SCHOOL OF AQUATIC AND FISHERY SCIENCES
UNIVERSITY of WASHINGTON

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Eleanor Ott, PSNGP Permit Writer
Department of Ecology
Water Quality Program
PO Box 47600
Olympia, WA 98504-7600

Regarding: Puget Sound Nutrients General Permit, Preliminary Draft

Introduction & Background

The Washington State Department of Ecology (hereafter Ecology), intends to implement the Nutrients General Permit on the basis that the state's water quality standard of is not being met due, in part, to nitrogen discharge from wastewater treatment plants (WWTP). Statements A and B given below are two of the relevant sections from the preliminary draft document.

Statement A (Page 1, Section IIA):

> "Ecology's application of the Salish Sea Model (Khangaonkar et al., 2018) as presented in the Bounding Scenarios Report (Ahmed et al, 2019) has shown that nutrients discharged from domestic wastewater treatment plants (WWTPs) contribute to the low dissolved oxygen levels, below state water quality criteria, in Puget Sound. Therefore, Ecology must require wastewater treatment plants to control nutrients consistent with the Clean Water Act and Washington's Water Pollution Control Act."

Statement B (Page 7, Section IIIA):

> "The SSM confirmed that these discharges have reasonable potential to cause or contribute to the D.O. impairment."

Both statements clearly state that Ecology used its implementation of the Salish Sea Model (SSM) to determine: a) the dissolved oxygen water quality standard is not being met, and b) WWTP are contributing to this non-compliance. These two factors are the basis for the Nutrients General Permit and, as such, questions about the SSM and the compliance determination process are relevant to Nutrients General Permit under consideration. Myself and other scientists with relevant expertise have challenged Ecology's assertion that the SSM is sufficiently precise and accurate to determine compliance to standard. In short, these scientists believe that model uncertainty in predicting natural conditions is too large to say that the standard is likely not being met. Ecology, of course, disagrees and cites model performance comparable to the Chesapeake Bay model and extensive peer-review as sufficient evidence to conclude model results are valid.

The Nutrient Forum has been the primary venue by which Ecology has engaged with the scientific community with regard to the SSM. On 9 March 2021, two talks were given in the Nutrient Forum as a "refresher course" on the regulatory models and using the SSM to manage nutrients. Both talks emphasized that Ecology's use of the SSM to determine compliance to the

Box 355020 Seattle, WA 98195-5020 (206) 616-7041 FAX: (206) 685-7471 email: gholt@uw.edu

DO standard is robust because of the extensive peer-review the model has undergone. Extensive peer-review has been, and remains, a primary justification used by Ecology for dismissing concerns by myself and others related to the use of the SSM to determine compliance. Peer-reviewers were listed on slide two of the talk by Anise Ahmed. There was a total of 16 reviewers listed. These individual were affiliated with the National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, King County, Pacific Northwest National Lab, Washington Department of Ecology, and the University of Washington at the time of their reviews.

Finally, Statement C given below is inaccurate.
Statement C (Page 7, Section IIIA):

> "About 70% of the nutrient load comes from domestic wastewater treatment plants (WWTPs, or plants, or facilities) discharging to Puget Sound and the estuarine areas during the critical warmer season when D.O. impairments occur."

Analysis
Statements A and B both assert that the scientific methods presented in Ahmed et al (2019) can determine scientifically whether the dissolved oxygen standard is being met in the Puget Sound. However, Ahmed et al. (2019) inappropriately quantifies models uncertainty in the analysis, with only minimal effort to communicate that uncertainty, and thereby leads to a general overconfidence that nutrients are in fact a meaningful problem in the Puget Sound. Note that a previous commentary by this author, submitted to Ecology and the Puget Sound Partnership, highlighted a number of statistical assumptions and decisions that should be revisited in order to accurately quantify model uncertainty. The details will not be listed here other than to say that initial reanalysis of the modeling data suggests that uncertainty in the results are on the order of 4 times greater than the 0.2 mg/L dissolved oxygen standard that the model aims to detect. Put another way, the margin of error in the results exceeds the standard by around 400%. When the uncertainty in the model results is much greater than the target value you aim to detect, it is impossible to conclude there is a "reasonable potential" of human nutrients impacting dissolved oxygen in excess of the standard. The numbers quoted here are approximate because their determination involves multiple subjective decisions that should have been clearly stated in Ahmed et al. (2019) but were not. The statistical aspects of the data analysis should have been reviewed in detail by independent experts, but was not.

