A Survey of Fish Diversity and Water Quality on Randall's Island

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Randall's Island sits between Manhattan and the Bronx, bordered by the Harlem River, East River, and Bronx Kill. Parts of the Island, such as the Little Hell Gate Salt Marsh, have recently undergone restoration efforts in hopes of repairing damages caused by the invasion of non-native species and dumping of construction debris. Beginning in 2008, restoration efforts sought to restore the island's salt marshes to their natural state through the removal of debris and invasive species. Despite this, the waterways surrounding the island are still regularly exposed to toxins from industrial pollutants, boat activity, and urban runoff, and the aquatic life that occupies them are thus subject to lower levels of water quality (Wang 2014). Changes in water quality parameters such as salinity, turbidity and dissolved oxygen can indicate higher levels of pollution in urban waters, and these factors have also been shown to be correlated with changes in fish abundance (Woodhead 1994).

Historically, urban fish populations have played an important role in the ecosystem of New York City, while also providing ecosystem services as sources of both food and recreational fishing. In recent years however, high levels of toxins have threatened both urban fish populations and the ability for humans to rely on them as a food source. Due to an increase in industrial activity around New York in the 1900s, high levels of chemicals such as polychlorinated biphenyls (PCBs) accumulated in the waters surrounding the city, which remain to this day. Such chemicals build up in the tissues of fish due to bioaccumulation, and when consumed by humans, can lead to neurological damage and developmental problems in children (Ramos et al. 2001). Furthermore, fish populations in NYC waters are exposed to other pollutants from urban water traffic (both recreational and industrial), and sewage leakage and combined sewer overflow from the city's out of date sewer system (Swetz). Thus, the NYC Department of Health advises that children under 15 and women planning on having children avoid eating most fish caught in the city's waters (NYCDOH).

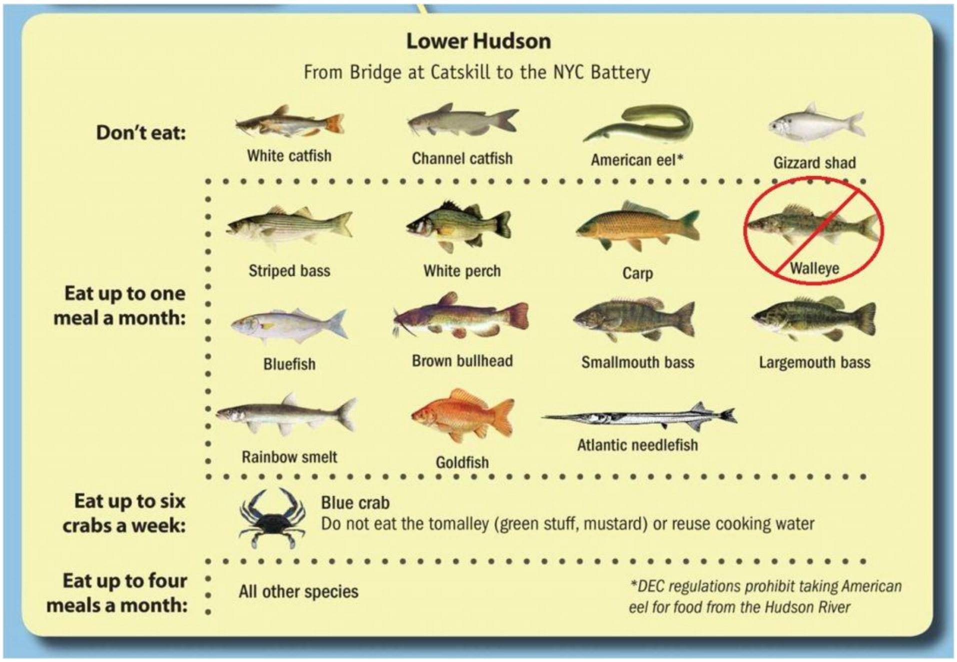


Figure 1: Health Advisory warning against eating fish caught in NYC waters (Hudson River Sloop Clearwater)

Aside from the health risks to humans, exposure of fish to toxins such as these also threatens the balance of the city's aquatic ecosystem, as many of NY state's fish species have become endangered in recent years, such as the shortnose sturgeon, silver chub, and round whitefish (DEC). Declines in populations of any of New York 's native fish species could have drastic effects on other species living in our waters, so better insights into what is causing their decline and how to manage such risks are essential in maintaining healthy ecosystems in our urban waters.

