HUDSON RIVER OYSTER RESTORATION

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BILLION OYSTER PROJECT
HUDSON RIVER FOUNDATION

HISTORY

- 1609   220,000 acres of Oyster Reefs
- 1906   Nearly Extinct--Pollution
- 1972 Clean Water Act
- 2003 Billion Oyster Project Launched

GOAL

- 2035 1 Billion Oysters
- 100 acres of Reefs

CURRENT

- 35,000,000 oysters, approx. 5 acres

FACTS

- One adult oyster filters 50 gals of water per day
- BOP
  - 19. 7 trillion gallons of water filtered
  - 72,500 pounds of Nitrogen removed
  - 1,000,000 pounds of shell recycled and reclaimed

Evaluating Effects of Pollution on Oyster Restoration in the Hudson River Estuary

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Introduction

Oysters were once as ubiquitous to the Hudson River, as pigeons are to the New York City sky. Oyster reefs once covered upwards of 200,000 acres of Hudson River basin, constituting nearly half of the world's total oyster population [1]. However, by the early 20th century there were no oysters left in the river, the culprits being overharvesting and severely polluted waters [1]. The oysters were not only a reliable food source for the city, but also a natural filtration system for the river an coastal protection for the shore.

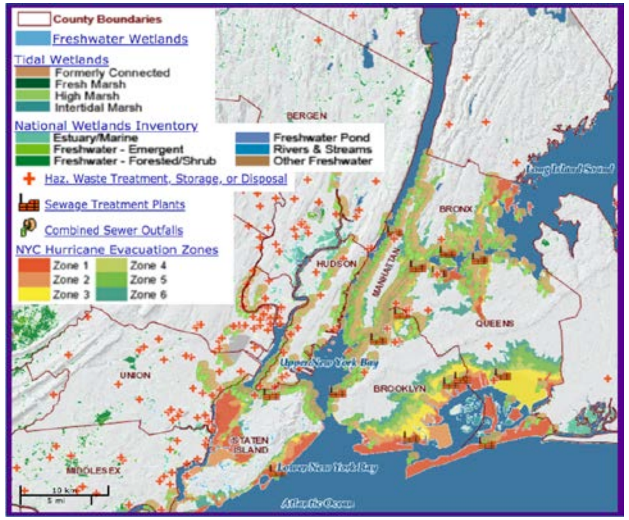


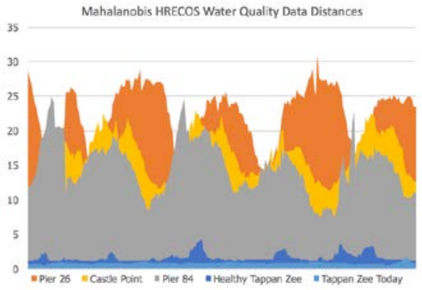
Figure 1:[2] The locations of the estuary's main pollutants

The potential benefits in the bivalves' return has led policy makers, researchers, restaurants, schools, and citizen scientists to collaborate and partner with organizations like The Billion Oyster Project and The Hudson River Foundation in an effort to restore the oysters. Yet, in its current state, the Hudson River is still nowhere near an ideal habitat. This study seeks to investigate the effects of the Hudson River's major pollutants [3]: Combined Sewage Overflows (CSO), the Indian Point Energy Center, coastally located hazardous waste facilities, stormwater runoff, etc. on water quality and how they may affect growing oysters.

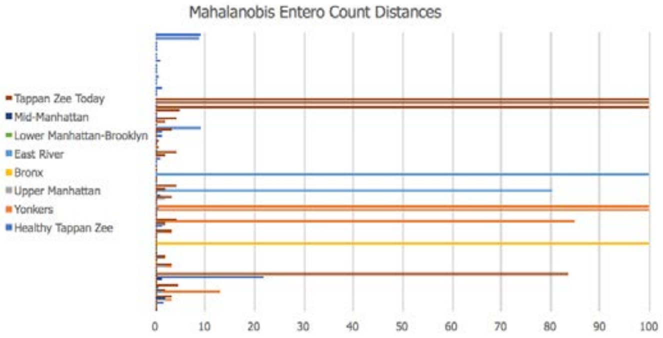
Methodology

- Data was complied from various government agencies, including Hudson River Environmental Conditions Observing System (HRECOS), along with databases complied by citizen scientists, most notably the Riverkeeper's Enterococcus count data. "Enterococcus is an EPA-approved fecal contamination indicator, a marker of combined sewage overflow" [4]
- Using MatLab, a Mahalanobis function was created which would compute Mahalanobis squared distances (MD) for data matrices representing different subdivisions of the Hudson River against a "healthy" region dataset
- The "healthy" region was determined to be the area of the Hudson River around the Tappan Zee Bridge construction site, within the years 2012-2013, where a self sustaining oyster reef of 200,000 was found, and later relocated in mid 2013 [6]

