Do Living Shorelines Have Superpowers

Restoring wetlands and reef habitats in Hoboken Coast and the Hudson River.

By Jacob Tennenbaum.

66th Annual Jersey City Medical Center / RWJBarnabas Health STEM Showcase

Project: J - G5 - 1382

Billion Oyster Project 10th Student Symposium

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Abstract

Sustainable shorelines are designed using nature-based features and practices and managed to promote coastal resilience. I aim to explore how restoring these habitats can benefit Hoboken and other communities along the Hudson River. Do they have superpowers? I collected data on how mussels purified water, tested the best materials to monitor eels, and, with my mops and cages, proved how reefs and vegetation will host life in the Hudson. I measured how effective reefs were at mitigating wave impacts. I concluded that the ribbed mussels effectively purified water, and my eel mops and oyster cages supported life. Eel mops with eco-friendly materials like coconut fiber are working. In June, it is still in good shape, hosting a lot of specimens, which is the same support that polypropylene is doing without creating any harm or pollution. For wave dissipation, I had inconclusive results on our first experiment in Hoboken Cove using oyster cages to recreate a reef. Still, when I saw the video at home, I saw that the water stopped going further inland when the water hit the reef. In my second experiment, I used a wave tank to simulate Hurricane Sandy conditions in the Hudson River. When I tested the existent topography with the hard structure, it flooded, but when I introduced my living shorelines, it didn't. It could have a significant ecological impact if we successfully restore the living shoreline in Hoboken and nearby cities. Having a healthy environment provides substantial ecosystem benefits for people and all other organisms; it also helps stop climate change and engage our community around living shoreline restoration, which will lead to deeper learning about ecology and the value of a healthy environment, allowing to create future stewards and advocates for the Harbor.

Objective

I aim to explore and demonstrate some of these living shorelines' "superpowers." Are they true? Will the presence of bivalves improve Hudson's water quality? Will restoring reefs and wetlands improve the living conditions for the wildlife? Do living

shorelines mitigate flood surges by reducing the force of waves? How can restoring these habitats benefit Hoboken, its citizens, the Hudson River, and its rich ecosystem? Hoboken has the opportunity to reintroduce these habitats.

Superpowers

The many 'Superpowers' (benefits) of the Living Shorelines include cost-efficient erosion control and shoreline stabilization. Absorption of energy from waves and currents. Habitat for a diversity of native species. Food and shelter for migrant species. Carbon sequestration to mitigate climate change. Pathways for wetland migration as the climate changes. Cleaner water through filtration of polluted runoff.[1].

Background

There are major efforts to bring back oyster reefs to Manhattan with the Billion Oyster Project, and ribbed mussels (Geukensia demissa) to the Bronx River by NOAA. Bivalves are foundational species in habitats like living shorelines. Inspired by this, I contemplate doing the tank experiment with bivalves to prove water quality improvement. I used Ribbed Mussels[2] instead of Eastern Oysters; my experiment will prove they are equally effective in enhancing water quality and habitat conditions. New habitats will likely stay intact because they are less prevalent than oysters for human consumption. The meat is rubbery and tough to chew. The meat can also be loaded with organic bacteria, which gives it a slightly metallic taste. They are a native species to the East Coast, so they won't disturb the Hudson ecosystem. They can filter 6.8 liters of the estuarine water per hour, and keep wetlands healthy. Adult ribbed mussels partially bury themselves in the mud attached to the stems and roots using their byssus. They hang there in groups so tight that they help prevent erosion. Conducting this type of experiment can bring awareness of the importance of permitting oyster restoration in the New Jersey coast, leading to the changes in the laws.

Other species that are also in decline for similar reasons than the oysters and mussels, is the American Eel. Possible factors are habitat loss, overfishing, pollution, etc. The Eel Project funded in 2008, by the New York Department of Environmental Conservation, catches eels and releases them above barriers, helping these animals access better habitat. It provides a baseline data on young eel population in the Hudson River. It's a way of protecting biodiversity and to permit a sustainable human consumption. The appearance of living shorelines along the Hudson River will give natural habitats for native and migration species to shelter and feed. In relation to this, I am conducting, in partnership with Resilience Paddle Sports at Pier 12, a monitor project for Glass Eels, Eastern Oysters, and Ribbed Mussels from February to October.

