South Puget Sound Dissolved Oxygen Study: Using Models To Inform Management Decisions

Skip Albertson, Anise Ahmed, Greg Pelletier, and Mindy Roberts, Washington State Department of Ecology

Publication No. 09-03-026. www.ecy.wa.gov/biblio/0903026.html. June 2009.

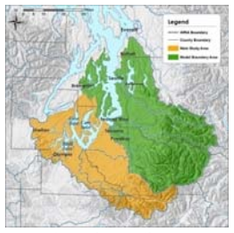
Project description

Ecology's *South Puget Sound Dissolved Oxygen Study* (Albertson et al., 2007) will quantify the effects of human and natural sources of nitrogen on dissolved oxygen in South and Central Puget Sound. The project includes data collection and model development.

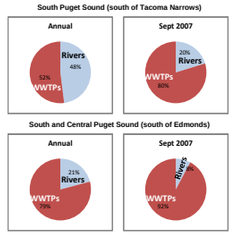
The data report (Roberts et al., 2008) summarizes the marine and freshwater information collected to provide model input data and data for comparison with model results during the calibration process.

Both the circulation model and the water quality model will be developed through 2009. The models are described in the context of how they will be used to understand the effect of human and natural nitrogen sources on dissolved oxygen in South Puget Sound.

Why does the model include areas so far north of Tacoma Narrows?



- The primary area of interest is South Puget Sound, defined as south of Tacoma Narrows.
- Given that the population in the Central Puget Sound area is much higher than in the South Puget Sound area, we must determine whether the additional sources to Central Puget Sound affect South Puget Sound water quality.
- The population of South and Central Puget Sound contributes human sources of nitrogen through wastewater treatment plant discharges and through enhanced river loads.
- Rivers and wastewater treatment plants discharging to Central Puget Sound contribute 28,600 kg/d of nitrogen on an annual basis, compared with 5,700 kg/d from rivers and wastewater treatment plants to South Puget Sound (Roberts et al., 2008).

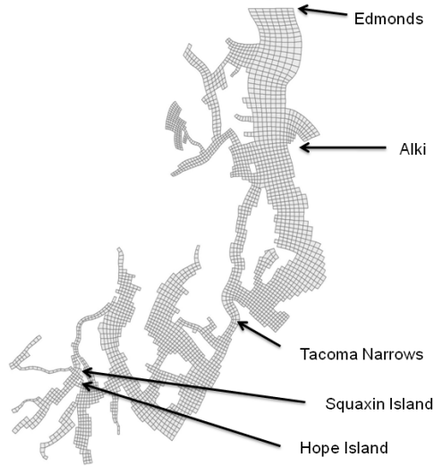


- Whether the Central Puget Sound or human source contributions make a difference in South Puget Sound dissolved oxygen concentrations depends on how much nitrogen comes in, and from where and when.
- The circulation model will track where the nitrogen discharges travel to provide an initial sense of the areas influenced by specific sources.
- Water quality modeling will build from the circulation model to include the complex biochemical processes that govern dissolved oxygen.

Contact information

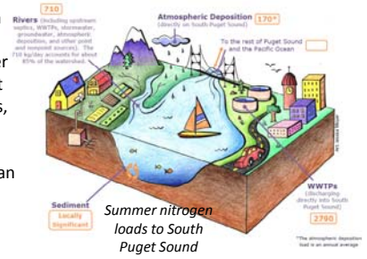
Skip Albertson, P.E.	salb461@ecy.wa.gov	360-407-6676
Anise Ahmed, Ph.D., P.E.	aahm461@ecy.wa.gov	360-407-6767
Greg Pelletier, P.E.	gpel461@ecy.wa.gov	360-407-6485
Mindy Roberts, Ph.D., P.E.	mrob461@ecy.wa.gov	360-407-6804

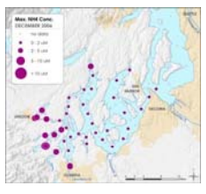
South and Central Puget Sound 3-D model grid

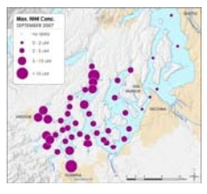


Nutrient sources

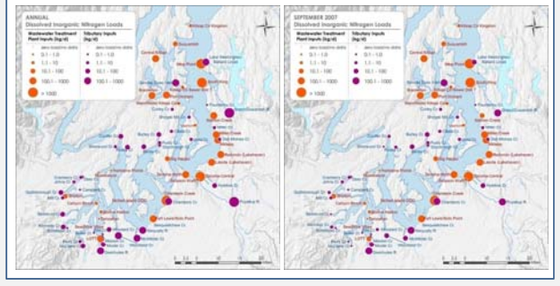
Nitrogen comes from local sources such as rivers and wastewater treatment plants, but also from other areas, such as atmospheric deposition as well as incoming Pacific Ocean water and northern Puget Sound water.







In the winter, marine nitrogen levels are higher than in the summer. Highest marine concentrations do not coincide with highest sources.