The purpose of this study was to better understand the ways in which decreased water quality (as measured by dissolved oxygen, water temperature, salinity, and turbidity) impact New York City's urban fish populations, and which fish species are most sensitive to changes in these measures of water quality. Using three sites on urban waterways surrounding Randall's Island, we conducted surveys of fish and water quality, and using the data collected, were able to analyze the relationship between urban fish species and water quality, in hopes of better understanding what aspects of water quality affect local fish populations and how they can be better protected.

Methods:

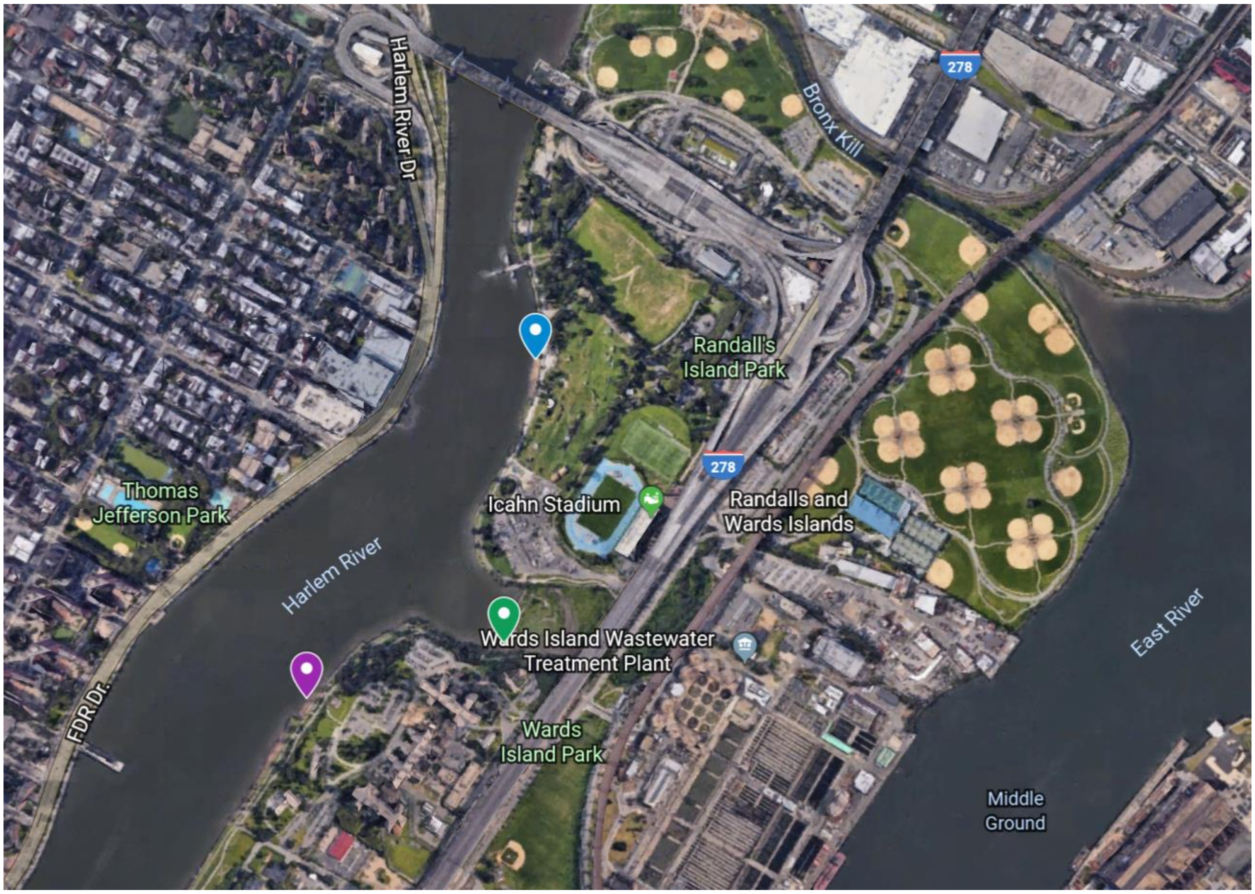
Materials:

