Ap(eel)ing to Macroinvertebrates: A Study on American Eel and Macroinvertebrate Populations in the Bronx River

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Introduction

The American eel (*Anguilla rostrata*) is a catadromous fish native to North America. It is listed as "endangered" on the IUCN Red List, and is threatened by the effects of anthropogenic climate change, increasing urbanization in riparian zones, and construction of offshore renewable energy infrastructure.[6] *A. rostrata* larvae hatch in the Sargasso Sea before migrating towards the continental shelf, swimming into freshwater and brackish waterways, and growing into adults (Fig 1). Most of the eels found in freshwater rivers such as the Bronx River are juvenile elvers or adult yellow eels (See Image 2).[2]

The Bronx River, New York City's only freshwater river, is especially vulnerable to anthropogenic pollution.[1] The Bronx River is home to many diverse species of macroinvertebrates such as scuds, sowbugs, and aquatic worms. Macroinvertebrates are a key food source for eels resident in riparian ecosystems, and are also considered an indicator species due to their varying tolerance to pollutants.[3]

This study constitutes only one part of a long-running WCS survey on *A. rostrata* in the Bronx river in collaboration with the NYC Parks Department. This study examines the effects of Bronx River dams on resident *A. rostrata*, whether the diversity of local macroinvertebrate communities can predict the density of co-occurring *A. rostrata* populations, and whether a correlation exists between substrate diversity and diversity of local macroinvertebrate communities.

Image 1. Leaf Pack in River at Twin Dams Site. *Photo credit: L. Solórzano Escobar*

Image 2. *A. rostrata* Adult Yellow Eel. *Photo credit: L. Solórzano Escobar*

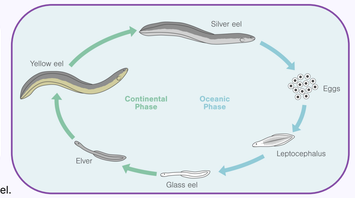

Figure 1. Eel Life Cycle.[7]

Methodology

Eel Surveys
In order to capture eels, eel mops, which imitate eels' natural hiding places, were used. Three eel mops were placed at each site. One to two times a week, each mop was removed from the water and rinsed in a bucket with river water. The water in the bucket was then filtered through a net, allowing for identification of the eels and macroinvertebrate bycatch in the mop. Eel life stage and length in centimeters was recorded.

Macroinvertebrate Surveys
Macroinvertebrates were surveyed through eel mop bycatch, kicknets, and leaf packs. Macroinvertebrates were identified using a dichotomous key, iNaturalist, or a microscope. Kicknet surveys consisted of submerging a net into the water at one of six predetermined locations at each site and kicking rocks in front of the net, which allowed macroinvertebrates to flow into the net. The net remained submerged for five minutes, and upon being removed, its contents were examined, recorded, and released back into the water.

Leaf packs consist of approximately 30 grams of leaves in a mesh drawstring bag. One leaf pack was used for data collection at each site. Leaf packs were filled with beech, maple, and oak leaves (with the addition of ginkgo leaves in the 182nd St leaf pack). Leaf packs were left submerged underwater for two weeks before they were opened and their contents recorded. The leaf packs were created and examined in accordance with information from the Leaf Pack Network.[5] Data from the macroinvertebrate surveys was used to calculate a Pollution Tolerance Index rating for each site.

Substrate Surveys
To record substrate diversity, a substrate survey was performed during the fourth week of the study. A 0.25 m × 0.25 m PVC pipe frame, known as a quadrat, was set down at each of the twelve kicknet survey locations. The amount of each of four types of substrate—sand, pebbles, rocks, and boulders—on the riverbed in each quadrat was recorded and used to calculate the diversity of substrate types at each quadrat.

Image 3. Map of 182nd St Dam Site. Dots represent Eel mops, X's represent kicknet & substrate survey location. Each kicknet is 1 m apart from the shore and from the other kicknet. Eel mops are 2 m from each other. *Photo credit: S. Chhapra*

Image 4. Conducting Research (Kicknets and Eel Mops) at the 182nd St Dam Site. *Photo credit: M. Falkenberg*

Fig 2. Map of Research Sites. The distance between the two sites is 1300 m.

Abstract

The American eel (*A. rostrata*) is an endangered species of catadromous fish that spends its adult life in freshwater rivers. As part of a long-running survey by the Wildlife Conservation Society and NYC Parks Department, this study focuses on eel populations in the Bronx River, a freshwater tributary of the Hudson River estuary, and how they are affected by the placement of dams along the river. This study also investigates macroinvertebrate communities in this freshwater river. We hypothesized that eels would be smaller and more abundant below dams than above them, more diverse macroinvertebrate communities would correlate with higher eel populations, and that more diverse streambed substrate would correlate with more diverse macroinvertebrate communities. Eel and macroinvertebrate populations were surveyed over five weeks, using eel mops, kicknets, and leaf packs. Field work was conducted at two sites: the 182nd St Dam site, below the first dam on the river, and the Twin Dams site, above the first dam on the river. The data showed that eels were significantly less abundant above the first dam, but it does not seem to be related to macroinvertebrate diversity. There was a slight but insignificant negative correlation between macroinvertebrate diversity and eel abundance, and a slight but insignificant positive correlation between substrate diversity and macroinvertebrate diversity. The results of this study underline the need for more research into the sensitive riparian urban ecosystems of the Hudson River watershed.

Research Questions & Hypotheses

Research Question 1: How do Bronx River dams affect *A. rostrata* size and abundance at two sites along the river?
Hypothesis: Eels will be smaller on average and more abundant downstream of the first dam on the river (182nd St Dam).

