Puget Sound Nutrient Dialogue

Workshop Summary

July 19, 2017

DEPARTMENT OF
ECOLOGY
State of Washington

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ENVIRONMENTAL

Publication and Contact Information

This summary is available on the Department of Ecology's website at
http://www.ecy.wa.gov/puget_sound/reducing-nutrients.html

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1. Overview

The Washington State Department of Ecology (Ecology) launched the Puget Sound Nutrient Source Reduction Project in the Spring of 2017, aimed at reducing sources of nutrient loads that are contributing to decreased dissolved oxygen (DO) in Puget Sound. The goal of the project is to develop a nutrient source reduction strategy, a roadmap for how to achieve the desired source reduction goals. Key to the success of this plan is the engagement and support of stakeholders and interested public who are affected or impacted by the low DO problem. Their engagement will help ensure that appropriate corrective approaches are selected and that implementation is successful.

This project is a multi-year undertaking, and will involve collaboration with federal, state and local governments, tribes and communities to both understand the impacts on nutrients on Puget Sound and develop strategies to manage the problem.

On July 19th 2017, Ecology hosted a 1-day workshop on the state of the science of nutrients in Puget Sound. The workshop featured presentations across a range of topics including water quality, benthic communities, plankton, eelgrass and kelp, salmon survival, and food web dynamics. The workshop also featured a presentation by a team of modeling experts on the Salish Sea Model, a multi-agency effort to develop a robust tool for tracking changes in nutrients and other water quality parameters, predicting future conditions, and evaluating solutions. The meeting agenda is provided in Appendix A. For a complete list of presenters and links to the presentations, please see Appendix B.

The final hour of the workshop included a robust question and answer session, drawing in questions from the audience as well as from presenters. Throughout the workshop, participants were asked to write down their questions, ideas and comments on index cards that were collected and discussed during the final Q&A session. The questions and take-way highlights from the responses are captured in the Section 3 below.

Ecology contracted Sarah Brace of Veda Environmental to support the meeting planning activities, facilitate the workshop and produce a summary report.

2. Workshop Presentations -- Takeaway Points

The presenters were each asked to address the following four perspectives on their topic:

- Current status and historic trends of their topic/work
- What's ahead – e.g. climate change and population growth
- Data gaps
- Key takeaways

The key takeaways were compiled and shared in the workshop materials and are provided below:

Nutrient and phytoplankton trends and ties to climate in central Puget Sound -
Kimberle Stark and Stephanie Jaeger, King County

- Over the last two decades, observations in the Central basin of Puget Sound do not show large changes in annual nutrient concentrations or ratios, with the exception of beach sites near a freshwater source. However, when comparing seasonal trends over time, some small increases are observed for all nutrients in the Central basin, including dissolved inorganic nitrogen, silica and phosphorus. Further comparisons to historical data collected prior to 1997 are needed to better understand long-term changes.
- Patterns in near-surface nutrient concentrations are driven by changes in phytoplankton and algae production, which in turn are impacted by weather, climate, circulation, river flow, and other environmental factors that vary from year to year.
- Seasonal and geographic differences in phytoplankton composition and abundance occur in the Central Basin and are associated with temperature and salinity differences as well as weather and climate factors. In general, Central Basin phytoplankton assemblages are diatom-dominated in biovolume and abundance throughout the year. In Quartermaster Harbor, dinoflagellates can comprise a more substantial fraction of the community abundance in the fall, and in some years biovolume as well.

More info: http://green2.kingcounty.gov/marine

Changes in Puget Sound from Ecology's long-term marine water quality monitoring program -
Christopher Krembs, Ecology

- Many water quality indicators vary with larger scale climate fluctuations. Despite these large inter-annual variabilities, trends in long-term monitoring data are evident.
- On a Puget Sound-wide scale, marine nitrate concentrations have increased over the period from 1999-2012 in many regions of Puget Sound. This trend is affecting the nutrient balance in Puget Sound which has implications for nutrient cycling and the species composition at the base of the food web.
- Many eutrophication indicator species (macro-algae, *Noctiluca*, other dinoflagellates, and jellyfish) have been documented in large quantities near the surface of Puget Sound. At the same time phytoplankton has decreased in the upper water column.

