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Impacts of Combined Sewer Outflow Overflows on Dissolved Oxygen and Turbidity in Possession Sound

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Predictive Model of Combined Sewer Outflow Overflow Impacts on Dissolved Oxygen and Turbidity in Possession Sound

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Introduction

Combined Sewer Outlet (CSO) overflows pose a threat to water systems and have been shown to have negative impacts on dissolved oxygen (DO) and turbidity – two important measures of water quality. In an important ecosystem such as Possession Sound, knowing these impacts is an essential part of monitoring water quality. This research intended to make a predictive model of the impacts of CSO overflows on DO and turbidity to make analysis simpler using variables that have been established in similar research studies.

Study Site

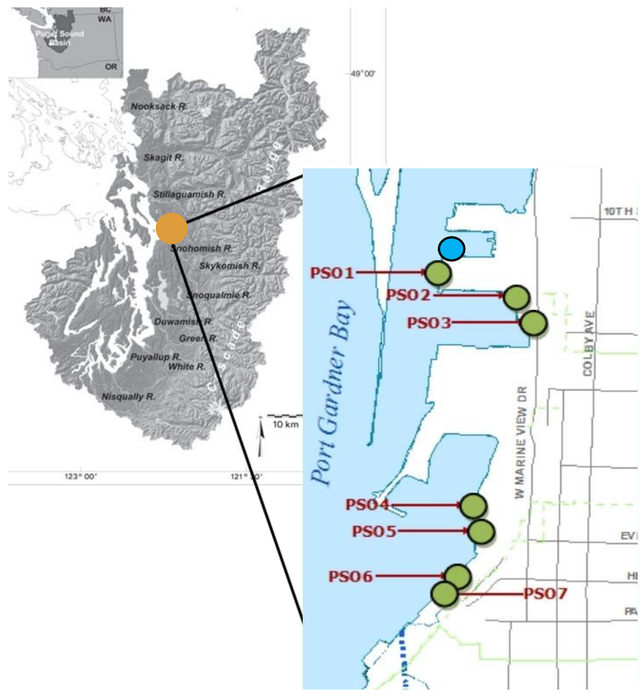


Fig. 1 Map showing Puget Sound (left) with Possession Sound marked by an orange circle ●. The close up of the Snohomish River Estuary system in Possession Sound (right) shows the Puget Sound Outfall (PSO) CSOs in green ● and the Everett Marina CTD in blue. ●

Methods

DO and turbidity data were collected over 2019 from a CTD stationed in the Everett Marina. CSO overflow volume, dates, and duration data were collected from the City of Everett's 2019 Combined Sewer Overflow Event Report. From the background research, four variables were selected to make the models for DO and turbidity:

- Combined volume of discharge from CSO overflows
- Longest duration of an overflow
- Average duration of an overflow from all overflowing CSOs
- Precipitation

A Principal Component Analysis (PCA) was conducted. Using the first 2 components in both data sets, which covered over 90% of the variability, a model was made for both DO and turbidity.

ORCA

The Ocean Research College Academy is a dual enrollment program where high school juniors and seniors experience innovative, interdisciplinary and student-centered learning. A longitudinal study of the local estuary forms the backbone of the first-year experience, and leads students to conduct independent research in their second year of the program. ORCA has received grants for a research lab, research vessel, and summer research funded by the National Science Foundation.