1. One large seining net
2. Waders
3. One bucket
4. Turbidity tube
5. Salinity refractometer
6. YSI dissolved oxygen meter

Procedure:

Three sites on Randall's Island were surveyed; one on the Harlem River near the Randall's Island Event Lawn, another further south along the Harlem River, and one at the entrance to the Little Hell Gate Salt Marsh (Figure 2). At each site, measurements were taken after high tide on three separate days.

Figure 2: Site Map



- Site 1 (Little Hell Gate Salt Marsh)
- Site 2 (Event Lawn)
- Site 3 (Waterfront South)

On each survey date, each of the three sites were visited and one fish survey was conducted. This was done using a weighted seining net, which was carried by two people and dragged in a U-shaped path through the water, then pulled onto the shore. The net was then inspected, and all organisms found were placed in a bucket filled with water. Each organism was then identified, recorded, then released. While this survey was specifically interested in the fish species present in the water surrounding Randall's Island, other organisms such as crabs, jellyfish, snails, and shrimp were also recorded when found in the seining net.

Water quality measurements were taken at each site at the time of the fish survey. Measurements of salinity, dissolved oxygen and water temperature were taken using the salinity refractometer and YSI meter. A measurement of turbidity was taken using a turbidity tube, by filling the tube with water and slowly releasing the water until the disk at the bottom of the tube was visible, at which point the level of the water in the tube was recorded.