More Info: http://www.ecy.wa.gov/programs/eap/pscoastalintro.htm

Impacts of excessive nutrients on eelgrass and kelp – *Bart Christiaen, Washington DNR*

- Eelgrass and kelp are critical nearshore vegetation types that provide habitat for diverse communities.
- Excessive nutrients have contributed to global declines in eelgrass and kelp, through increased shading in the water column and changes in sediment chemistry.
- Some areas in Puget Sound may be similarly affected, especially protected embayments and areas with longer water residence times.

More Info: http://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science

Regional declines in Puget Sound benthic communities – *Sandy Weakland, Ecology*

- Changes in species abundance and diversity have been observed in Puget Sound benthos between 2 spatial surveys, Baseline (1997-2003) and Second Round (2004-2014). Similar patterns have been observed at several long-term ambient monitoring stations with data extending back to 1989. Benthic species are adversely affected in terminal inlets.
- Increase in pollution/hypoxia-tolerant species and a decrease in sensitive species has occurred over time.
- Laboratory chemistry measures and toxicity tests do not correlate well with the benthic community indices.

More Info: http://www.ecy.wa.gov/programs/eap/psamp/

Salish Sea Model (SSM) Panel

Cristiana Figueroa-Kaminsky, Tarang Khangaonkar, Anise Ahmed, Teizeen Mohamedali, Greg Pelletier

Salish Sea Model framework

- The modeling system includes a comprehensive biogeochemical component for impact assessments related to nutrient pollution management, sea level rise, climate change, and ocean acidification for Puget Sound.
- The model has already been used for applications to assist with nearshore habitat restoration planning and design, analysis in support of re-establishment of fish migration pathways, and assessment of basin-wide water quality impacts.
- The SSM currently exhibits a generally high level of skill in reproducing hydrodynamic and water quality variables both spatially and temporally. Further performance improvements are expected as model enhancements are implemented.

Salish Sea residence time distribution

- The SSM confirms that high residence times play an important role in biogeochemical processes and are characteristic of 'trapped' basins within the Salish Sea.
- We can now use the SSM as a tool to quantify residence times for any portion of the model domain or year.
- Residence time maps show us areas that are susceptible to biogeochemical stressors, and can be made available to the scientific community.

Nutrient loading in the Salish Sea model

- Nutrients are an important part of productivity in the Salish Sea, however, excess nutrients, particularly nitrogen, can be problematic for water quality and can deplete oxygen levels.
- The Pacific Ocean is the largest source of nitrogen to the Salish Sea and upwelled waters are a major driver of productivity. However, over-enrichment of nutrients from human sources result in increased oxygen depletion and acidification.
- Wastewater treatment plants are the largest local source of nitrogen, followed by watershed loads (which include all sources upstream, delivered to Puget Sound by rivers).

- We have estimated reference conditions for nutrient loading to the Salish Sea in the absence of human activities.
- In the absence of reductions in human nutrient sources, the impact of local human nutrient sources on water quality will increase in the future due to projected climate change and population growth, which result in changes in the timing of river flows, reduced flushing in the sound, urbanization/land use change, and increases in wastewater discharges.

Current model results

- Puget Sound is sensitive to the influx of anthropogenic organic carbon which micro-organisms consume for energy resulting in decreasing dissolved oxygen levels and changes to the carbonate system chemistry.
- Specific parts of the Sound, such as shallow inlets and bays in southern Puget Sound and areas north of the Triple Junction, within the Whidbey basin, are more sensitive to eutrophication and acidification from human sources.
- Multiple areas of Puget Sound exhibit low dissolved oxygen levels that fall below state and federal water quality standards for extended periods of time on the order of weeks to several months long.

More Info: http://www.ecy.wa.gov/programs/wq/PugetSound/DOModel.html OR http://salish-sea.pnnl.gov/

The role of nutrients in Puget Sound food webs: insights from empirical and modeling studies – *Chris Harvey and Correigh Greene, NOAA*

- The Northwest Fisheries Science Center is investigating how nutrients are affecting primary production and thereby influencing the base of Puget Sound's food webs.
- Through the Salish Sea Marine Survival project, this question is being tested by examining how marine survival of Chinook and Coho salmon is related to zooplankton and early growth. Preliminary modeling indicates a very robust effect of diatom production on marine survival.
- A long-term metric of primary production using growth in geoducks is also under development.
- Nutrient loading and primary production scenarios will be tested in a Puget Sound ecosystem model presently under development.