Other important topics for coastal residents is flooding. I was born a week before Hurricane Sandy. We were one of the luckiest families living in high ground of Hoboken, we didn't suffer from electricity cut or lack of clean water. Nowadays, urban planning in Hoboken is focusing on preventing flooding. There are a lot of cool projects to collect and storage water, like the Resilience Park, or the Maritime Park in the former NY Ferry Dry Dock that will reintroduce living shorelines. My idea is that we should take this last example and repeat it in other places of Hoboken.




Materials, Procedures, and Results

Cleaner water through filtration: Mussels Tank. (On-site experiment).

Materials		Procedure
Two tanks of 6.5 Gal.	12 Gal of water from the Hudson River.	Experiment duration: 1 day. Two tanks filled with 6 Gal. of Hudson River's water. Introduce 40 ml. of plankton in each tank. Introduce, in one of the tanks, 30 live mussels. Water qualities were tested at the beginning and at the end of the 24 hours. Observe the water and the mussels through a microscope. Note: Our Ribbed Mussels were taken from Hoboken Cove, and they were attached to small rocks. They were introduced in the tank attached to their rocks. Our efforts were to keep them alive and undisturbed. At the end of the experiment, we reintroduced them in their natural habitat.
Live Ribbed Mussels.	Water analysis test instruments.	
80 ml. Plankton	Timer.	
1600x Digital Microscope.	Gloves.	
Camera.	Air pump	
Measuring mat		

Results

After 24 hours, the pH, Nitrate, Salinity, and Oxygen values were very similar. We waited for the sediment to settle in the tank. The turbidity in the water was very different at the beginning, it was 70 JTU (approximately 1 ½ ft visibility). It passed to 0 JTU at the end of the experiment. When looking at the water through the microscope, there was mud, plankton (green areas), and organisms (moving small white dots) at the beginning. In the end, the green color and moving dots disappeared. We concluded that Ribbed Oysters are filter feeders, and they ate the tiny organisms and toxins contained in the water, so the result was clear water.

Habitat for diverse native species: Eel Mops. (On-site experiment).

Materials

Coconut fiber rope.	Jute fiber rope.	Polypropylene rope.
Ceramics Tile.	Plastic ties.	Microscope.
Scale.	Rope and floaters.	Camera.
Water test.	Buckets.	Elastic bands.
Net and strainer.	Container.	Life jacket.
Measuring mat.		

Procedure

Deploy tree eel mops (coconut, jute, and polypropylene) in the Hudson River. Collect information after 15 days. Register which specimens were found (amount, size), observe the conditions of the materials used for mops (adequate, durability), and define the impact these materials may have on the specimens (location, amount, and type). Register water quality, weather, and river conditions at the moment of the experiment. (This experiment will continue to October).

Results

We observed that the three mops of different materials equally attracted the same type and amount of specimens. We concluded that the eco-friendly materials worked the same as the traditional plastic mop. We saw amazing specimens like: A Glass Eel, Amphipods, Isopods, crabs, shrimps, an Eastern Mud Snail, etc. We were very excited to catch the first eel of the year, but it was dead. The eel was inside the jute mop. We will monitor if jute is the right material for a mop. Right now, we speculated that jute might be heavy and difficult to go in and out for some species. But because we found so many alive specimens in the jute mop, and a dead clam worm, which was inside the plastic mop. We can't conclude if the death of the eel is related to the jute material. At the end of the experiment, we concluded that helping to restore natural habitats along the harbor will create more shelters for all the native and migratory species of the Hudson River. All of the mops are in good shape, but they all have been inside the water for a short time. We will evaluate the durability of the materials later on. The eel mop further out from the shore was the one with a few more specimens, and we will check out if this tendency continues.

Note: We used Ceramic Flame Tamer Tiles that use high-content cordierite raw material. Cordierite is a naturally occurring mineral compound containing magnesium, iron, aluminum, and silicon. It is a non-absorbent and lead-free material. It has been widely used in applications where thermal shock resistance is important.

