Investigation of Biodiversity of Marine Life and Estuary Health in City Island, NY

Maya Dominguez[1], Sophia Gbadebo[1], Kavya Mahindru[1]
Mentors: Dr. Oxana Litvine[1], Mrs. Stacy Unkenholz[1], Bill Livingston[2]
1 - The Ursuline School, 1354 North Ave, New Rochelle, NY 10804
2 - Urban Eco; Outdoor Science, 105 S. Elliot Pl., Brooklyn, NY, 11217

Funded by the Thompson Family Foundation

Abstract

This summary assesses marine biodiversity and estuary health on City Island, NY, by analyzing selected marine organisms such as crabs, worms, mussels, snails, and seaweed. Through DNA barcoding, the study identified species diversity and detected invasive organisms within the ecosystem. The research involved collecting, photographing, and cataloging specimens on iNaturalist, complemented by field guide identifications. DNA extraction and PCR were performed at the Regeneron DNA Learning Center to ensure precise results. The outcomes were intended to inform local conservation efforts, highlighting potential impacts of pollution on species adaptation and survival, thereby contributing to broader ecological preservation initiatives within this vibrant coastal habitat.

Introduction

- The coastal ecosystems of City Island, NY, represent a diverse and vibrant habitat for various marine organisms.
- These organisms play crucial roles in maintaining the ecological balance and health of estuarine environments.
- Increasing pollution poses a significant threat to marine biodiversity and estuary health.
- The current research highlights the urgent need to assess biodiversity in these habitats to improve conservation efforts and to understand the ecological significance they hold.
- Understanding the genetic diversity among marine species through DNA barcoding can provide valuable insights into population dynamics, species diversity, and the health overall of the City Island beach ecosystem.
- Typical organisms in this environment would include:
  - *Hemigrapsus sanguineus* (Asian Shore Crab)
  - *Callinectes sapidus* (Atlantic Blue crab)
  - *Ilyanassa obsoleta* (Eastern mudsnail)
  - *Alitta succinea* (Clam Worms)
  - *Chthamalus fragilis* (Fragile Barnacle)
  - *Geukensia demissa* (Atlantic Ribbed Mussel)
  - *Tricellaria inopinata* (Bushy Bryozoans)
  - *Sargassum*
  - *Agardhiella subulata* (Agardh's Red Weed)
  - *Sea Lettuce or Genus Ulva*
- The objective of this study was to assess marine biodiversity through the collection and identification of species. In order to identify species accurately, DNA barcoding techniques were used. Additionally, iNaturalist was used to document species observations.

Figure 1: Map of City Island Beach
https://hiddenwatersblog.wordpress.com/2019/04/11/turtlebx/

Figure 2: *Ilyanassa obsoleta*

Materials & Methods

COLLECTING SPECIMEN

1. Approximately 66 specimens were collected, including crabs, worms, mussels, snails, and seaweed from City Island Beach. Photos were taken of the specimens and uploaded to iNaturalist. The app attempted to identify the species based on visual similarities and regional data.

2. For DNA barcoding, the specimens were archived and labeled with collection data, including the date of collection and species name. They were then preserved in a freezer for future barcoding. Samples were taken to the Regeneron DNA Learning Center in Sleepy Hollow, NY, for barcoding. Classification was attempted using the app, but more accurate identification was achieved through barcoding.

DNA BARCODING PROCEDURE

- The samples were taken to the Regeneron DNA Learning Center in Sleepy Hollow, NY
- The DNA processing and barcoding must be done carefully to avoid cross-contamination.
- The purpose of this procedure is to classify living things to monitor diversity and their biological effects.

1. First, the DNA of the species was extracted by collecting a small amount of tissue (we will use Silica DNA isolation for all organisms we collected, see table 1). This can be done using samples of muscle, or a whole organism if it is small.

2. The DNA underwent a DNA amplification procedure using a PCR machine. The barcode region of the sample will be replicated millions of times to prepare for sequencing. We will conduct PCR with primers specific for marine invertebrate organisms and algae (see table 1 for details).

3. Gel electrophoresis was used after PCR, to make sure that enough DNA was available in the staples to proceed with sequencing.