More Info: http://marinesurvivalproject.com/

3. Question/Answer Panel Discussion

Throughout the workshop, participants were asked to submit questions that they had for the presenters on index cards. The table below summarizes the questions and any resulting discussion.

TOPIC	QUESTION	RESPONSE
Water Quality	Are phytoplankton blooms seen in Quartermaster Harbor (extended blooms, higher proportion of dinoflagellates) typical for enclosed embayments with poorer circulation? Would you expect to see this in other enclosed embayments in Puget Sound?	Yes, this is typical for a shallow embayment with poor circulation. QMH has unique physical characteristics like a very shallow inner harbor (average depth of 6-m) and south facing entrance that make it more susceptible to eutrophication. A 4-year nitrogen loading study was done that looked at sources, and nutrient remineralization from the sediments likely played a large role in fueling late summer/fall blooms and contributed to low dissolved oxygen conditions. The final data and observational report can be found here: http://green2.kingcounty.gov/ScienceLibrary/Document.aspx?ArticleID=199 The final nitrogen loading and management report can be found here: http://green2.kingcounty.gov/ScienceLibrary/Document.aspx?ArticleID=262
	With the Importance of ocean acidification impacts in our region, it seems especially important to monitor for ocean acidification parameters such as alkalinity and dissolved inorganic carbon. These data are needed for OA models. Is Ecology investing in adding these parameters to its long-term monitoring program?	The University of Washington and the Washington Ocean Acidification Center are the organizations charged with monitoring for parameters related to ocean acidification. We defer to them for responding to questions about monitoring. More information can be found here: https://environment.uw.edu/research/major-initiatives/ocean-acidification/washington-ocean-acidification-center/ DNR is also partnering with local universities, WDFW, NOAA, and non-profit groups to investigate ocean acidification issues in the shallow marine areas where most human activity occurs. More information can be found here: http://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/aquatic-assessment-and-monitoring-team/adaptive
	During one of the presentations, it was stated that there were “No large changes in annual nutrient	King County focused on the deep Central Basin (average depth > 100-m) with a higher temporal and spatial resolution in this area, while Ecology focused on a larger monitoring station network and grouped all Puget

TOPIC	QUESTION	RESPONSE
	concentrations or ratios of the past 2 decades". Is this in line with findings from other presentations today? Are we just seeing increases in nutrients from human sources?	Sound stations together, including deep and shallow locations. There was a difference in findings between King County and Ecology's water quality data depending on this scale of resolution and data grouping for nutrient concentrations. In the King County dataset, some seasonal increases were observed in both dissolved inorganic nitrogen as well as silica, suggesting that changes are not due to human sources alone in the Central Basin, since silica comes from natural sources. Nutrient concentrations are dynamic and differences can also result from uptake from phytoplankton in the euphotic zone, physical mixing and reflux at the sills (which will have lag time), sediment flux, remineralization within the water column, as well as human sources. Nutrients may have originally come from the ocean but have since been recycled back into the water, so these could get confused with local sources in this approach. These are complicated processes that are difficult to represent with a single number and this is where the Salish Sea model can help. Further comparison with historical data beyond two decades will improve our understanding of long-term changes. It is also important to note that Puget Sound as a whole is not uniform, and diverse areas and basins will show different changes over time depending on physical and biological characteristics. Shallow areas with long flushing times will have more susceptibility to eutrophication and human-derived sources.
	Why was residence time lower in the late 1990's? The trend seems upward but was there a major change or is it solely due to changes in river inputs?	The index covers only central Puget Sound and has a lot of variability given some assumptions that are needed to calculate residence time from salinity measurements in Puget Sound. We don't have specific monitoring data on the residence time. This is such a crucial piece of the picture and emphasizes the importance of using tools like the Salish Sea model to estimate circulation which is highly variable over time.
	How do inter-annual variability and ocean conditions (upwelling, Pacific Decadal Oscillation, etc.) relate? Do	Yes, these cycles likely play a role in terms of physical conditions and ventilation of deep waters in Puget Sound, as well as impacts on phytoplankton production, which drive nutrient concentrations near the