Habitat for diverse native species: Oyster Cages. (On-site experiment).

Materials

Metal bait cages.	Ceramics Tile.	Empty shells.
Caliper.	Plastic ties.	Water test.
Net.	Rope and floaters.	Microscope.
Container.	Buckets.	Strainer.
Scale.	Camera.	Life jacket.
Measuring mat.		

Procedure

Deploy two oyster cages (7" x 6" x 4") in the Hudson River. Collect information after 15 days. Register which specimens were found (amount, size). Observe the conditions of the materials used for the cages (adequate, durability), and define the impact these materials may have on the specimens (location, amount, and type). Register water quality, weather, and river conditions. (This experiment will continue to October).

Results

Oyster Cages had several specimens sheltering inside like: Lacy Bryozoans, Barnacles, Mud Crabs, Shore Shrimps, Clams, and Amphipods. We didn't detect any Oysters (Spats) or Mussels. Maybe they're too small to be seen just with my eyes. Most of the specimens were located between the tile and the empty shells, we don't know if this is because they got trapped there while the cage was pulled out of the water or because they like to be less exposed to the outside. The cage with the textured tile to the inside had more specimens than the one that has the texture to the outside. We don't know if this observation is important, yet. All the cages were in pretty good shape.

Note: We used Ceramic Flame Tamer Tiles that use high-content cordierite raw material. Cordierite is a naturally occurring mineral compound containing magnesium, iron, aluminum, and silicon. It is a non-absorbent and lead-free material. It has been widely used in applications where thermal shock resistance is important.

Wave Dissipation. Oyster Cages Reefs (On-site experiment).

Materials			Procedure
Bait cages.	Scale.	Empty shells.	Six cages (6" x 6" x 3"), containing ten to twelve empty oyster shells. I designed a natural zigzag figure with them, mimicking natural oyster reefs. Use plastic ties to put them together. I introduced them in the shore. Use the stakes to maintain them put. Observe how the waves behave. Use the long ruler to check out the height of the waves.
Waders with boots.	Caliper.	Mat.	
Tent stakes.	Camera.	Cut resistant gloves.	
Rope and floaters.	Plastic ties.	Full arm gloves.	
Long ruler.			

Results

My findings to prove wave dissipation were inconclusive. My reef wasn't big enough to be on the Hoboken Cove shore, and the results were not easy to see. However, after I watched the videos at home, I concluded that when the water hit the reef, the water slowed down and stopped going further inland. I will need to design a bigger reef and test it again.

Wave Dissipation with a Wave Tank (Off-site experiment).

Materials

Hoboken and Hudson River topography map.	Glass Aquarium 6.7 in x 23.6 in x 9.4 in.
Polystyrene Sheets 0.02 in width.	Lego Spike robot.
Plastic glue.	Silicone.
Cutting pad.	Knife.
Metal ruler.	Tap water

Procedure

Use a glass tank to create your model. Define the scale you will work with to define the width of the plastic sheets. Take the plastic sheets and cut them in the size of the tank. Use a ruler and a knife to make the cut out better. Then, get a Hoboken and Hudson River topography map, cut specific lines on the map, and transfer them to the plastic sheets. Cut the plastic sheets following the topography lines. When you glue them in the tank altogether, it will form a 3d model of a topography of the Hudson River and Hoboken. Indicate on the tank, the highest Hurricane Sandy wave and the zero-level elevation. Add tap water until it reaches 11 feet surge above sea level. Use a lego spike robot and code it to move its arm up and down so it can create waves. Create a code to mimicate Hurricane Sandy conditions with waves up to 14 feet. Test wave dissipation with original topography and with proposed living shorelines. Observe and record how waves behave. (Note: Sandy had 80-mile-per-hour peak wind gusts).