Results

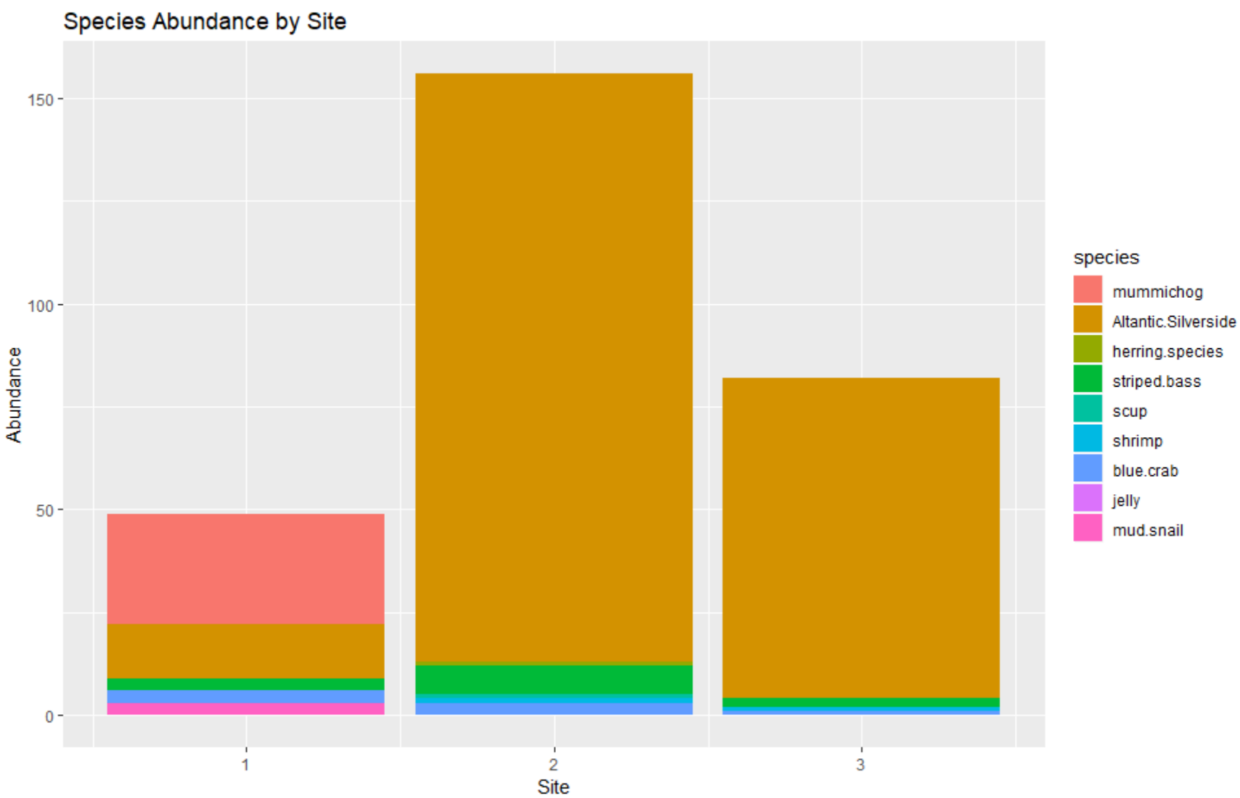


Figure 3: Abundances of Aquatic Species by Site

After summing all fish of each species found at each study site, there were a total of nine aquatic species found (five fish species and four other aquatic organisms, such as crabs, jellies, shrimp, and snails). The most abundant overall was the Atlantic silverside, with 234 individuals found over the course of the study. Silversides were the most common fish species found at sites 2 and 3, while the most abundant fish at site 1 was the mummichog, of which 27 individuals were found, but exclusively at this site. The next most abundant fish was the striped bass, which was found at each site, though only twelve individuals were found overall. Other fish found included a scup and an unidentified species of herring, of which only one were found over the course of the study.

