Assessing Invertebrate Abundance in NYC Wetlands

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Introduction

Wetlands play a significant role on Earth, acting as storm buffers, animal nurseries, and water filters. Wetlands are especially important in urban areas like New York City (NYC) in which 460 CSO (Combined Sewage Overflow) discharge sites release raw sewage and stormwater into local waterways when treatment plants are overwhelmed.[5] This, along with other aspects of urbanization, influences the many symbiotic relationships that play a vital role in maintaining the structure and productivity of wetland ecosystems.

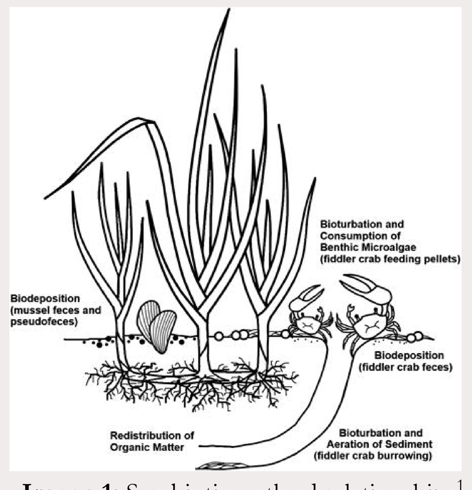


Image 1: Symbiotic wetland relationships[1]

For example, fiddler crab *(Uca* spp.*)* burrows encourage vegetative growth by increasing soil oxygen content. Similarly, Atlantic ribbed mussels *(Geukensia demissa)* serve as a buffer for plants, protecting them from severe weather conditions and erosion while providing nutrients to the soil.[3] In return, salt marsh vegetation provides protective coverage from predators, food sources, and a stable environment for the invertebrates to form habitats. The goal of this study is to determine what environmental factors may influence the abundance of these vital invertebrate species, so that we can further understand urban wetlands.

Research Questions

Question: What is the difference in abundance of *Uca* spp. burrows and *Geukensia demissa* at CSO and non-CSO sites?
Hypothesis: There will be a lower abundance of *Uca* spp. burrows and *Geukensia demissa* at CSO sites, while there will be higher abundances at the non-CSO site.

Question: How does vegetative coverage affect the abundance of *Uca* spp. burrows?
Hypothesis: As vegetative coverage decreases, *Uca* spp. burrow abundance will increase.

Question: How does water quality affect the abundance of *Uca* spp. burrows and *G. demissa*?
Hypothesis: *Uca* spp. burrow and *G. demissa* abundances will increase with higher water quality.

Methods

We studied three different sites: Hutchinson River (HR), Spring Creek (SC) and Udall's Cove (UC). SC and HR are associated with CSO discharge sites, while UC is not.

Quadrat Sampling

- We sampled $1m^2$ quadrats at 5m intervals along a 50m transect that was placed along the intertidal shoreline.
- Total quadrats: 91(about 30 per site)
- We labeled and photographed each quadrat and plotted their GPS coordinates using "Easy GPS" app and Google Earth (Images 6-8).
- Within each quadrat, we recorded the abundance of *Uca* spp. burrows and *G. demissa*, and estimated percent cover of vegetation, water and litter.

Water Quality Testing

- We recorded abiotic factors (time, air temperature, humidity and cloud cover) before testing water quality.
- We used a DO 6+ probe to measure salinity, water temperature and dissolved oxygen.
- We used a refractometer to measure salinity.
- We also used a LaMotte water quality kit to measure pH levels, carbon dioxide, nitrates and phosphates found in the water.
- Parameters were measured 3 times per site.

Image 2 (left): Tafari Loyd examining the quadrat for fiddler crab burrows and ribbed mussels

Images 3-4 (right): Male *Uca* spp. specimens

Results

Image 5: CSO site Spring Creek, Queens.