Observations



The main goal of Mahalanobis analysis is to observe a clear separation between groups. The graph on the left compares the variables of dissolved oxygen (a marker of algae that feeds on bacteria), temperature, salinity (heat pollution from the Indian Point Energy Center), and acidity of samples. There is a clear separation of the main groups, however the Pier 26, Pier 84, and Castle Point monitoring stations are within 1-2 miles of one another. The estuary is a very complex system and these results put that on display. The next graph compares the Entero Count MDs for grouped stations along the Hudson River. Clear separation between groups is not apparent, although the Lower Manhattan-Brooklyn, Upper Manhattan, and Mid Manhattan groups had the fewest extreme Entero count spikes. Entero count and CSOs are highly dependent on weather and more needs to be done on reducing these spikes in sewage contamination of



Conclusions

Oyster restoration projects provide a vision of a more sustainable and healthy Hudson Valley. Yet, for these projects to ultimately be successful more research should be done on where the reefs and cages should be placed. The estuary is a highly complex system and statistical analysis can give insight without having to spend resources testing sites that are still too heavily polluted or are simply not right for oyster growth. Further investigation should be done on the hazardous waste that is released into the river. It would also be interesting to compare the Hudson Estuary to the Long Island Sound and Jamaica Bay waterways.

Works Cited

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[2] NYC OASIS, Center for Urban Research, CUNY Graduate Center
[3] Wang, J. (2014) Combined Sewer Overflows (CSOs) Impact on Water Quality and Environmental Ecosystem in the Harlem River. *Journal of Environmental Protection*, **5**, 1373-1389. doi: 10.4236/jep.2014.513131.
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[5] Casey, Nell. "200,000 Oysters Moved For Tappan Zee Dredging." *Gothamist*, 26 July 2013, gothamist.com/2013/07/26/200000_oysters_moved_for_tappan_zee.php.

Acknowledgement

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NYU TANDON SCHOOL OF ENGINEERING

The Effect of Environmental Factors on Oysters Life

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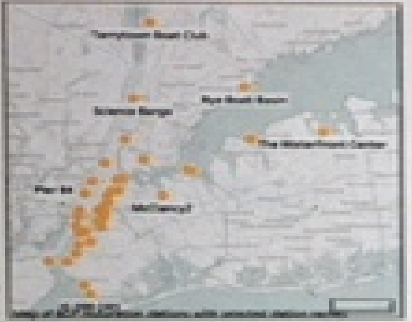
Background on the Project



Oysters are one of the keystone marine species that can balance a marine ecosystem by cleaning the water and absorbing extra CO_2. The number of oysters in the Hudson River Estuary decreased dramatically in 20th century due to overfishing and pollution. Aiming to restore oysters to a sustainable population, programs like Billion Oyster Project (BOP) and the Hudson River Foundation have put 25 million oysters in New York Harbor since 2010. The BOP aims to restore 1 billion oysters by 2035. To effectively restore oysters in Hudson River, it is necessary to investigate the different factors that affect their life.

Goal

This research study investigated environmental factors involved in successful oyster restoration projects by analyzing the extensive data available from BOP and from other sources such as the Hudson River Environmental Conditions Observing System(HRECOS) and the NOAA Centralized Data Management Office (CDMO). The datasets were first cleaned, and the most influential factors were found out by statistical methods.

Data Collection and Preparation

The death rate of Hudson River oysters was calculated from Billion Oyster Project's dataset [1]. The result shows a severe death trend of oysters within 3 years of their birth.

Data containing environmental variables collected at Hudson River areas (Pier 84 from Lower Hudson River and Tivoli North Bay from Upper Hudson River) are each compared separately with the same variables collected from 2015 to 2018 at Chesapeake Bay, where oysters grow very well [2][3]. The datasets were cleaned by filtering out missing values and anomalies and were then separated by year and grouped by date.

