Uncovering the Effects of Combined Sewage Overflows on New York City Wetlands

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Introduction

Wetlands, such as salt marshes, are ecosystems where land meets water that is present at varying times.[1] These wetlands filter out harmful concentrations of nutrients such as nitrates and phosphates.[2] Urbanization in New York City, however, can pose significant threats to the preservation and function of these ecosystems. One such threat is combined sewage overflows (CSOs), which are a product of the city's sewage infrastructure. When a heavy storm occurs, stormwater combines with untreated wastewater, leading to an overflow where untreated waste discharges into surrounding waterways. Considering there are approximately 400 CSOs located throughout the city, discharge can flood local wetlands, potentially threatening their function as "nature's kidneys"[3] in NYC.

Although a few isolated restoration efforts have mitigated some negative effects of CSOs, most of the city's wetlands remain unprotected. Through our research, we hope to uncover the negative effects of CSOs and relay the importance of further efforts to preserve wetlands.

Research Questions & Hypotheses

Research Question: How does proximity of the closest CSO discharge site affect water quality of the wetland?

Nitrate and phosphate levels will decrease as distance from CSO discharge site increases.

How do dissolved oxygen (DO) levels affect pollution-tolerant fish[4]?

As DO decreases, the average abundance of killifish will increase.

How does the proximity of a CSO affect bird diversity?

As distance from CSO site increases, bird diversity increases.

How do nitrate and phosphate concentrations at a remediated site differ from non-remediated sites?

Nitrate and phosphate concentrations will be greater at non-remediated sites compared to Udall's Cove, a remediated site.[5]

Methods

Water Quality

- We used LaMotte Water Quality kits to test water samples for pH, nitrates, phosphates, dissolved oxygen, carbon dioxide, and silica.
- We also used a handheld refractometer to determine salinity.

Figure 1. Students measuring water quality indicators

Bird Surveys

- We conducted point counts to find bird abundance and richness at each site. Two people used binoculars to observe and record birds within a 50 meter radius, at the beginning and end of every field day, for ten minutes each.

Fish Surveys

- We used a 20' X 4' seine net to catch marine organisms. Each seine lasted 5-10 minutes and organism species and abundance were recorded.
- We also caught fish with a minnow trap deployed for an hour at a time.

Figure 2. Students conducting bird counts.

Figure 3. Students using a seine net to catch fish.

Results

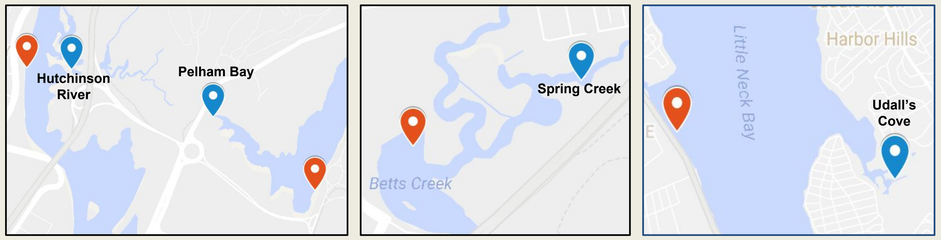

***Figure 4.* Maps of Wetland Sites and Closest CSO Discharge Sites.** In order from increasing distance to CSO: Hutchinson River (HR): 400 meters, Spring Creek (SC): 620 meters, Pelham Bay (PB): 836 meters, Udall's Cove (UC): 2570 meters. The blue pins represent the sampling sites and the red pins represent the location of the CSO discharge site. Distance between wetland site to nearest CSO was traced using Google Earth.

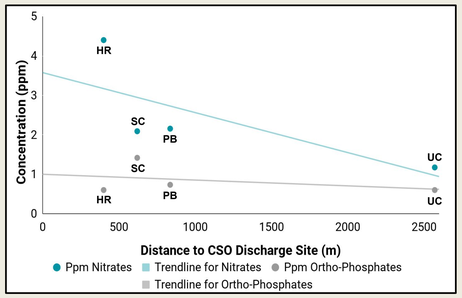

***Figure 5.* Relationship between Nitrates and Phosphates and Distance to CSO Discharge Site.** Both trendlines show negative correlations, suggesting that as distance to CSO increases, the levels of nitrates and phosphates decrease. Distance to CSO showed a stronger negative correlation with nitrates (r^2 = 0.537) than phosphates (r^2 = 0.139).