Results

When I tested the Hurricane Sandy condition wave, I saw that the shoreline armoring didn't stop the water, the riprap rock and bulkhead were insufficient to avoid the flood reaching the buildings. However, when I introduced the living shorelines in the wave tank, the strength of the waves changed once it collided with the reef. It backed off, slowed down, and stopped going further inland. Just like our expectations were. I concluded that the living shorelines did the job: wave dissipation in extreme conditions. I think the living shoreline found to dissipate the wave in three ways. One of them is absorption and it happens when the marshes and sediments absorb the energy of the wave. Another one is scattering where the water crashes into a living shoreline which has lots of angles, and different surfaces in different directions so that the water will scatter around in different places losing its energy. The last one is reflection where the water bounces back into the river when it collides with the reef.

Data

Data

Hudson River's Conditions and Weather	02/09/2024	02/21/2024	03/04/2024	04/23/2024	5/16/2024
Time	3 P.M.	12 P.M.	4 P.M.	3 P.M.	4 P.M.
Ph	6.5 - 6.0	6.5 - 6.0	6.5 - 6.0	7	7.5
Ammonia	0.6	0.6	0.6	1.2	1.2
Nitrite	0.3	0.3	0.3	0.3	0.3
Nitrate	5	5	5	5	5
Oxygen PPM	11	11	12	9	11
The salinity	12 ppt	10 ppt	10 ppt	18 ppt	12 ppt
Temperature Water	47℉ / 8.33℃	41℉ / 5℃	45℉ / 7.22℃	54℉ / 12.22℃	64℉ / 17.78℃
Temperature	52℉ / 11.11℃	37℉ / 2.78℃	55℉ / 12.78℃	60℉ / 15.56℃	62℉ / 16.67℃
Humidity	57	59	90	39	50
Rain	0%	0%	0%	0%	15%
Currents	Slack	Ebb -2.5 kts	Flood 0.3 kts	Ebb -2.3 kts	Flood
Turbidity			Less than 1 ft.	1 3/4 ft	2 ft
Weather Conditions over the previous 2 days.	Clear sunny warmer day.	Cold clear gusts of wind.	Cold cloudy gusts of wind.	Sunny and windy.	Cloudy and windy.
Water Observations (color, clear, dirty, etc).	Turbid and wavy. Unseasonably warm.	Rather turbid.	Turbid, and turbulent. Cold.	Wavy and turbid.	Wavy and turbid.

LIVING SHORELINES SUPERPOWERS / BY JACOB TENNENBAUM

Metadata

School/Organization Name: (if applicable)	STEM Showcase, Hoboken Charter School.		
School Grade (if applicable):	5th Grade		
Number of Students Monitoring: (if applicable):	1	Number of Adults Monitoring	4
Name(s) of Team Members:	Jacob Tennenbaum, Noelle Thurlow, Matthew Mahoney, Jeremy Roche, and Mom.		
Name of Site:	Pier 12		
Oyster Research Station Tag #:	Resilience Paddle Sports Headquarters		
Mentoring	Noelle Thurlow, Master of Arts in Teaching (MAT) and a Master in Biology (Urban Ecology)		
Date of data collection:	02/21/2024		
Time of data collection:	12:00 P.M.		
Reference: Billion Oyster Project / Oyster Measurement Data Sheet.			

Data collection used	
Standard	X
Short-on-time	

Tally of oysters less than 15mm
No visible spat or oyster.

Total Number of oysters less than 15mm	Dead: 0	Alive: 0
Total Number of oysters greater than or equal to 15mm	Dead: 0	Alive: 0

Notes or other observations: Ex: It's raining, if there is trash in the water, most oysters are >15mm and some are <15mm, etc.	We didn't find any oyster or spat. We found baby clams, shrimps, crabs, etc. It was very cold and hard to do the job. There wasn't any garbage in the water

LIVING SHORELINES SUPERPOWERS

Biological Species

Polypropylene Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Clams	~100	1 - 8	X	
2	Shore Shrimp	10	10 - 15	X	
3	Amphipods	19	5 - 10	X	
4	Clam Worm (fragment)	1	30		X
5	Isopods	1	12	X	

Observations:	Sample showed more oil than the others. We didn't relate it to the material.

Coconut Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Clams	~100	1 - 8	X	
2	Shore Shrimp	8	10	X	
3	Amphipods	20	5 - 10	X	

Observations:	Closest to shore. Coconut fiber is in good shape.