TOPIC	QUESTION	RESPONSE
	ocean conditions explain variability in nitrogen over 20- year record (2006-08 higher nitrogen)?	surface. In 2006 in particular, observations of higher nitrate are also reflected by lower phytoplankton biomass, and phytoplankton growth was likely impacted by dry conditions and weaker stratification during this time period. In Ecology's dataset of Puget Sound monitoring stations we have found a strong correlation of water temperature with the Pacific Decadal Oscillation Index, a correlation of dissolved oxygen at depth with the upwelling index of our coast, and a correlation of dissolved oxygen at the surface with the North Pacific Gyre Oscillation. These correlations were predicted but in recent years correlations are less strong due to unusually large climate patterns that affected the Northwest and were well outside of our historical range of observations. All data of boundary conditions are provided by NOAA.
	Do you think current DO standards are more stringent than necessary? Is the 0.2mg/L allowance for human sources to lower DO from the natural condition the correct number to protect aquatic species?	The current DO standards are set at levels intended to be protective of the biological integrity of aquatic species. When the numeric criteria and the 0.2mg/L threshold for DO were established, it was intended to be set at levels that protected the most sensitive species and the allowance for human sources was set at the measurement error level because the intent is to not allow more than a measureable change from natural conditions. We will be trying to understand the biological responses from nutrient levels that result in violations of the state water quality standards and incorporate that into our water quality objectives, However, there is no justification for lowering the standard at this time.
Habitat/eelgrass	Why the huge decrease in many areas worldwide in eelgrass in recent years?	Eutrophication has contributed to the global decline in seagrass beds by lowering water clarity and increasing the abundance of epiphytic algae and certain types of green algae, such as Ulva sp. However, there are a lot more human activities that impact and degrade seagrass habitats worldwide. Dredging can cause sediment plumes that suffocate seagrass beds, intertidal seagrass beds can be damaged by anchoring and prop scars, and overfishing can cause changes in the food web propagating all the way

TOPIC	QUESTION	RESPONSE
		down to the level of seagrass beds.
Benthic Communities	Is the bivalve *Parvilucina* that was shown earlier in the presentation, a taxa that is generally tolerant of low dissolved oxygen conditions?	No, they are a taxa that are moderately tolerant of pollution and like areas of nutrient enrichment; for example in areas with higher sewage input. We are seeing an increase of *Parvilucina* in those areas and over time.
	Are there good indicator species that we can focus on?	Yes there are several, but only *Parvilucina* was included in the presentation.
	In areas where you found *Parvilucina*, were there indications of increased organic enrichment in the sediments? It seems organic particulate loading has been going down with advanced wastewater treatment improvements over the last	As part of the marine sediment monitoring program, Ecology has not monitored to address organic enrichment. The particulate pilot study may be a start to help get at that question. We do not have the data to compare *Parvilucina* with organic enrichment. However, *Parvilucina* has been associated with organic enrichment by the Coastal Water Research Project in Southern California with increased densities near outfalls. In the Sound we are seeing increases in abundance over the last 20 years. These increases are occurring in areas where human populations are rapidly growing such as South Sound, Central Sound, and the Skagit area.
Modeling	Can you include vessel discharge and net pens into the Salish Sea Model? I'm sure they are a large or significant source.	We are looking into including net pens in the model and will depend on loading information/data being developed by NOAA. The model will help determine the level of significance for these sources relative to others. Due to the spatial and temporal variability of vessel movement, we currently do not have the capacity to include vessel discharge in the model.
	Does the Frasier River flow rate alone influence residence times shoreward of Admiralty Inlet, or is it only Puget Sound River flows (and ocean inputs) that influence residence times?	No, the Fraser river is not the only river that influences residence times shoreward of Admiralty Inlet. The relative influence of different freshwater inflows on residence times (Fraser river, other Puget Sound rivers) varies over time and space in Puget Sound. Puget Sound watershed inflows are also important and also play a significant role in circulation and residence time for marine waters in Puget Sound.
	West Point Treatment Plant was offline	Yes, we plan to run a 2017 model run with the nutrient loading to simulate