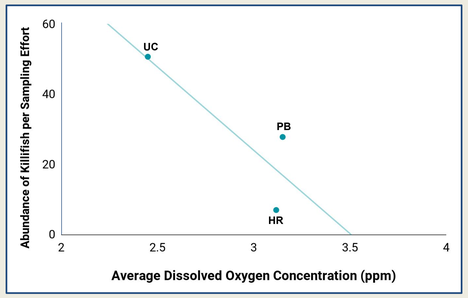

***Figure 6.* Relationship between Average Dissolved Oxygen and Average Abundance of Killifish.** The weak negative correlation (r^2 = 0.328) suggests abundance of killifish decreases with increased dissolved oxygen levels. Abundance at Spring Creek was omitted due to lack of data.

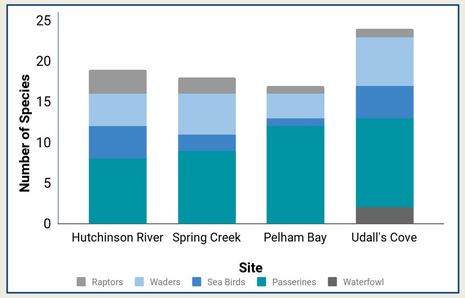

***Figure 7.* Species Richness of Birds in Wetland Sites.** Data from point counts were used to categorize birds based on the main groups of birds.

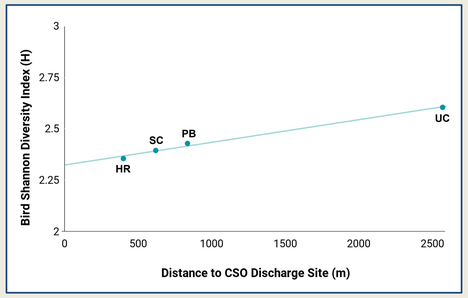

***Figure 8.* Relationship between Bird Shannon Diversity Index and Distance to CSO.** The strong positive correlation (r^2 = 0.991) suggests that as distance from CSO discharge site increases, bird diversity increases.

Figure 9. Udall's Cove at low tide[7]

Discussion

Water Quality

- We found that as the distance to CSO discharge site increased, the concentration of nitrates/phosphates at each site decreased (Figure 5). This moderate association supports our hypothesis, as it shows that wetlands that are closer to a CSO can be negatively affected by high levels of nitrates/phosphates. This could lead to eutrophication, and in turn, decreased DO levels and less species diversity.
- Unexpectedly, our data suggests that Hutchinson River has higher levels of certain water quality indicators, which did not support our hypothesis and is surprising, considering that it is closest to a CSO.

Fish

- We took the average abundance of killifish (mummichogs and striped killifish)[4] and found there to be larger populations in sites with lower levels of DO (Figure 6), supporting our hypothesis. The presence of killifish can indicate poor water quality, as they are known to survive in extreme water conditions, including low DO levels.
- We found the highest abundance of these pollution-tolerant fish[4] (Figure 12) at Udall's Cove, indicating low water quality, which is surprising considering it is a remediated site and also furthest from a CSO discharge site.

Birds

- The bird diversity was calculated using Shannon-Wiener Diversity Index[6], which incorporates species richness and abundance. Our hypothesis was supported as we found that more species of birds prefer to be around wetlands that are further away from a CSO (Figure 8). These wetlands have been found to have less nitrates and phosphates, which could possibly be better habitats for aquatic wildlife, in turn, attracting a greater diversity of birds for feeding.
- Avian composition of each site shows that Udall's Cove has the greatest avian species richness and most diverse representation of bird groups compared to the other three sites (Figure 7). Passerine birds represented the most common group at each site.

Remediated Site

- Our hypothesis was partially supported, finding that the remediated site (Udall's Cove), had the lowest concentration of nitrates. However, it also had the second highest concentration of phosphates, and lowest DO levels. These results are surprising, considering annual restoration efforts have been taking place at Udall's since the late 1960s.[5]
- Before determining Udall's has the lowest water quality, it is important to note that tide levels and weather could not be controlled, and further samples from this site could help establish the true concentrations of certain water quality indicators.
- Our results can be used to help the NYC Parks Department determine how they can better mitigate the effects of CSOs on NYC wetlands.

Figure 10. Juvenile Striped Bass (UC)

Figure 11. Atlantic Silverside (HR)

Figure 12. Mummichog (PB)

Future Research

In future research, the impact of CSOs on water quality could be further studied using coliform counts, which serve as indicators of human sewage. Additionally, we observed a pipe leaking into Udall's Cove, which, after measuring salinity, we suspect carries freshwater. We recommend investigating the possible impact of this leak.

Acknowledgements

We would like to thank WCS, NSF, and Fordham University for the opportunity to conduct this research. We would also like give special thanks to Dr. Jason Aloisio, Dr. Jason Munshi-South, Su-Jen Roberts, Jocelyn Harrison, Emily Casper, Julia Sese, and the whole CPZ team for their continuous help and support.

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