4. The samples were sent to the company Genewitz for sequencing. DNA subway was used to analyze sequencing results.

5. The sequencing result were matched to the DNA sequence that was represented in the database. If the barcodes were entirely new, then the unknown species were placed in a phylogenetic tree with close family members.

6. Following this, the sequences were organized using the website, DNAsubway.org.

Results

Out of the 30 samples brought to the DNA Learning Center, 8 samples were successfully sequenced. The BLAST results identified species from several different groups, indicating moderate biodiversity. Most samples had a high match percentage, confirming accurate species identification. Some sequences had low match percentages, possibly due to contamination or errors in sample processing. Successfully sequenced samples include amphipods, isopods, snails, barnacles, and oysters.

Alpconsen.#	Blast Results	Wikipedia Link	Domain	Kingdom	Phylum	Subphylum	Class	Order	Family	Genus	Species
1	*Gammarus annulatus*	https://en.wikipedia.org/wiki/Gammarus	Eukarya	Animalia	Arthropoda	Crustacea	Malacostraca	Amphipoda	Gammaridae	*Gammarus*	*Gammarus annulatus*
2	*Leptocheirus plumulosus*	https://en.wikipedia.org/wiki/Leptocheirus_plumulosus	Eukarya	Animalia	Arthropoda	Crustacea	Malacostraca	Amphipoda	Aoridae	*Leptocheirus*	*Leptocheirus plumulosus*
3	*Semibalanus balanoides*	https://en.wikipedia.org/wiki/Semibalanus_balanoides	Eukarya	Animalia	Arthropoda	Crustacea	Thecostraca	Sessilia	Balanidae	*Semibalanus*	*Semibalanus balanoides*
4	*Synsiphonia laticauda*	https://invasions.si.edu/nemesis/species_summary/-48963	Eukarya	Animalia	Arthropoda	Crustacea	Malacostraca	Isopoda	Idoteidae	*Synsiphonia*	*Synsiphonia laticauda*
5	*Lekanosphaera rugicauda*	https://en.wikipedia.org/wiki/Lekanosphaera	Eukarya	Animalia	Arthropoda	Crustacea	Malacostraca	Isopoda	Sphaeromatidae	*Lekanosphaera*	*Lekanosphaera rugicauda*
6	*Urosalpinx cinerea*	https://en.wikipedia.org/wiki/Urosalpinx_cinerea	Eukarya	Animalia	Mollusca	n/a	Gastropoda	Neogastropoda	Muricidae	*Urosalpinx*	*Urosalpinx cinerea*
7	*Ilyanassa obsoleta* (formerly *Nassa obsoleta*)	https://en.wikipedia.org/wiki/Ilyanassa_obsoleta	Eukarya	Animalia	Mollusca	n/a	Gastropoda	Neogastropoda	Nassariidae	*Ilyanassa obsoleta* (formerly *Tritia obsoleta*)	*Ilyanassa obsoleta* (formerly *Tritia obsoleta*)
8	*Urosalpinx cinerea*	https://en.wikipedia.org/wiki/Urosalpinx_cinerea	Eukarya	Animalia	Mollusca	n/a	Gastropoda	Neogastropoda	Muricidae	*Urosalpinx*	*Urosalpinx cinerea*