TOPIC	QUESTION	RESPONSE
	for weeks and months, with no pollution removal. Can this additional nutrient loading be evaluated by the Salish Sea Model?	the West Point incident.
	Budd Inlet TMDL model indicated external nutrient sources are 2nd largest contributors to low dissolved oxygen after Capital Lake dam. How will the Salish Sea model be used to calculate WLAS?	The Budd Inlet TMDL will identify what the boundary condition for external sources to Budd Inlet need to be in order to meet water quality standards in Budd Inlet. The Puget Sound Nutrient Source Reduction Project will use the Salish Sea Model to ensure that nutrient reduction solutions will meet that boundary condition for Budd Inlet as well as improving water quality in other parts of Puget Sound so that the sum of human sources do not lower DO by more than 0.2mg/L.
	In 1995, the PS/Georgia Basin Task Force evaluated then correct nutrient loadings and estimated future loadings due to population growth. These estimates showed that the increase in nutrients removal due to secondary treatments would be completely offset by increased population growth and increased POTW loading. The Salish Sea model should be used to test/verify those results and estimate correct and future loading. Is this part of the plan? What about tertiary treatment? Will the model be used to evaluate treatment now and into the future?	Yes, a 2011 report (Ecology Publication #11-10-060) looked at costs to add tertiary treatment. We will run model scenarios that include point source nutrient loading from WWTPs under tertiary treatment. We will be using that information plus info from permittees to look at possible solutions, run scenarios to evaluate how well those solutions meet our water quality goals, and find a balance between solutions that provide the most impact for the environment and cost of solutions so that we strategically invest in solutions that work.
	How does the Puget Sound/Salish Sea Model scale down to the bay or inlet level? How accurate are inferences made from the model at that scale?	The current model scale provides adequate resolution at the inlet scale (please refer to Pelletier et. al 2017a and 2017b for overall model skill). We are currently in the process of refining the model grid to evaluate finer scale patterns in south and central Puget Sound. We expect that this will improve

TOPIC	QUESTION	RESPONSE
		predictions at the nearshore scale, but will have to see how well the model performs. We also have a concurrent modeling effort for Budd Inlet that is specifically being used for the Budd Inlet TMDL.
	How do we connect the Salish Sea Model to freshwater systems?	We have included freshwater inflows from all watersheds entering into the Salish Sea model via rivers and streams (Mohamedali et al, 2011).
	There is work that outlines how/what it takes for water to intrude into Puget Sound. Will the model look at this?	The model simulates all the relevant circulation patterns, including water intrusion into Puget Sound. However, we have not yet looked closely at specific intrusion events, but can query the model outputs at specific times/locations, and analyze results further.
	With issues like climate change, what changes will be considered the processes we have based our predictions on?	We're not sure we understand the question, but we will be running future scenarios in the Salish Sea model that include changes in river flow, temperature, etc. due to climate change as well as population growth.
	Can the Atlantis model run a scenario without all human inputs?	The Atlantis model can evaluate a baseline scenario with zero anthropogenic nitrogen inputs. However, it would be hypothetical and include some untestable assumptions, but it could be informative on a qualitative level.
Marine Species Survival	Are jellyfish and *Noctiluca* now the largest total mass of biological organisms in the water column? Is our future given current trends a die-off of salmon and an explosion of these organisms?	*Noctiluca* biomass is difficult to study with present field sampling methods, and current sampling programs are studying jellyfish biomass only in Skagit Bay. We don't know that jellyfish and *Noctiluca* in fact have the highest biomass in pelagic waters of Puget Sound, but data from NOAA/NWFSC suggest that warm years yield more jellyfish, particularly 2005 and 2015 (see PSEMP Marine Waters 2015 Overview). *Noctiluca* stands for a group of microzooplankton grazers that are important in the food web and we have very little data about them. One of the key missing pieces of understanding the dynamics of the lower food web is primary productivity and food web dynamics. For jellyfish, if they ever are the most abundant biomass pool, it is probably in fairly localized areas and may be more abundant in warmer years.