Jute Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Clams	~100	1 - 8	X	
2	Shore Shrimp	1	20	X	
3	Amphipods	15	5 - 10	X	
4	Glass Eel	1	20		X
5	Eastern Mud Snail	1	20	X	
6	Crab	1	8	X	

Observations:	Further from shore. Dead eel. This material seems heavier than the others, and it is peeling apart leaving strings in hands.

Other observations:	At this moment, eel mops materials support same form of life. Satellite topography map of the Hudson River shows a constant depth of 16 mts. for all the area were experiment it's taking place, I concluded all oyster cages and eel mops are located at the same depth.

Reference: Resilience Paddle Sports / Data Collection Sheet

LIVING SHORELINES SUPERPOWERS

Biological Species

Oyster Cage (Corrugated Side-Down Tile)					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Barnacle	1	2	X	
2	Mud Crab	1	10	X	
3	Shrimp	1	20	X	
4	Amphipod	1	8	X	
5	Lacy Bryozoan	1	10	X	
6	Clams	~ 50	1 - 5	X	

Observations:	Furthest from the shore of all cages and mops. No visible oysters.

Oyster Cage (Corrugated Side-Up Tile)					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Barnacle	1	3	X	
2	Amphipod	2	5	X	
3	Lacy Bryozoan	1	10	X	
4	Clams	~ 50	1 - 5	X	

Observations:	No visible oysters.

Other observations:	Most organisms were found near or attached to the tile.

Cage with Soft Surface
8 oyster shells going from a thickness of 3 mm to 18 mm, going from a length of 100 mm to 80 mm, and having widths going from 6 ½ mm to 48 mm. All the oysters in the cage combined, in weight, is 0.94 kg and the cage alone weighs 0.32 kg. Vinyl coated wire cage, size: 7" x 6" x4".
Cage with Textured surface
8 oyster shells going from a thickness of 25 mm to 2 mm, going from a length of 100 mm to 85 mm, and having widths going from 76.20 mm to 55 mm. All the oysters in the cage combined, in weight, is 1.08 kg and the cage alone is still 0.32 kg. That's because the ceramic tile has different textures, we just flipped over the ceramic tile for this cage. Vinyl coated wire cage, size: 7" x 6" x4".

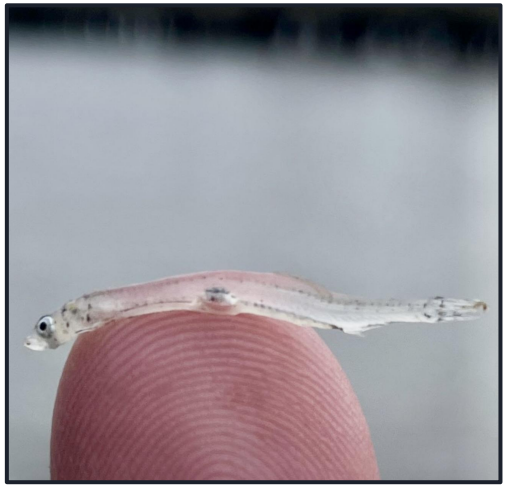
Reference: Resilience Paddle Sports / Data Collection Sheet