#	Coordinates where it was collected	Field Guide, Common Name of species, scientific name	iNaturalist, Common Name of species, scientific name	Link to iNaturalist
1	40.85717o N 73.79504o W	Asian Shore Crab or Hemigrapsus sanguineus	Asian Shore Crab or Hemigrapsus Sanguineus	https://www.inaturalist.org/observation/c243838385
2	40.85717o N 73.79504o W	Asian Shore Crab or Hemigrapsus sanguineus	Asian Shore Crab or Hemigrapsus sanguineus	http://www.inaturalist.org/observations/243840103
3	40.85717o N 73.79504o W	Atlantic Blue Crab or Callinectes sapidus	Atlantic Blue Crab or Callinectes sapidus	http://www.inaturalist.org/observations/243841519
4	40.85717o N 73.79504o W	Clam Worm or Alitta succinea	Clam Worm or Alitta succinea	http://www.inaturalist.org/observations/243839621
5	40.85717o N 73.79504o W	Clam Worm or Alitta succinea	Clam Worm or Alitta succinea	https://www.inaturalist.org/observation/c243842390
6	40.85717o N 73.79504o W	Clam Worm or Alitta succinea	Clam Worm or Alitta succinea	http://www.inaturalist.org/observations/243840924
7	40.85717o N 73.79504o W	Clam worm/Alitta succinea	Clam worm/Alitta succinea	https://www.inaturalist.org/observation/c243841899
8	40.85717o N 73.79504o W	Clam Worm or Alitta succinea	Clam Worm or Alitta succinea	http://www.inaturalist.org/observations/243841689
9	40.85717o N 73.79504o W	Bushy Bryozoan	Knotted Wrack	
10	40.85717 o N 73.79504o W	*Genus ulva (Sea Lettuce)*	*Genus ulva (Sea Lettuce)*	https://www.inaturalist.org/observation/c243840168
11	40.85717 o N 73.79504o W	Bryopsis	Crisped Pincushion	https://www.inaturalist.org/observation/c243840330
	40.85717 o N 73.79504o W	*Mya arenaria* or soft-shelled clam	*Mya arenaria*	http://www.inaturalist.org/observations/244031698
13	40.85717 o N 73.79504o W	*Scytosiphon*	Small Pondweed or potamogeton pusillus	https://www.inaturalist.org/observation/c243841090
14	40.85717 o N 73.79504o W	Agardh's Red Weed Agardhiella subulata	*Agardhiella subulata*	http://www.inaturalist.org/observations/243841125
15	40.85717 o N 73.79504o W	*Sargassum and Alliies*	Sargassum and Allies	http://www.inaturalist.org/observations/243841814
16	40.85717 o N 73.79504o W	Eastern Mudsnail or Ilyanassa Obsoleta	*Ilyanassa obsoleta*	(http://www.inaturalist.org/observations/244160796
17	40.85717 o N 73.79504o W	Eastern Mudsnail or Ilyanassa Obsoleta	Eastern Mudsnail or Ilyanassa Obsoleta	https://www.inaturalist.org/observation/c244162993
18	40.85717 o N 73.79504o W	Eastern Mudsnail or Ilyanassa Obsoleta	Eastern Mudsnail or Ilyanassa Obsoleta	http://www.inaturalist.org/observations/244906782
19	40.85717 o N 73.79504o W	Eastern Mudsnail or Ilyanassa obsoleta	Eastern Mudsnail or Ilyanassa Obsoleta	http://www.inaturalist.org/observations/244163100
20	40.85717 o N 73.79504o W	Eastern Mudsnail	Eastern Mudsnail or Ilyanassa obsoleta	http://www.inaturalist.org/observations/244163510
21	40.85717 o N 73.79504o W	Eastern Mudsnail or Ilyanassa Obsoleta	Eastern Mudsnail or Ilyanassa Obsoleta	http://www.inaturalist.org/observations/244906785
22	40.85717 o N 73.79504o W	Eastern Mudsnail	Eastern Mudsnail or Ilyanassa Obsoleta	http://www.inaturalist.org/observations/244164683
23	40.85717 o N 73.79504o W	Eastern Mudsnail or Ilyanassa Obsoleta	Eastern Mudsnail or Ilyanassa Obsoleta	https://www.inaturalist.org/observation/c244164955
24	40.85717 o N 73.79504o W	Eastern Mudsnail or Ilyanassa obsoleta	Eastern Mudsnail or Ilyanassa Obsoleta	http://www.inaturalist.org/observations/244165082
25	40.85717 o N 73.79504o W	Eastern Mudsnail or Ilyanassa Obsoleta	Eastern Mudsnail or Ilyanassa Obsoleta	http://www.inaturalist.org/observations/244906785
26	40.85717 o N 73.79504o W	Atlantic Ribbed Mussel	Atlantic Ribbed Mussel or Geukensia demissa	
27	40.85717 o N 73.79504o W	Eastern Mudsnail	Eastern Mudsnail or Ilyanassa Obsoleta	http://www.inaturalist.org/observations/244165907
28	40.85717 o N 73.79504o W	Atlantic Ribbed Mussel	Atlantic Ribbed Mussel or Geukensia demissa	
29	40.85717 o N 73.79504o W	Atlantic Ribbed Mussel	Atlantic Ribbed Mussel or Geukensia demissa	
30	40.85717 o N 73.79504o W	Atlantic Ribbed Mussel	Atlantic Ribbed Mussel or Geukensia demissa	