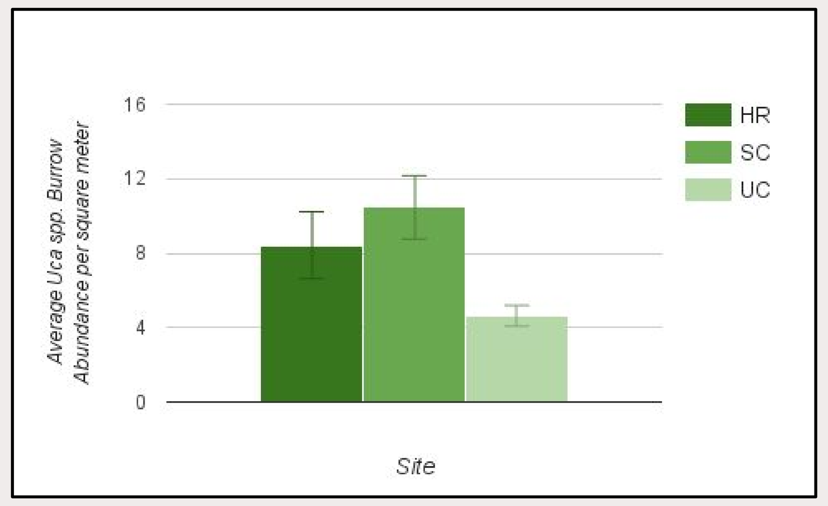


Fig.1: Mean *Uca* spp. Burrows Abundance Across Sites
A one-way ANOVA test resulted in a statistically significant difference in mean *Uca* spp. burrow abundance between sites ($F(2,88)=3.66$, $p<0.05$). A Tukey post-hoc test revealed that there was a statistically significantly higher burrow abundance at Spring Creek compared to Udall's Cove ($p<0.05$). All other differences between sites were nonsignificant.

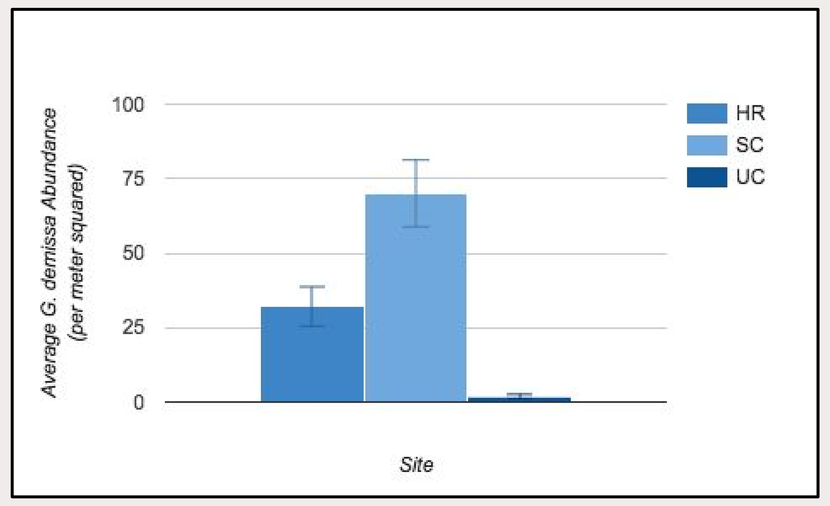


Fig. 2: Mean *G. demissa* Abundance vs. Site
A one-way ANOVA test resulted in a statistically significant difference in mean *G. demissa* abundance between sites ($F(2,88)=21.05$, $p<0.0001$). A Tukey post-hoc test revealed that there was a statistically significant difference in the abundance between all three sites (HR vs SC, $p<0.01$) (HR vs UC, $p<0.05$) (SC vs UC, $p < 0.01$).

