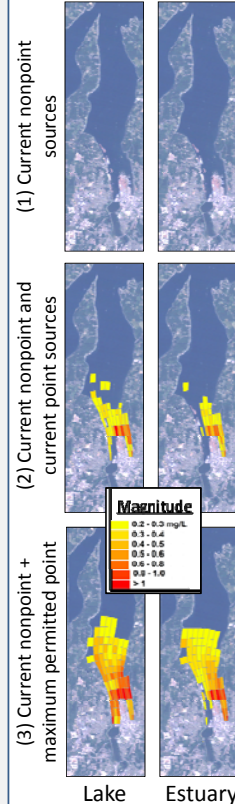
- Of the water that enters Budd Inlet from the north, very little water makes it to southern Budd Inlet.
- The tides tend to create counter-clockwise flow patterns.
- A gyre sometimes forms in central Budd Inlet.
- A 3-dimensional model simulates circulation and water quality in Budd Inlet and Capitol Lake.
- Outflows from Capitol Lake enter Budd Inlet as a series of pulses at low tides.
- Converting Capitol Lake to an estuary would change hydraulics.

Using data to confirm models

- Before using models to predict what might happen under alternative future management strategies, we must make sure they describe today's conditions appropriately.
- We collect data on how the water moves and what levels of DO currently exist and tune the models in a process called calibration.
- For Budd Inlet, we relied on the previous extensive data collection program and model development (Aura Nova et al., 1998).



Nitrogen sources, and lake versus estuary, affect on DO



- Under either the Capitol Lake or Deschutes Estuary alternatives
- Current nonpoint (diffuse) sources decrease DO in comparison with natural conditions, but nonpoint sources alone do not deplete DO more than >0.2 mg/L.
 - The combined effect of current nonpoint and point (discrete) sources causes some portions of southern Budd Inlet to violate the water quality standards.
 - The combined effects of current nonpoint sources and the maximum permitted point sources would cause more extensive and severe violations of the water quality standards.

- Capitol Lake vs. Deschutes Estuary
- If an estuary replaced Capitol Lake, the West Bay of Budd Inlet DO would improve, and fewer areas would violate the water quality standards.
 - Even with an estuary, portions of Budd Inlet would not meet standards.

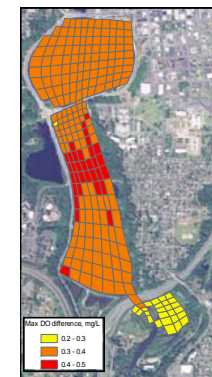
How these differences in DO translate to nutrient reductions will be determined in the next phase of the project.

Capitol Lake

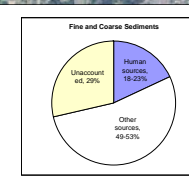
- Nonpoint sources from the watershed cause water quality violations in Capitol Lake.
- Violations persist throughout the summer.

Factors affecting water quality

- Low circulation within the lake.
- Shallow water depths.
- Warm temperatures.
- High phosphorus from sediments and watershed.
- High macrophyte biomass.
- Algae blooms.



Ideal growing conditions
 A lesson in controllable sources: Sediment deposition has reduced the depth and volume of Capitol Lake over the years, exacerbating water quality problems. However, most of the sediment sources are natural within the Deschutes River watershed.

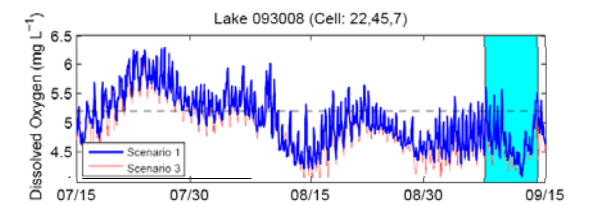


Why do we need a computer model of Budd Inlet?

- Modeling allows us to separate how different sources and factors influence DO.
- In the virtual world of modeling, we can remove Capitol Lake and look at how an estuary would work.
- We can turn on and off different pollution sources to isolate the influence of specific sources.

Seasons and tides influence DO

- Lowest DO concentrations occur in late summer, highlighted below.
- DO generally decreases from July through September.
- DO varies with the ebb and flood of the tides.
- The spring/neap tidal cycle influences DO.



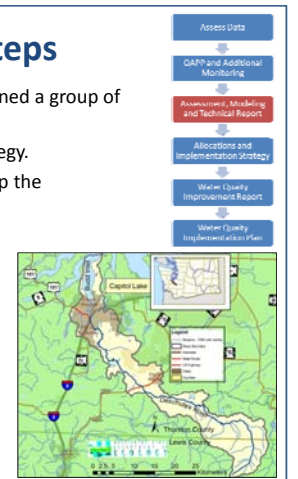
(See X under "Using data to confirm models" for location of model grid cell plotted above)

Next steps

The Department of Ecology has convened a group of stakeholders to:

- Develop the implementation strategy.
- Use modeling tools to help develop the implementation plan.

Dissolved oxygen in Budd Inlet and Capitol Lake is part of a larger project that includes studying temperature, fecal coliform bacteria, DO, pH, and fine sediment throughout the Budd Inlet and Deschutes River watersheds.



For further information

Budd Inlet, Capitol Lake, and Deschutes River Total Maximum Daily Load (TMDL; water cleanup plan) web page: www.ecy.wa.gov/programs/wq/tmdl/deschutes/index.html

Aura Nova Consultants, Inc., Brown and Caldwell, Evans-Hamilton, J.E. Edinger and Associates, Washington State Department of Ecology, and the University of Washington Department of Oceanography. 1998. Budd Inlet Scientific Study Final Report. Prepared for the LOTT (Lacey, Olympia, Tumwater, Thurston County) Partnership, Olympia, Washington.

Roberts, Mindy, Anise Ahmed, and Greg Pelletier. 2009. Deschutes River, Capitol Lake, and Budd Inlet Temperature, Fecal Coliform, Bacteria, Dissolved Oxygen, pH, and Fine Sediment Total Maximum Daily Load, Water Quality Study Findings. External review draft. (To be finalized as a Department of Ecology publication.)