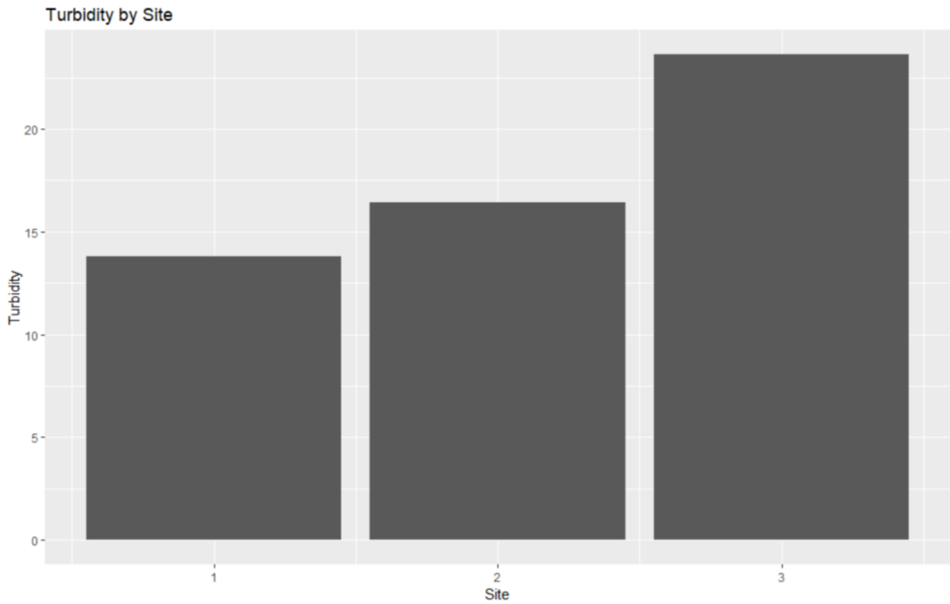


Figure 4: Average Turbidity at each survey site

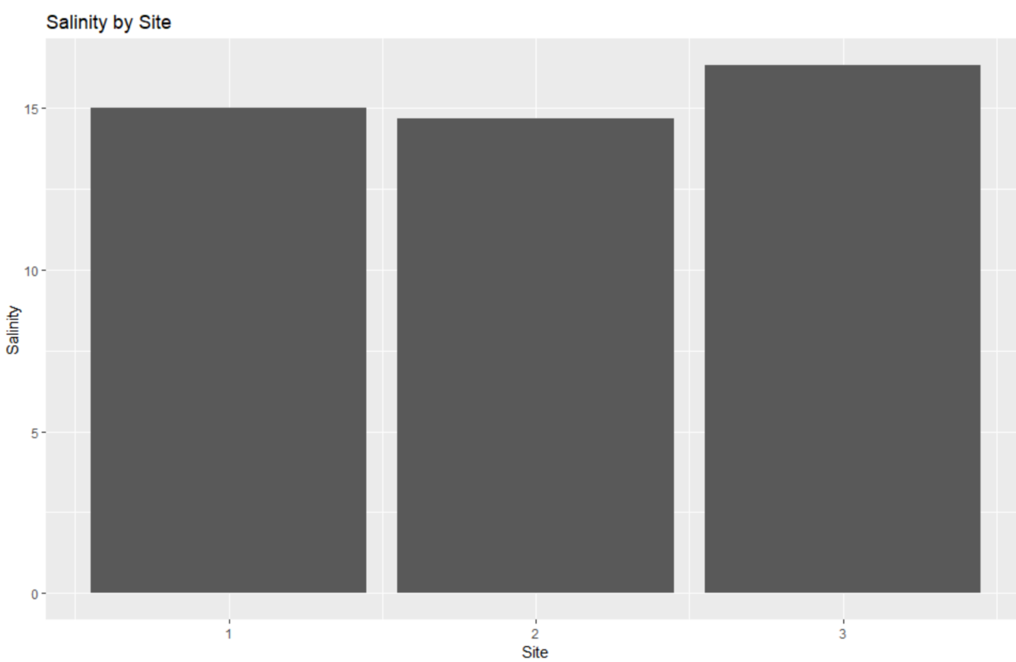


Figure 5: Average Salinity at each survey site

Figures 4 and 5 display the differences in turbidity and salinity at each site. Differences in dissolved oxygen and water temperature were negligible, and as shown in Figure 5, there was slight variation, yet no clear pattern of difference in salinity across the three sites. There was however a difference in average turbidity between sites, with site 3 (Waterfront South) having the highest average turbidity, followed by site 2 (Event Lawn), then site 1 (LGHSM).

As turbidity seemed to be the most likely water quality parameter to have had any effect on fish abundance, a correlation test was run, comparing turbidity to the abundance and Shannon diversity score for each survey date at each site. These tests resulted in correlation coefficients of -0.2584 and 0.4103 and P-values of 0.5021 and 0.2727 for turbidity vs abundance and turbidity vs. Shannon index score, respectively. Both P-values were far above the standard significance level of 0.05, suggesting that neither correlation was statistically significant.

Due to the small sample size and not normally distributed pattern of the data, a nonparametric analysis of variance (ANOVA) test was run for each variable by site. The P-values calculated from these tests are displayed below:

Variable	Abundance	Shannon score	Turbidity	Salinity	Dissolved Oxygen
P-value	0.6267	0.3935	0.3977	0.9654	0.9865

For all of these tests, the p-value was above the significance level of 0.05, which suggested that there was no statistically significant variation in any of these variables between each study site. Thus, possibly due to the small size of our sample, no statistically significant results pointing toward a difference in fish communities between sites could be obtained from this study.