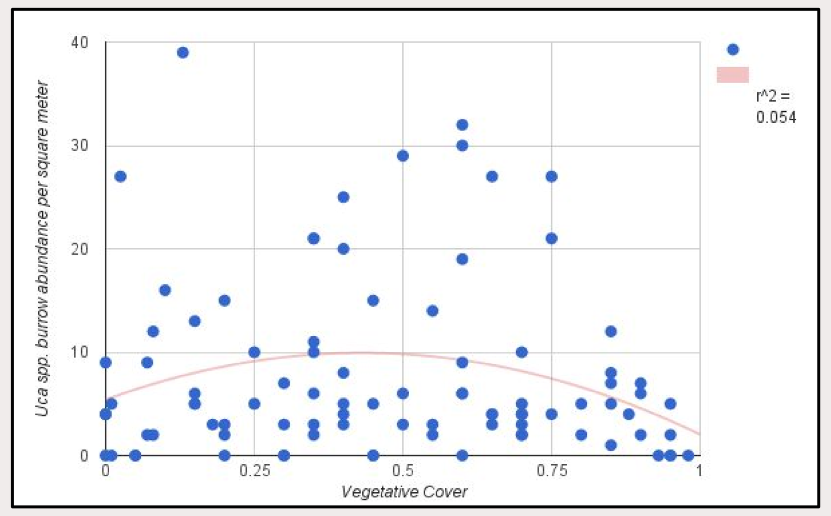


Figure 3: *Uca* spp. Burrow Abundance vs. Vegetation Cover Across Sites
Shows the relationship of the *Uca* spp. burrow abundance and vegetative cover from all three sites. A parabolic trendline suggests highest abundance at medium coverage, although the low R^2 value implies a weak fit.

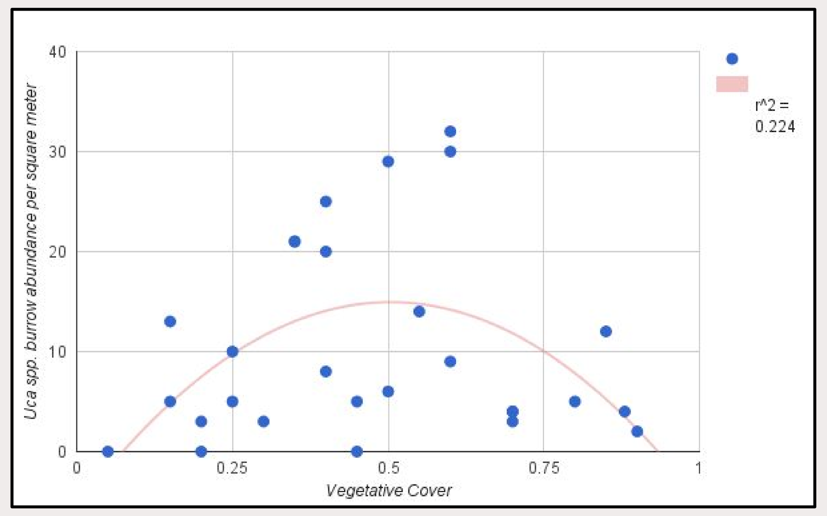


Figure 4: *Uca* spp. Burrows vs. Vegetation Cover at Spring Creek
The parabolic trendline indicates highest burrow abundance at medium coverage. The 0.224 R^2 value indicates a stronger trend at Spring Creek compared to all three sites combined.

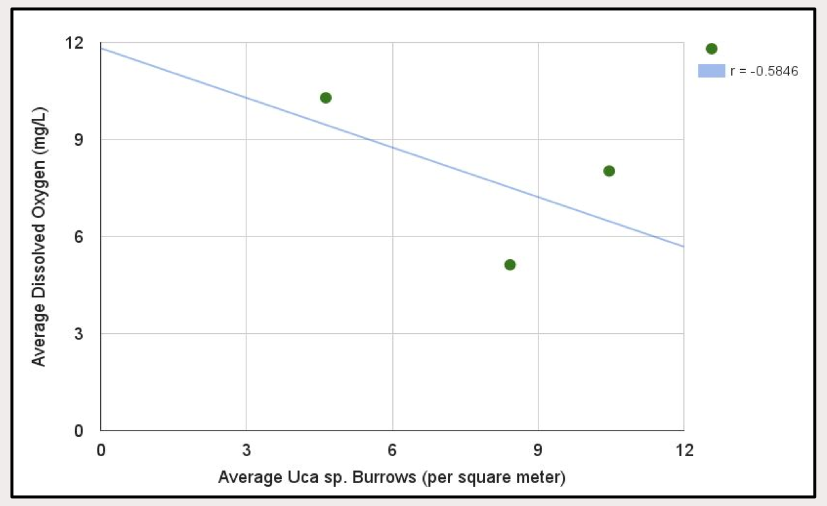


Figure 5: Average *Uca* spp. Burrows vs. Average Dissolved Oxygen
A Pearson's r value was calculated to assess the relationship between the average amount of *Uca* spp. burrows and the average amount of dissolved oxygen. The r value of -0.5846 indicates a moderate negative correlation.