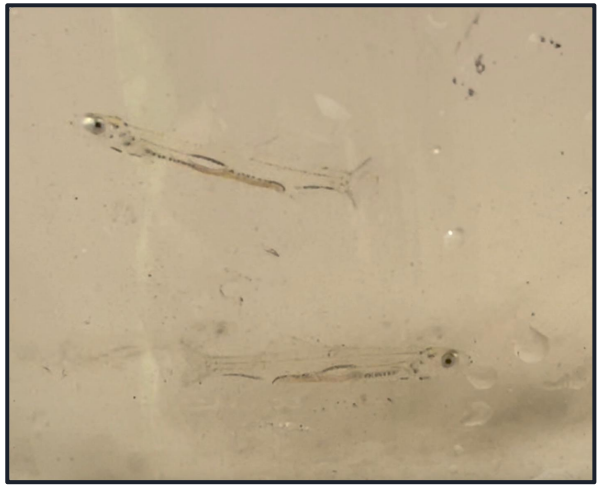
LIVING SHORELINES SUPERPOWERS

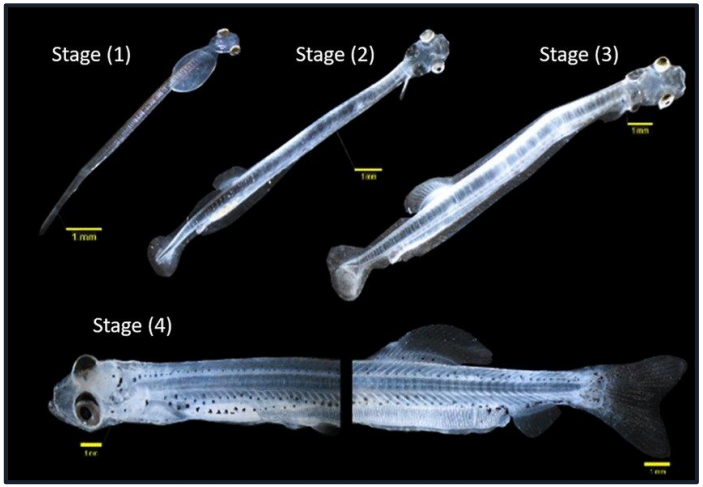
Updated 05/2024 - Biological Species - 02/21/2024

As you can tell, on our data collection on February 21, we were very excited by finding our first glass eel of the season. But in further observation, we concluded we were in the presence of a different species. My mentor believes this specimen can be either a juvenile Atlantic silverside or a type of herring. Later, I compare all of our pictures with others on the internet and I think it might be a herring in its last larva stage.

Below, to the left, we have other view of the specimen found in the jute mop. In this picture, we can see what it seems to be a collapsed caudal fin. Pier 12. February 21, 2024. In the center, we see a herring larvae in its different developmental stages. Figure - available from: Marine Biology 168(6) June 2021 DOI:10.1007/s00227-021-03894-z. To the right, a group of fish Resilience found on May 06, 2024.







LIVING SHORELINES SUPERPOWERS / BY JACOB TENNENBAUM

Metadata

School/Organization Name: (if applicable)	STEM Showcase, Hoboken Charter School.		
School Grade (if applicable):	5th Grade		
Number of Students Monitoring: (if applicable):	1	Number of Adults Monitoring	2
Name(s) of Team Members:	Jacob Tennenbaum, Noelle Thurlow, and Mom.		
Name of Site:	Pier 12		
Oyster Research Station Tag #:	Resilience Paddle Sports Headquarters		
Mentoring	Noelle Thurlow, Master of Arts in Teaching (MAT) and a Master in Biology (Urban Ecology)		
Date of data collection:	03/04/2024		
Time of data collection:	4:00 P.M.		
Reference: Billion Oyster Project / Oyster Measurement Data Sheet.			

Data collection used	
Standard	X
Short-on-time	

Tally of oysters less than 15mm
No visible spat or oyster.

Total Number of oysters less than 15mm	Dead: 0	Alive: 0
Total Number of oysters greater than or equal to 15mm	Dead: 0	Alive: 0

Notes or other observations: Ex: It's raining, if there is trash in the water, most oysters are >15mm and some are <15mm, etc.	We didn't find any oyster or spat. We found black spots not identified. We found baby clams. Water was turbid and turbulent. It rained on Saturday, two days ago.

LIVING SHORELINES SUPERPOWERS

Biological Species - 03/04/2024

Polypropylene Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Clams	~50	1 - 8	X	
2	Shore Shrimp	2	20 - 35	X	
3	Amphipods	5	2 - 8	X	
4	Clam Worm	2	10 - 30	X	

Coconut Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Clams	~100	1 - 8	X	
2	Shore Shrimp	1	20	X	
3	Amphipods	10	2 - 8	X	

Observations:	Polypropylene and Coconut fiber are in good shape.

Jute Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Clams	~500	1 - 8	X	

Observations:	The jute material is peeling apart leaving strings in the hands.