TOPIC	QUESTION	RESPONSE
		It is also unclear at this time how these species will affect salmon populations. Ecosystem models, such as Atlantis, may help in clarifying these questions.
	How are we going to deal with new species moving in?	Past monitoring within Puget Sound and other large Pacific Coast estuaries can help provide insight into which species are likely to expand their ranges into Puget Sound.
	Are salmon preyed upon by larger species when they go out into the sea? Is this accounted for in the Marine Species Survival model?	Yes, predation by marine mammals, fish, and birds has been incorporated into existing models and will be incorporated into Atlantis.
Other	Is there any accounting for the historical structure, function and process of estuarine wetlands in mediating nutrients and providing habitat in the Salish Sea/Puget Sound ecosystems?	Estuarine wetlands promote denitrification processes. There are existing programs and activities to protect and restore estuarine wetlands. We will consider the ecological benefits that restored estuarine wetlands provide to nitrogen and carbon reduction, but modeling may be constrained by a lack of performance data.
	What timeline can we expect for the WWTP to increase treatment?	Some municipalities are already looking at their options. We are concurrently developing our permitting strategy which will provide certainty for permittees and make it clear how we will proceed with any potential changes for NPDES permittees. The strategy will account for 5 year permit cycles and how we sequence improvements over multiple permit cycles. Wastewater management decisions and targets will be evaluated with the Salish Sea Model to provide certainty on the efficacy of potential solutions so we invest in the right kinds of solutions. It is likely that nutrient reductions will need to come from both point and nonpoint sources both within watersheds and from discharges directly to Puget Sound.
	How do we approach climate change in the future with past scenarios and models that did not account for climate	Past Salish Sea Model scenarios represent the weather/climate for the year(s) the model is run. For future climate change scenarios, we will be using down-scaled regional

TOPIC	QUESTION	RESPONSE
	change during that period?	climate models produced by the Washington Climate Impacts Group to make sure we are using the correct input variables for future climate impacts and will be rerunning the model to evaluate any revised outputs. Climate change will have significant impacts on water quality in Puget Sound, especially regarding water circulation. We recognize the importance of coming up with solutions that will also account for climate change and that will help Puget Sound be resilient to those impacts during years when the effects are greatest.
	Please speak to expected sea level rise and its influence on nutrient loading, dissolved oxygen and residence times. (Climate change issues addressed in presentations seemed specific to river inputs.)	Climate change is having a greater impact on vulnerable areas of Puget Sound. Sea level rise will be a factor for wetland habitat and infrastructure that is within areas of potential inundation. The impacts on reduced summer streamflows from climate change has a more significant impact on circulation and residence time in Puget Sound compared to sea-level rise
	How do you account for the increase in agricultural loading influence when the rate we are losing agricultural lands is increasing and producers are increasingly using no-till and other best management practices? Also, many agricultural lands are adding habitat restoration and reducing nutrient influences.	The presentation on nutrient loading into the Salish Sea model did not show *increasing* agricultural loading, it was simply a snapshot in time comparing annual contributions of nutrients from different human land use activities on a per unit area basis (kg N/area). The values were based on a 2011 study that monitored nitrogen loads in stormwater runoff from watersheds with predominantly one type of land use (agriculture, residential, industrial/commercial and forested). Results showed that agriculture contributed more nitrogen per unit area than the other land uses, but did not look at upward or downward trend over time in these contributions Future land use projections show that as the population of Puget Sound increases, we will likely see an increase in residential areas, and actually little change in agricultural areas, and even a decrease in some areas like you point out.

4. Next Steps

The Washington Department of Ecology will be conducting project scoping and stakeholder outreach from July through December in 2017. The information gathered during this time will be used to inform the kickoff of a Nutrient Implementation Strategy development process that will be integrated with other Puget Sound recovery strategic initiatives in support of the Puget Sound Action Agenda.

The primary project objectives are to develop and implement a Puget Sound Nutrient Source Reduction plan that will guide regional investments in point and nonpoint source nutrient controls so that Puget Sound will meet DO water quality criteria and aquatic life designated after the plan has been implemented.

One of the key outputs of the Nutrient Implementation Strategy will be key nutrient reduction actions, evaluated for efficacy by the Salish Sea model, that will necessary to meet our water quality objectives.

To learn how you can get involved, please contact the project manager:

Dustin Bilhimer
WA Department of Ecology, Water Quality Program
(360) 407-7143
Dustin.bilhimer@ecy.wa.gov