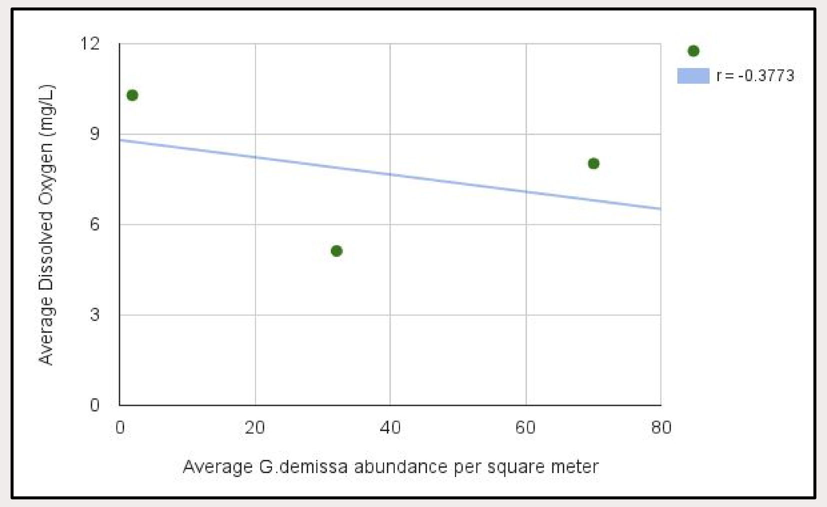
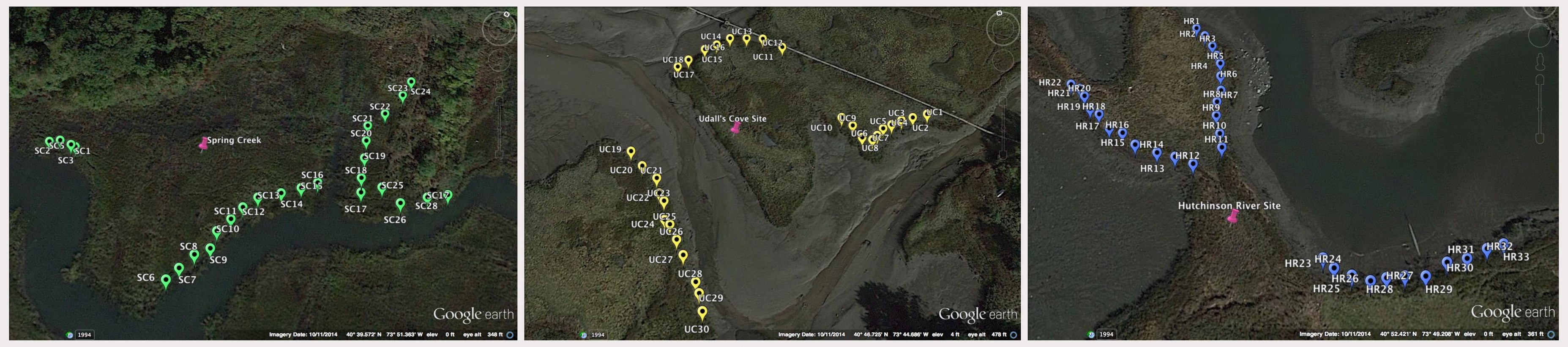


Figure 6: Average *G. demissa* Abundance vs. Average Dissolved Oxygen
A Pearson's r value was calculated to assess the relationship between the average amount of *G. demissa* and the average dissolved oxygen. The r value was reported as -0.3773 indicating a weak negative correlation.



Images 6-8: Each quadrat's GPS coordinates were plotted using Google Earth (left to right: Spring Creek, Udall's Cove, Hutchinson River)

Discussion/Conclusions

CSO vs non CSO

Our results led us to reject our hypothesis. We hypothesized that there would be a higher abundance of *Uca* spp. burrows and *G. demissa* at Udall's Cove compared to Hutchinson River and Spring Creek. However, our results indicate the opposite outcome. It is possible that the increased levels of nutrients coming from CSO sites like Spring Creek and Hutchinson River benefit the two species by increasing levels of food sources like algae. This is especially relevant for *G. demissa* which filters nitrogen, bacteria, and other suspended organic particles as it feeds.[4]

Vegetative Coverage

In regards to the relationship between *Uca* spp. burrows and the vegetative coverage, the results suggest that *Uca* spp. burrows are more abundant when there is medium plant coverage (Figures 3 and 4). However, the low R^2 values imply very weak correlations. Therefore, we reject our hypothesis that burrow abundance increases with decreased coverage. Vegetation, such as *Spartina alterniflora* and *Spartina patens* allow *Uca* spp. to make burrows in soft sediments, obtain a detrital food source, and have protection from predators[3]. Medium cover might be favorable because lower vegetative coverage could risk exposure to predators, while higher coverage with thick root density would not produce adequate substrate for burrows.