Regarding the peer-review process as an indicator of the scientific robustness of the DO compliance determination, it is important to note that nearly all of the reviewers listed in the talk on 9 March 2021 have significant conflicts of interest. Seven of the 16 reviewers were/are employees of Ecology. Three reviewers were/are from U.S. EPA, who funding part of the work and had employees directly involved in the science. The individual from PNNL was the original model developer with vested interest in applications of the model. Two reviewers were from King County, which is one of the municipalities being regulated under the General Nutrient Permit. That leaves three reviewers without conflicts of interest, one from NOAA and the others from the University of Washington. The reviewer from NOAA, Simone Alin, has expressed to me that she is uncomfortable with being designated as a reviewer because she reviewed only a small part of the model and paid no attention to the dissolved oxygen components (personal

communication[1]). This leaves two of 16 listed reviewers without known conflicts or concerns. Selecting reviewers without conflicts of interest is a critical part of the peer review process because it helps to remove biases when evaluating methods and results. When determining whether or not a piece of scientific work is technically robust and results are sound, it is standard practice to use only unconflicted reviewers. More independent review of the work is needed.

Statement C referenced above is incorrect and gives the impression that WWTP contributes proportionally far more dissolved organic nitrogen (DIN) to Puget Sound than they do. Furthermore, this statement should come with a citation of the data source. Ecology's own report clearly states that, in the Puget Sound and Strait of Juan De Fuca, natural oceanic DIN is 79% of the total DIN (68% south of Deception Pass; Mohamedali et al. 2011). The remaining 21% is from human sources, which includes point and non-point sources. Of the human DIN, approximately 70% is from WWTP, which is back calculated to be 14.7% of the total DIN (0.7 X 0.21 = 0.147 = 14.7%).

Conclusions

It is my professional opinion that Ecology has not made a scientifically defensible case that human nutrients, including those from WWTP, are contributing to dissolved oxygen declines in the Puget Sound. More specifically, the research presented in Ahmed et al. (2019) fails to show that their use of the Salish Sea Model can reliably detect human-induced changes in dissolved oxygen within the range of the 0.2 mg/L standard. As such, Statements A and B above are incorrect, as are any other statements implying that the application of the SSM has demonstrated "reasonable potential to cause or contribute to the D.O. impairment." If Ecology has failed to demonstrate there have been impacts of humans on dissolved oxygen such that the standard is not being met, then it is also not possible for them to demonstrate that WWTP are the cause of dissolve oxygen declines, leaving no basis for the proposed changes to the Nutrients General Permit. My professional opinion is that it may be possible in the future to robustly demonstrate that nutrients from WWTP are resulting in violations of the dissolved oxygen standard, but this will require additional analysis using different methodologies than those presented within Ahmed et al. (2019). Furthermore, a more thorough and independent review of Ecology's use of the SSM in determining compliance to the DO standard is necessary.

Recommendations with Regard to Water Quality Compliance Determination

1. Revise Ahmed et al. (2019) to include the model uncertainties in a transparent and scientifically-defensible way that specifically includes the range of likely values (i.e., confidence intervals), not just a single number, for each model-generated result. When determining compliance to the dissolved oxygen standard, present the areas deemed to be out of compliance with an associated type I error probability. That is, specify quantitatively both the best estimate of the model and the expected probably of that estimate being incorrect. State explicitly the acceptable level of type I error for compliance determination and the basis for that decision.
2. Solicit an independent review of the science related to compliance standards and incorporate all relevant suggestions into a new presentation of results. The Washington State Academy of Sciences frequently conducts this type of scientific review for issues of high policy

[1] It should be noted that Gordon Holtgrieve and Simone Alin are a married couple.

importance such as this. It is therefore recommended that Ecology requests a full scientific review from the Academy.

3. Statement C should be revised to reflect WWTP contribution to the total DIN pool, including natural and human sources, as per Mohamedali et al. (2011).

Sincerely,

Gordon W. Holtgrieve
H. Mason Keeler Associate Professor
School of Aquatic & Fishery Sciences
Center for Quantitative Science
University of Washington

Qualifications of Commenter

I am the H. Mason Keeler Endowed Associate Professor in the School of Aquatic and Fishery Sciences at the University of Washington. I also hold an appointment with the Center for Quantitative Science, where I participate in undergraduate and graduate programs in mathematics and statistics for natural resources. My scientific expertise is in aquatic biogeochemistry of oxygen, nitrogen, and carbon. I have published over 50 peer-reviewed journal articles, book chapters, and technical reports. One of my most cited papers, Holtgrieve et al. (2010; 122 citations), presents a mechanistic model of diel dissolved oxygen dynamics to calculate rates of ecosystem metabolism and quantify uncertainties; this model is the current gold-standard methodology. I am also an invited member of the Washington Ecology and Puget Sound Partnership Marine Water Quality Implementation Strategy (MWQ IS) Interdisciplinary Team (IDT).

Given my expertise in biogeochemical modeling and statistics and the previous invitation to be involved in the IDT process, I believe I am highly qualified to comment on issues related to modeling of nutrients and dissolved oxygen in Puget Sound. I further declare no conflicts of interest in presenting this comment for your consideration. As tenured faculty, my employment with the State of Washington is not contingent in any way on the outcome of this General Nutrient Permit. I have also never taken payment of any kind for my work on this issue.

References Cited

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