Research Question 2: Can the diversity of local macroinvertebrate communities predict the density of co-occurring *A. rostrata* populations in the Bronx River?
Hypothesis: Eels will be more abundant when macroinvertebrate diversity is higher.

Research Question 3: Does a correlation exist between substrate diversity and the diversity of macroinvertebrate communities in two sites on the Bronx River?
Hypothesis: Yes, a positive correlation will exist between substrate diversity and macroinvertebrate diversity.

Results & Figures

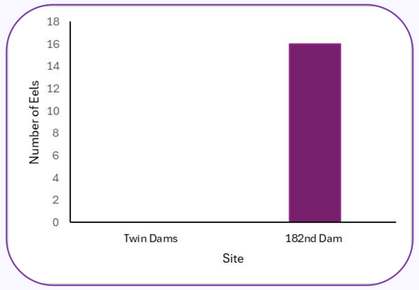

Fig 3. Eel Abundance at each Research Site. A significant relationship was found between eel abundance and research site ($\chi^2 = 16$, $p = 6.3 \times 10^{-5}$).

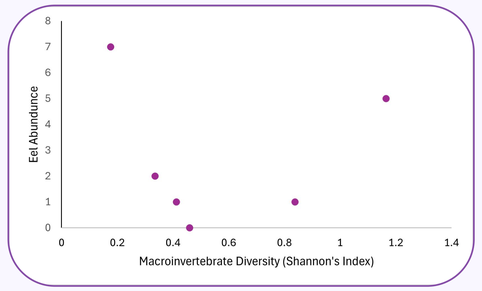

Fig 4. Impact of Macroinvertebrate Diversity on Eel Abundance at the 182nd St Dam Site. No correlation was found between macroinvertebrate diversity and eel abundance ($r = -0.011$, $p = 0.984$).

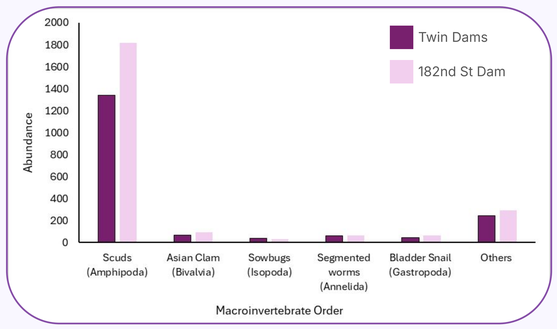

Fig 6. Distribution of Macroinvertebrates by Order Across Research Sites. Shows the populations of the top 5 most abundant species at each research site, as well as the sum of the populations of all other species. Data recorded from eel mops, kicknets, and leaf packs.

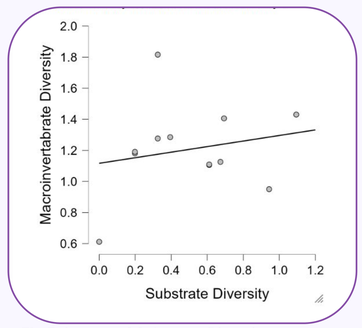

Fig 5. Impact of Substrate Diversity on Macroinvertebrate Diversity Across 12 Quadrats. No correlation was found between substrate diversity and macroinvertebrate diversity ($r = 0.200$, $p = 0.533$).

Analysis

A chi-square test was performed to determine the significance of the relationship between eel abundance and research site. Research questions 2 and 3 were analyzed using Pearson's r and a simple regression. Macroinvertebrate and Substrate diversity were calculated using Shannon's Diversity Index.[4] The Pollution Tolerance Index was calculated using macroinvertebrate survey data and the Leaf Pack Network manual.[5]

Discussion

Research Question 1
Our data showed that dam placement has a significant effect on eel populations, consistent with the findings of previous studies on eels in the Hudson River watershed. However, our conclusion, while statistically significant, was based on a very small dataset, and no eels were found at the site above the dam. This may have been due to a weather event displacing eel mops at the Twin Dams site. Additionally, colleagues at the NYC Parks Department noted that there were fewer eels present in the Bronx River this year than in previous years.

Research Questions 2 and 3
Both the slight negative correlation between macroinvertebrate diversity and eel abundance and the slight positive correlation between substrate diversity and macroinvertebrate diversity were found to be statistically insignificant. It should be noted that the vast majority of macroinvertebrates surveyed belonged to one taxon (*Amphipoda*), which could have skewed the data, the nets used for surveys at each of the two sites had significantly different porosity, and the proportions of each of the four types of substrate in each quadrat were recorded only to the nearest 0.05. Additionally, water quality could have been a confounding factor: the Twin Dams site had a Pollution Tolerance Index rating of 19 (good), whereas the 182nd St Dam site had a Pollution Tolerance Index rating of 14 (fair). Furthermore, summer macroinvertebrate communities can differ significantly from autumn and winter communities. A colleague from the Stroud Water Center noted that leaf packs produce best results in autumn rather than summer, since more aquatic nymphs and larvae are present in autumn. We conclude that further research on Bronx River macroinvertebrate communities is needed.

Conclusions
This study highlights the importance of fragile riparian urban ecosystems and the endangered species to which they provide habitats, and the need for further research of such ecosystems, especially the Bronx River. Some ideas for future research could include examining why no eels were found at the upstream site (considering that eels found at the downstream site were released above the 182nd St Dam), a more extensive survey of macroinvertebrates in the Bronx River, or a replication of this study using more effective methods of eel capture, such as electrofishing.

Acknowledgements

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