Water Quality

Our results indicate that there was no strong correlation between the amount of dissolved oxygen and *Uca* spp. burrows (Figure 5) and between the amount of dissolved oxygen and *G. demissa* (Figure 6). Although studies generally show that marine life typically thrives under conditions where the dissolved oxygen is higher, our results contradict this. Our inability to find a relationship could potentially be caused by an insufficient number of data entries, varied locations of dissolved oxygen tests (within sites), and fluctuating tidal rhythms. In addition, both *Uca* spp. and *G. demissa* demonstrate a large tolerance for different levels of salinity, water temperature, and dissolved oxygen.[2,6] Therefore, other factors such as erosion could have impacted these species more than water quality.

Future Studies

The lack of correlations between water quality parameters, vegetative coverage, and invertebrate abundance led to the conclusion that other environmental factors may be influencing our results. Erosion data supplied by NYC Parks Department indicates that Udall's Cove is eroding at a faster rate (3.06 ft/yr) than both Spring Creek (0.56 ft/yr) and Hutchinson River (1.33 ft/yr). Using our abundance data, we found that the average abundance of both *Uca* spp. and *G. demissa* negatively correlated with each site's shoreline loss per year (Figures 7 and 8). Further research could help determine if erosion is influencing the invertebrate populations more than the factors we initially studied.

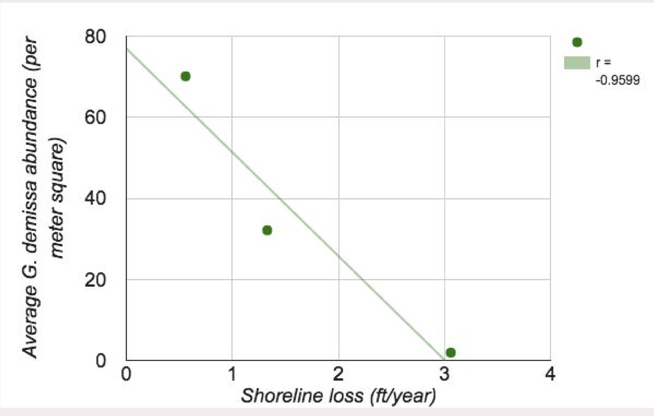


Figure 7: Mean *G. demissa* abundance vs. Shoreline loss
A Pearson's r value of -0.9599 indicates strong negative correlation between *G. demissa* abundance and shoreline loss.

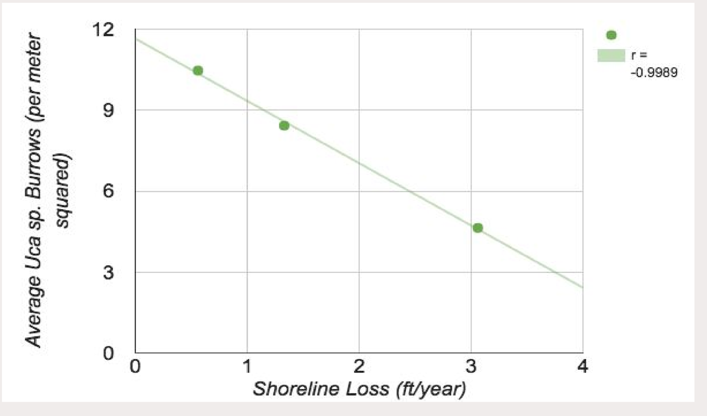


Figure 8: Mean *Uca spp.* Burrow Abundance vs. Shoreline Loss
A Pearson's r value of -0.9989 indicates a strong negative correlation between *Uca spp.* burrow abundance and shoreline loss

Acknowledgements

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References

1. Image retrieved from: https://www.researchgate.net/figure/261569300_fig3_Figure-1-Activities-of-fiddler-crabs-Uca-sp-and-ribbed-mussels-Geukensia-demissa-can
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