Results

Figure 2. Predicted versus Test DO data

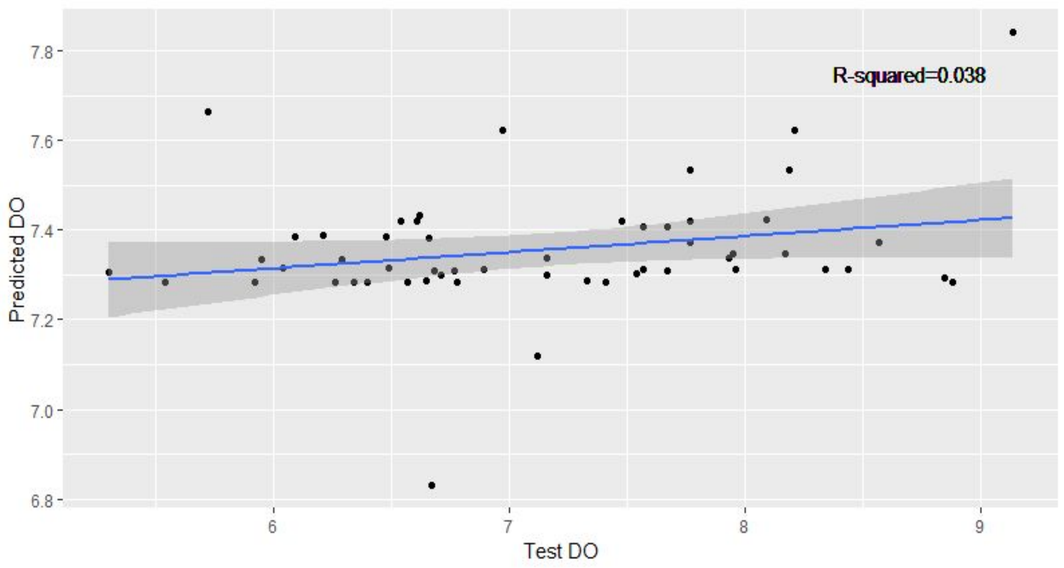


Figure 3. Predicted versus Test turbidity data

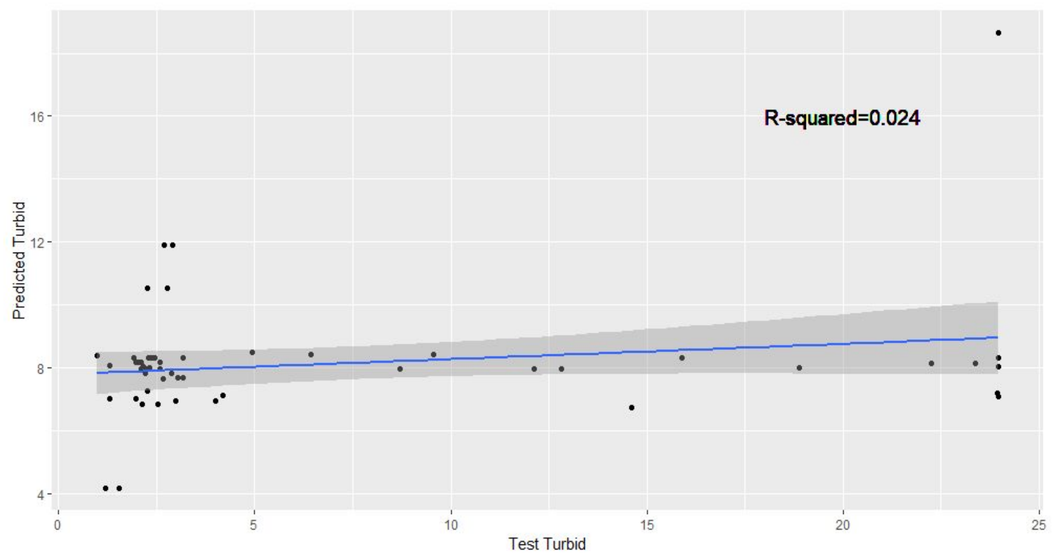


Figure 4. PC 1 and PC 2 for DO

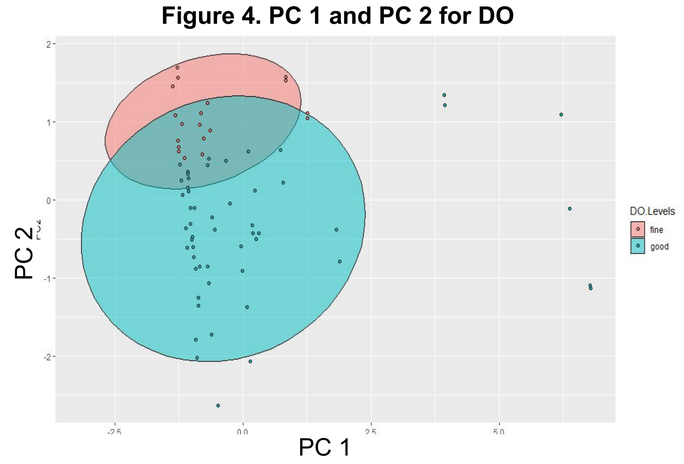
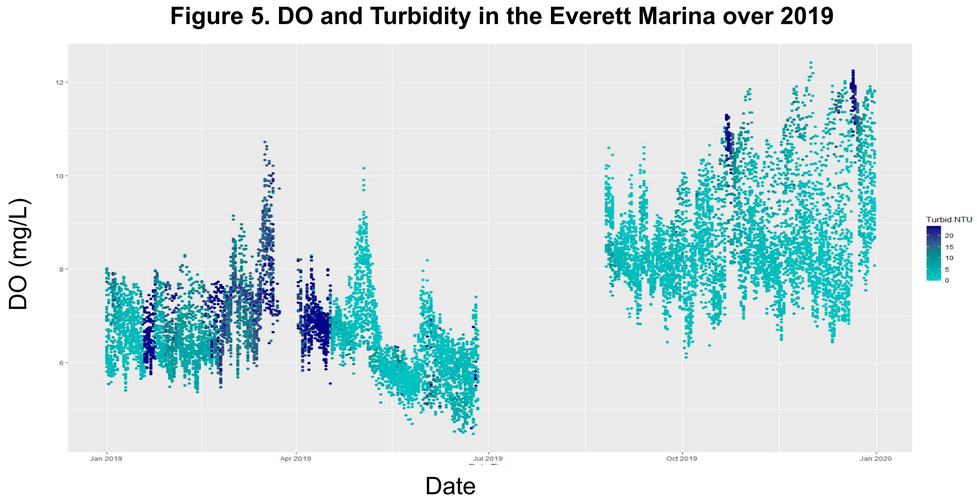


Figure 5. DO and Turbidity in the Everett Marina over 2019



The models based on these variables do not appear to be accurate to the test data. Both graphically represented models, with linear models overlaid with their corresponding R^2 values, support this.

Fig 2. Predicted dissolved oxygen from the PCR model visualized with the test dissolved oxygen values and a trendline which covers 95% of the data. According to this model, there is nearly no correlation between the modeled and test values, the R^2=0.038.

Fig 3. Predicted turbidity from the PCR model visualized with the test turbidity values with a trendline which covers 95% of the data. According to this model, there is nearly no correlation between the modeled and test values, the R^2=0.024. Slightly less correlation from the dissolved oxygen model.

Fig 4. Principal component (PC) one and two for the dissolved oxygen PCA compared. The colored ellipses cover 95% of the variability, the blue representing "good" DO levels and red is poorer or "fine" DO levels. This graph shows the accuracy of the PCA and subsequent PCR based on these first two principal components. A similar process was performed for the turbidity PCA.

Fig 5. Dissolved oxygen compared to turbidity from the Everett Marina CTD over the year of 2019. The time when the CTD was non functional is reflected in the gap in the data set. There is a large correspondence between DO and turbidity during the spring, likely due to phytoplankton blooms.

To-Date Summary

The PCR based models for turbidity and DO using CSO-related variables do not appear to match the test data in any statistically significant way. There is nearly no correlation between the predicted and test values. This may be due to the severely limited data available and the difference in the water system from the river system in Poland, where the original study was conducted, versus the Possession Sound estuary. The data available in the original study was from a far larger time span, and the sensors were mounted directly on the CSOs. There is also a seasonal impact on DO and turbidity (as shown in Figure 5) which is not accounted for in the model.

In future research, this seasonal impact should be further accounted for, and data collection made more effective by proximity to the CSOs over a larger time span. In addition, an investigation into the bacteria released during a CSO overflow could provide important insights into the true impact of CSO overflows on the Possession Sound estuary and wider Puget Sound.

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