APPENDIX A: Workshop Agenda

Schedule	Topic	Presenter
8:15 – 9:00am	Registration and Networking	
9:00 – 9:30am	Welcome and Introduction Opening Remarks	Sarah Brace, Facilitator, Veda Environmental Heather Bartlett, Ecology
9:30 – 9:45am	What is the Puget Sound Nutrient Source Reduction Project	Dustin Bilhimer, Ecology
9:45 – 10:15am	Nutrient and phytoplankton trends and ties to climate in central Puget Sound	Kimberle Stark and Stephanie Jaeger, King County
10:15 – 10:30am	*Break*	
10:30 – 11:00am	Changes in Puget Sound from Ecology's long-term marine water quality monitoring program	Christopher Krembs, Ecology
11:00 – 11:30am	Impacts of excessive nutrients on eelgrass and kelp	Bart Christiaen, DNR
11:30pm – 12:30pm	*Lunch- Will be available for purchase in the college cafeteria or bring you own*	
12:30 – 1:00pm	Regional declines in Puget Sound benthic communities	Sandy Weakland, Ecology
1:00 – 2:00pm	Salish Sea Model Panel • Salish Sea Model Framework • Salish Sea Residence Time • Nutrient loading in the Salish Sea model • Current Model results	Cristiana Figueroa-Kaminsky, Ecology Tarang Khangaonkar, PNNL Anise Ahmed, Ecology Teizeen Mohamedali, Ecology Greg Pelletier, Ecology
2:00 – 2:10pm	Break	
2:10 – 2:55pm	Salish Sea Marine Survival Project- The role of nutrients in Puget Sound food webs: insights from empirical and modeling studies	Correigh Greene and Chris Harvey, NOAA
2:55 – 3:45pm	Q&A Panel: this will be an opportunity for open questions between audience members and presenters. Questions will be collected throughout the day on notecards and the audience can ask questions about the science, potential challenges, data gaps, and where we are headed.	Sarah Brace and all previous speakers
3:45 – 4:00pm	Closing remarks	Sarah Brace and Dustin Bilhimer
4:00pm	Adjourn	

APPENDIX B: List of participants

Staff from the following organizations were registered to attend this workshop:

- Brown and Caldwell
- CH2M Hill
- City of Federal Way
- City of Tacoma
- Deschutes Estuary Restoration Team
- Earth & Space Research
- U.S. Environmental Protection Agency
- HDR Engineering
- Jamestown S'Klallam Tribe
- King Conservation District
- King County
- Long Live the Kings
- LOTT Clean Water Alliance
- Midway Sewer District
- Muckleshoot Tribe
- NOAA Northwest Fisheries Science Center
- Northwest Environmental Advocates
- Northwest Indian Fisheries Commission
- Office of Governor Inslee
- Pacific Science Center, Mercer Slough Environmental Education Center
- Pierce Conservation District
- Pierce County
- Pacific Northwest National Labs
- Public Health Seattle
- Puget Soundkeeper Alliance
- Puyallup Tribe
- Seattle Audubon Society
- Sierra Club & Olympic Environmental Council
- Snohomish County Beach Walkers
- South Seattle College Arboretum
- Suquamish Tribe
- University of Washington Tacoma
- USGS Washington Water Science Center
- Veda Environmental
- Washington Department of Health
- WA Department of Ecology
- WA Department of Natural Resources
- WA Department of Fish and Wildlife
- Washington Environmental Council
- Washington Sea Grant
- Sierra Club Washington State Chapter
- Wild Fish Conservancy
- Washington State University Snohomish County Extension

APPENDIX C: Resources

Speaker Biographies can be found in the Puget Sound Nutrient Dialogue Presentation Info and Speaker Bios handout available on the project webpage here: http://www.ecy.wa.gov/puget_sound/reducing-nutrients.html

Programs/projects:

- Ecology's Puget Sound Nutrient Source Reduction Project: http://www.ecy.wa.gov/puget_sound/reducing-nutrients.html
- King County's Nutrient and Plankton Monitoring Program: http://green2.kingcounty.gov/marine/
- Ecology's Water Quality Monitoring Program: http://www.ecy.wa.gov/programs/eap/pscoastalintro.htm
- Ecology's Benthic Monitoring Program: http://www.ecy.wa.gov/programs/eap/psamp/
- DNR Eelgrass and Kelp Project: http://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science
- NOAA's Marine Survival Project: http://marinesurvivalproject.com/
- Salish Sea Model: http://www.ecy.wa.gov/programs/wq/PugetSound/DOModel.html OR http://salish-sea.pnnl.gov/

Maps and other information:

- Ecology's Water Quality Atlas: https://fortress.wa.gov/ecy/waterqualityatlas/StartPage.aspx
- DNR Eelgrass Data Viewer: http://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/puget-sound-eelgrass-monitoring-data-viewer

References for reports and publications cited or referred to in the presentations:

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Speaker Biographies can be found in the Puget Sound Nutrient Dialogue Presentation Info and Speaker Bios handout available on the project webpage here: http://www.ecy.wa.gov/puget_sound/reducing-nutrients.html