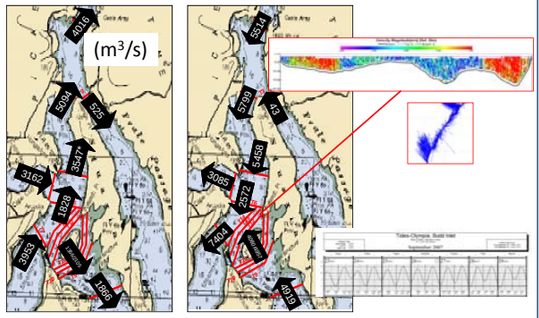


Using data to confirm models

We compare model predictions of today's conditions in a process called *calibration*. For example, we used current meters to measure how much water passed through an inlet and how quickly at a single time. We will compare model predictions to the data to ensure the circulation model correctly predicts how water moves in the western inlets of South Puget Sound. However, the data also provide insights to circulation in several key locations.

Hope Island acts like a plug

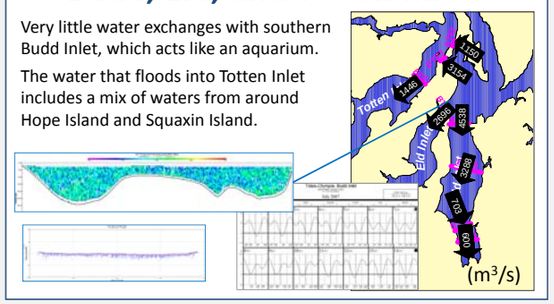
Anyone who has boated in the area knows how fast water moves around the island, producing a series of eddies and complicated flow patterns. We measured velocities and flow rates around Hope Island during ebbing and flooding tides in July 2007.



Budd, Eld, and Totten Inlets

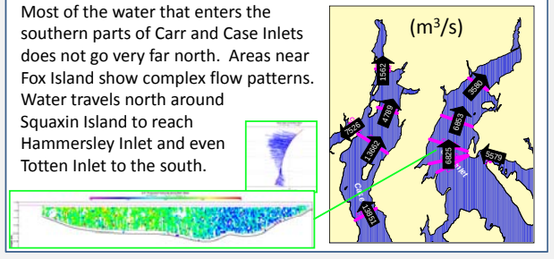
Very little water exchanges with southern Budd Inlet, which acts like an aquarium.

The water that floods into Totten Inlet includes a mix of waters from around Hope Island and Squaxin Island.



Northern Carr and Case Inlets

Most of the water that enters the southern parts of Carr and Case Inlets does not go very far north. Areas near Fox Island show complex flow patterns. Water travels north around Squaxin Island to reach Hammersley Inlet and even Totten Inlet to the south.



Why do we need a model of circulation and dissolved oxygen in South and Central Puget Sound? Why not use data?

- Low water circulation and natural sources of nitrogen likely produce areas with low dissolved oxygen even without the effect of human activities. Data cannot distinguish between natural and human-caused problems.
- Circulation and water quality models provide the only means to distinguish human contributions from natural conditions.
  - The circulation model will help identify how water moves around so we can determine (1) where water stagnates, creating sensitive areas, and (2) what sources contribute to these areas and have the potential to influence water quality.
  - The water quality model will link the physical, chemical, and biological processes and interactions governing dissolved oxygen. Results will determine whether human sources influence dissolved oxygen in these sensitive areas.
- The models will be powerful tools to test and prioritize alternative management strategies:
  - Are zones of low oxygen affected by just one or by many sources? If multiple, we must manage all of them together.
  - What if the population doubles around Puget Sound? What's the effect on dissolved oxygen?
  - What if we reduce nitrogen in rivers? Will it alleviate the dissolved oxygen problems?
- Models provide virtual laboratories to tease apart the effects of humans from natural conditions.

We know how much nitrogen comes in, from where, and when.
We will not know whether this makes a difference in dissolved oxygen until models are complete.

Next steps

1. Circulation model calibration will be completed in spring 2009.
2. The water quality model will be developed in 2009.
3. The final project report will be published in summer 2010.
4. If the models indicate that humans are adversely affecting dissolved oxygen levels and that nitrogen reductions are necessary, Ecology may convene local jurisdictions and interest groups in either a water cleanup planning process– known as a Total Maximum Daily Load study– or some other plan of action to achieve clean water.

References and further information

Albertson, Skip, Julia Bos, Karol Erickson, Carol Maloy, Greg Pelletier, and Mindy Roberts. 2007. South Puget Sound Water Quality Study, Phase 2: Dissolved Oxygen, Quality Assurance Project Plan. Publication No. 07-03-101. www.ecy.wa.gov/biblio/0703101.html.

Kolosseus, Andrew, 2008. Focus on Modeling Dissolved Oxygen in Puget Sound. Publication No. 08-03-032. www.ecy.wa.gov/biblio/0803032.html.

Roberts, Mindy, Julia Bos, and Skip Albertson, 2008. South Puget Sound Water Quality Study, Phase 2: Dissolved Oxygen, Interim Data Report. Publication No. 08-03-037. www.ecy.wa.gov/biblio/0803037.html.

South Sound Dissolved Oxygen web page: www.ecy.wa.gov/puget_sound/dissolved_oxygen_study.html

South Sound Phase 1 Study (1999-2003): www.ecy.wa.gov/programs/eap/mar_wat/focused_south.html.