Reference: Resilience Paddle Sports / Data Collection Sheet

Other observations:

At this moment, eel mop materials support the same form of life. Coconut fiber is in better shape than jute fiber. Microscopic Zooplankton, smaller than 1 mm, was found in the mud attached to the mops. There was a storm on Saturday, and, today the river was turbid and turbulent at the moment of data collection. The dire conditions and the storm may be a reason for the lack of animals in mops and cages.

Oyster Cage (Corrugated Side-Down Tile)					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Clams	~ 100	1 - 10	X	

Oyster Cage (Corrugated Side-Up Tile)					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Clams	~ 100	1 - 10	X	

Observations:	No visible oysters. Black spots not identified.

Other observations:

Clams are indistinctly located in cage, ceramic tile, and empty shells. The are double the amount of last data collection, and grew in size. Black spots on empty shells. River and weather conditions may affect the presence of life in the cages. There was a storm on Saturday, and, today the river was turbid and turbulent at the moment of data collection. The dire conditions and the storm may be a reason for the lack of animals in mops and cages.

LIVING SHORELINES SUPERPOWERS / BY JACOB TENNENBAUM

Metadata

School/Organization Name: (if applicable)	STEM Showcase, Hoboken Charter School.		
School Grade (if applicable):	5th Grade		
Number of Students Monitoring: (if applicable):	1	Number of Adults Monitoring	3
Name(s) of Team Members:	Jacob Tennenbaum, Noelle Thurlow, Jeremy Roche and Mom.		
Name of Site:	Pier 12		
Oyster Research Station Tag #:	Resilience Paddle Sports Headquarters		
Mentoring	Noelle Thurlow, Master of Arts in Teaching (MAT) and a Master in Biology (Urban Ecology)		
Date of data collection:	04/23/2024		
Time of data collection:	2:00 P.M.		
Reference: Billion Oyster Project / Oyster Measurement Data Sheet.			

Data collection used	
Standard	X
Short-on-time	

Tally of oysters less than 15mm
No visible spat or oyster.

Total Number of oysters less than 15mm	Dead: 0	Alive: 0
Total Number of oysters greater than or equal to 15mm	Dead: 0	Alive: 0

Notes or other observations: Ex: It's raining, if there is trash in the water, most oysters are >15mm and some are <15mm, etc.	We didn't find any oyster or spat. We found baby clams. Water was turbid and wavy.

LIVING SHORELINES SUPERPOWERS

Biological Species - 04/23/2024

Polypropylene Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Shore Shrimp	15	15 - 30	X	
2	Amphipod	25	2 - 15	X	
3	Clam	50 - 120	2 - 10	X	
4	Isopod	9	2 - 8	X	
5	Crab	2	15	X	
6	Leech	3	10 - 30	X	

Observations:	The polypropylene is in good shape and had relatively the same amount of species than the coconut mop. However, the downside is that this mop isn't eco-friendly.

Jute Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Shore Shrimp	1	30	X	
2	Amphipod	20	2 - 10	X	
3	Clam	40	2 - 10	X	
4	Clam Worm	2	10 - 30	X	

Coconut Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Shore Shrimp	10	10 - 30	X	
2	Amphipod	3	2 - 20	X	
3	Clam	80 - 200	2 - 10	X	
4	Isopod	2	20	X	
5	Crab	4	10	X	
6	Clam Worm	2	35	X	
7	Barnacle out of its shell or a barnacle molt	1	20		X

Observations:	The coconut fiber is in good shape. And it's doing as good as the traditional mop of polypropylene. It always shows a diverse and good amount of living creatures.

Observations:	The jute material is continuing to peel apart. In result, the size of the mop has reduced. This mop is the one that always has less species inside.

Other observations:	Today, we didn't find a glass eel. The only glass eel found in this area, until now, was found by us in our first data collection. The team will check the mops more frequently because we are in the peek of migration season that goes from March to June. College students from the New Jersey City University are also monitoring the mops including the ones of my project, we will share our data. That means that I am, now, part of a bigger group of scientists and we will be monitoring the glass eels and sharing information.