Statistics Methodology and Model

Statistical methods, especially the Mahalanobis-Taguchi System(MTS), were used to analyze the datasets and determine the most influential environmental variables [4]. The Mahalanobis Distance (MD_j) is a squared distance for the j^{th} sample in a sample size of n with k variables. It is then used to calculate the Signal to Noise Ratio (S/N Ratio η_q) which identify the influential variables.

Some benefits of using MTS:

- To better manipulate data based on the shape of MDs than using the Eulean's distance.
- To decrease the number of variables used in further data analysis work.

MTS was used on data collected in each year from 2015 to 2018. Sample results and visualizations from 2016 are shown on the right.

$$MD_j = \frac{1}{k} Z_{ij}^{T} C^{-1} Z_{ij}$$

$$\eta_q = -10 \log \left[\frac{1}{t} \sum_{j=1}^{t} \left(\frac{1}{MD_j} \right) \right]$$

i = 1 to k, number of variables
j = 1 to n, number of samples
Z_{ij} = standardized vector obtained by standardized values of X_{ij}
T = transpose of the vector
C^{-1} = inverse of the correlation matrix

Conclusion and Future Work

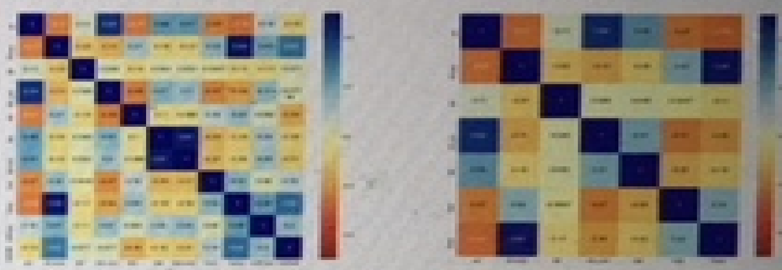
Conclusion:

- Based on the result of Mahalanobis Distance in each year, the separation of two Mahalanobis Distances in one plot indicates that the separation of the reference group (Chesapeake Bay) and the outside group (Tivoli North Bay or Pier 84) is correct.
- From the results of 2015 to 2018 (due to limited space in the poster, only results of 2016 are shown), the Signal to Noise Ratios of Chesapeake Bay vs Tivoli North Bay show that PH is the variable that has most different values in these two areas. The Signal to Noise Ratios of Chesapeake Bay vs Pier 84 indicate that salinity is the variable with most different values.

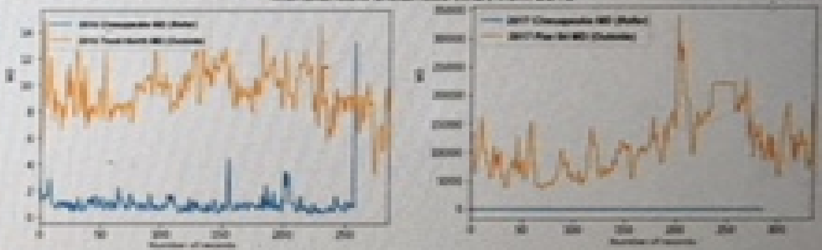
Further work should be done to:

- Test whether PH and salinity indeed affect oysters' life in Hudson River and whether there are other influential factors that didn't be tested in this research like genetic diseases.
- A more organized dataset for Hudson River oysters

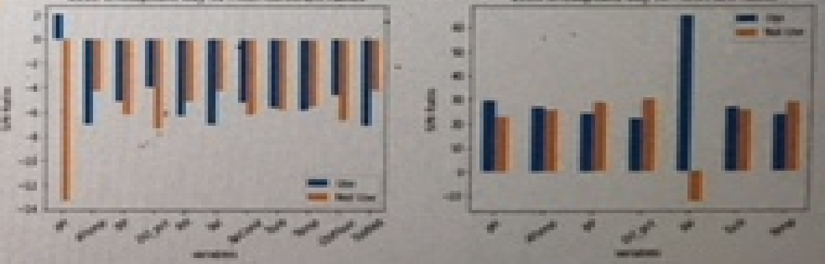
Correlation Matrices for Tivoli North Bay and Pier 84 Comparisons from 2016



Mahalanobis Distances (MD) from 2016



The Signal to Noise Ratio (S/N Ratios) from 2016



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