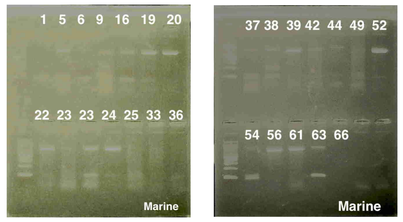

Figure 3: Gel electrophoresis images

Discussion

- iNaturalist and DNA barcoding provided insights into the species present on City Island Beach, the accuracy of these methods varied.
- iNaturalist, though a helpful tool for identifying organisms, may have struggled with accurately identifying marine species based on photographs alone.
- DNA barcoding provided a clearer understanding of the species composition of the City Island ecosystem.
- *Hemigrapsus sanguineus,* or the Asian Shore Crab, which is native to the West Pacific, is an example of an invasive species.
- Invasive species can be harmful to the environment because they can compete with the native species for food, possibly replacing them.
- Human activities, such as fishing and boating, can also unintentionally introduce non native species to City Island Beach.
- DNA Barcoding is important because early identification of non native species allows scientists to potentially take action to remove the invasive species.

References

Alitta succinea. (n.d.). Marine Invasions research at SERC. Retrieved October 25, 2024, from https://invasions.si.edu/nemesis/species_summary/-48

Atlantic Blue Crab. (n.d.). Oceana. Retrieved October 7, 2024, from https://oceana.org/marine-life/atlantic-blue-crab/

Chthamalus fragilis. (n.d.). Marine Invasions research at SERC. Retrieved October 25, 2024, from https://invasions.si.edu/nemesis/species_summary/89593

DNA Barcoding – International Barcode of Life. (n.d.). International Barcode of Life. Retrieved October 23, 2024, from https://ibol.org/about/dna-barcoding/

Geukensia demissa. (n.d.). Marine Invasions research at SERC. Retrieved October 7, 2024, from https://invasions.si.edu/nemesis/species_summary/79555

Hemigrapsus sanguineus. (n.d.). Marine Invasions research at SERC. Retrieved October 7, 2024, from https://invasions.si.edu/nemesis/species_summary/-2

Ilyanassa obsoleta. (n.d.). Marine Invasions research at SERC. Retrieved October 7, 2024, from https://invasions.si.edu/nemesis/species_summary/74111

Kadinsky, S. (2019, April 11). *Turtle Cove, Bronx – Hidden Waters blog*. Hidden Waters blog. Retrieved October 23, 2024, from https://hiddenwatersblog.wordpress.com/2019/04/11/turtlebx/

Life in an estuary. (2019, February 1). National Oceanic and Atmospheric Administration. Retrieved November 5, 2024, from https://www.noaa.gov/education/resource-collections/marine-life/life-in-estuary

Red & Purple Algae. (n.d.). New Jersey Scuba Diving. Retrieved October 25, 2024, from https://njscuba.net/marine-biology/marine-invertebrates/algae-seaweeds/red-purple-algae/

Sea Lettuce - Algae. (n.d.). Chesapeake Bay Program. Retrieved November 13, 2024, from https://www.chesapeakebay.net/discover/field-guide/entry/sea-lettuce

Tricellaria inopinata. (n.d.). Marine Invasions research at SERC. Retrieved November 13, 2024, from https://invasions.si.edu/nemesis/species_summary/-572

What is Sargassum? : Ocean Exploration Facts: NOAA Ocean Exploration. (n.d.). NOAA Ocean Exploration. Retrieved November 13, 2024, from https://oceanexplorer.noaa.gov/facts/sargassum.html

Acknowledgements

Thank you to Dr. Carol Henger, Cold Spring Harbor Laboratory, and the DNA Learning Center! Thank you also to our fellow classmates who helped collect data!

Figure 3: City Island Beach
https://www.nycgovparks.org/parks/city-island-wetlands