Discussion/Conclusion

While none of the results of this study were shown to be statistically significant, there are still several important findings and points from which future studies may draw on, including the addition of a new seining site to the Randall’s Island Natural Areas team’s protocol, and the observation of a fish species not commonly found around the island.

Regarding the relationship between water quality and fish abundance and diversity, none of the measurements taken in this study were statistically significant enough to show a correlation between any of the water quality or fish variables studied. However, there was a visible difference between the types of fish found at Site 1 (LHGSM) and the other two sites along the Harlem River, as well an overall lower average turbidity at Site 1. In particular, the mummichog was the second most abundant fish species found in this study, yet all 27 individuals of this species were found at Site 1. While neither the measurements regarding the decreased turbidity or high mummichog population at Site 1 produced statistically significant data, these observations suggest that further research regarding turbidity and fish species is worth pursuing.

If there is a correlation between the abundance of mummichogs or any other fish species and lower turbidity levels, this information would be useful in better understanding which fish species are less tolerant to higher levels of sediment and decreased clarity in their habitats. Past studies have shown that turbidity can cause a variety of health problems in estuarine fish species. One such study found that increased turbidity can cause delayed hatching in striped bass and white perch, increased egg mortality in striped bass, American shad, yellow perch, and white perch, and inhibited feeding in Atlantic silversides and the larva of the Pacific herring (Wilber & Clarke 2015). This suggests that perhaps the decreased turbidity at our LGHSM site could affect fish communities there. Due to time constraints, this study was only able to look at one site within the Little Hell Gate Salt Marsh, and only on three sampling dates. Future studies might be interested in adding a second site within the salt marsh to compare to the two sites along the Harlem River, as well as increasing the number of sampling dates to gather a larger pool of data.

Another notable finding of this study was the presence of a species of herring in one of our samples at Site 2. Due to overfishing, Atlantic herring populations have dramatically declined in recent years, with several entering the IUCN red list (Limburg). Our discovery of a species of herring (though the specific species could not be identified) suggests that a recently declining species of fish is present in the waters surrounding Randall’s Island. With further research and a larger sample size, this could possibly indicate that waters previously uninhabitable to such fish may now be a more viable habitat. Another significant finding regarding the herring found was that it was found at a never-before used seining site on the island. Previous fish surveys had only taken samples at the Waterfront South and LHGSM locations, so there was no previous data on this site to compare to, however, the discovery of a declining fish species such as the herring suggests that more research may be done to determine if some aspect of this new site makes it a more viable habitat than the other sites. Studies have shown that restoration of aquatic areas can lead to the rebuilding of native fish species that previously were not able to occupy certain habitats (Schaberg), so further research into the effects of water quality on fish species present at this site may be useful in understanding if and how this site might be a more viable habitat for threatened fish species such as herring, and if the past restoration projects undergone at Randall's Island have had any effect on this.

Another area of interest that this study was not able to focus on, but which could be useful in future studies is the presence of pollutants in the water surrounding Randall's Island. As discussed previously, PCBs are a threat to both fish communities and humans fishing in urban areas such as New York. Further research regarding water quality and fish communities might seek to determine PCB levels in the same sites and compare this to fish abundance and species present.

While no statistical conclusions could be made from this study due to constraints on the number of samples that could be taken, it has provided a framework for future studies to work from. Though not statistically significant, the data regarding turbidity and fish species between the three study sites suggest that sites on the Harlem River may differ in water quality from sites within the island's salt marshes, and the differences in fish species found at these sites could be a result of these differences in water quality. With further research and perhaps an expanding of the study sites and procedures used in this study, there is potential for significant findings regarding the ways that water quality affects the fish populations surrounding Randall's Island, how this has changed in response to restoration efforts, and how the area's fish communities can be further protected going forward.

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