

Programmatic Recommendations for Salish Sea Modeling

Puget Sound Institute Modeling Evaluation Group

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The Modeling Evaluation Group has reviewed the Salish Sea model and developed a Technical Memorandum in July 2023 in collaboration with the Puget Sound Institute (Salish Sea Model Evaluation and Proposed Actions to Improve Confidence in Model Application). The purpose of this document (Programmatic Recommendations for Salish Sea Modeling) is to provide an objective and unbiased perspective on the broader context of the research and modeling efforts being undertaken.

The Salish Sea environment and Puget Sound, in particular, is not highly degraded in comparison to many other regions that the authors have had extensive experience (e.g., Chesapeake Bay, Baltic Sea). But it is still worthwhile to continue to develop good monitoring data and build modeling capacity for the Salish Sea in the face of climate change and population pressures. Ecosystem protection is always extremely more cost effective than large scale ecosystem restoration, so maintaining a vigilant and robust monitoring program to inform ecosystem models is strongly recommended.

We have a series of recommendations to improve the Salish Sea Modeling effort at the programmatic scale—recommendations that extend beyond the actual modeling. Overall, there are good monitoring data sets and an emerging modeling capacity utilizing the data. But the problem that we see is in the existing structure and function of the effort which leads to uncoordinated efforts.

- 1. Major recommendation: An overall major recommendation is to develop a more integrated and coordinated effort. A list of specific recommendations that target integration and coordination is as follows:**
 - A. Synthesis: Developing a pattern of ongoing synthesis of monitoring data and research findings helps refine the monitoring effort and serves to provide more explanatory power of what is driving the observed trends. Synthesis efforts can be catalyzed with small competitive grants to form synthesis teams, or participation in synthesis centers (e.g., National Center for Ecological Analysis and Synthesis).
 - B. Communication: Enhanced science communication with data visualizations, conceptual diagrams, engaging maps (e.g., story maps), and compelling narrative will help both

researchers and resource managers better understand the key status and trends. Effective science communication can also extend to the elected officials and interested public (e.g., Chesapeake Bay report cards).

- C. Standardization: Data that is collected by different organizations that resides in different data bases in the region in different formats serves to make comparisons and integrated analyses difficult. Developing standardized data bases that collate and format data from the different entities will aid in synthesis and communication.
- D. Research: Developing an applied research program for closing existing knowledge gaps. The Monitoring Evaluation Group has identified several issues, where the foundation for the Salish Sea Modeling and the overall management of nutrient inputs to the Puget Sound could be improved (e.g. benthic-pelagic coupling). Another aim of such program is to strengthen the cross-institutional collaboration by formulating broad, multi-disciplinary research topics.

2. Major Recommendation: Develop a more open and transparent modeling effort that invites more access to the results and models. A list of specific recommendations that target open and transparent modeling are as follows:

- Access: Increase access to the Salish Sea Model, including shared inputs, shared outputs, and model coding and scripts. This increased access can stimulate researchers and graduate students to develop additional models and improvements on the existing models. Open source code is increasingly the industry standard. Adopt an ensemble modeling approach that considers extreme events and multi-parameter impacts (e.g. ocean acidification, temperature, toxins, etc.).
- A. Data base: Developing a more accessible model requires a shared data base that everyone can access and analyze. The Chesapeake Assessment Scenario Tool (CAST) is an example of a shared data base used by a wide diversity of researchers and resource managers. HELCOM and the BONUS research program in the Baltic Sea has a similar approach by establishing common databases for model forcings and monitoring data.
- B. Metadata: The success of open data bases is dependent on having adequate metadata associated with the data. The metadata provides the contextual background for the data and helps data users understand how to best utilize the data.

3. Major recommendation: Taking a more regional approach to management will aid in obtaining more consistent support, including federal support, and aid in coordination and integration.

- A. Regional management: The issues of climate change and development pressures expand the geographic scale of environmental issues in Puget Sound. What happens in Kings County is impacted by what is happening in adjacent jurisdictions. For example, nutrient inputs from Thurston County and Pierce County affect oxygen conditions in Kings County

waters, and vice versa. Moreover, large scale atmospheric and oceanographic conditions increasingly affect Puget Sound. Regional management can create shared decision-making power to coordinate model development and analysis in a less ad-hoc fashion.

- B. Independent review: The ability to make comparisons with other systems can lead to deep learning and effective adaptive management. Having a more regional approach will facilitate more interactions with other systems and independent reviews will enhance the rigor and credibility of the program. Nutrient speciation, an issue in the San Francisco Bay/Delta program is an example of an issue where Puget Sound scientists can learn from.
- C. Federal support: A more regional approach can lead to federal engagement, and diversified funding. Federal input could lead to more coordination, tap diverse federal resources, provide broader context.