Oyster Cage (Corrugated Side-Down Tile)					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Amphipod	8	2 - 8	X	
2	Crab	4	7 - 10	X	
3	Oyster Flatworm	1	10	X	
4	Clam	50	2 - 10	X	
5	Shore Shrimp	2	15 - 20	X	
6	Clam Worm	3	10	X	

Observations:	No visible spat, oysters or ribbed mussel. Shells show pilling and surface erosion.

Oyster Cage (Corrugated Side-Up Tile)					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Amphipod	11	10	X	
2	Crab	1	6	X	
3	Oyster Flatworm	3	10	X	
4	Clam	50	1	X	

Observations:	No visible spat, oysters or ribbed mussel. Shells show pilling and surface erosion.

Other observations:	The tile in one of the cages was missing (corrugated side-up). The shells showed signs of erosion in their surface. We weigned the cages again. At the beginning of the experiment the cage with the soft surface weigned 0.94 kg. Today, its weight was 1.02 kg. The cage with the textured tile missed its tile. This cage weighed at the beginning 1.08 kg. Today, its weight was 0.96 kg. There is an increase of weight but a deterioration of shell's surfaces in both cages.

Reference: Resilience Paddle Sports / Data Collection Sheet

LIVING SHORELINES SUPERPOWERS / BY JACOB TENNENBAUM

Metadata

School/Organization Name: (if applicable)	STEM Showcase, Hoboken Charter School.		
School Grade (if applicable):	5th Grade		
Number of Students Monitoring: (if applicable):	1	Number of Adults Monitoring	2
Name(s) of Team Members:	Jacob Tennenbaum, Noelle Thurlow, and Mom.		
Name of Site:	Pier 12		
Oyster Research Station Tag #:	Resilience Paddle Sports Headquarters		
Mentoring	Noelle Thurlow, Master of Arts in Teaching (MAT) and a Master in Biology (Urban Ecology)		
Date of data collection:	05/16/2024		
Time of data collection:	4:00 P.M.		

Reference: Billion Oyster Project / Oyster Measurement Data Sheet.

Standard	
Short-on-time	X

than 15mm
No visible spat or oyster.

Total Number of oysters greater than or equal to 15mm	Dead: 0	Alive: 0

Notes or other observations: Ex: It's raining, if there is trash in the water, most oysters are >15mm and some are <15mm, etc.	We didn't find any oyster or spat. We found baby clams and baby ribbed mussels. Water was turbid and wavy.

LIVING SHORELINES SUPERPOWERS

Biological Species - 05/16/2024

Polypropylene Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Crab	10	10 - 25	X	
2	Amphipod	~20	2 - 15	X	
3	Clam	~50	2 - 10	X	
4	Isopod	1	2 - 8	X	
5	Shore Shrimp	14	10 - 40	X	
6	Clam Worm	1	35	X	
7	Anemone	1	10	X	
8	Ribbed Mussel	1	1	X	

Jute Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Crab	1	55	X	
2	Amphipod	~20	2 - 10	X	
3	Clam	~50	2 - 10	X	
4	Clam Worm	~50	10 - 35	X	

Other observations:	Today, we didn't find a glass eel. Resilience found two glass eels at Weehawken Cove the following day of our data collection in Pier 12. They were around 60mm. It has been raining, the river was turbulent and turbid. We found oil in the mops, this may reflect the condition of the water in the area.

Coconut Mop					
	SPECIES	#	(mm)	**Alive**	**Dead**
1	Crab	35	10 - 30	X	
2	Amphipod	~50	2 - 20	X	
3	Clam	100 - 200	2 - 10	X	
4	Isopod	15	10 - 20	X	
5	Shore Shrimp	24	10 - 40	X	
6	Clam Worm	2	35	X	
7	Anemone	1	10	X	

Observations:	The polypropylene is in good shape and had relatively the same amount of species than the coconut mop. Considerable amount of oil was visible on the mop.

Observations:	The coconut fiber is in good shape. And it's doing as good as the traditional mop of polypropylene. It always shows a diverse and good amount of living creatures. here was a small presence of oil in it.

Observations:	The jute material is continuing to peel apart and decaying. In result, the size of the mop has reduced almost around 60%. It was heavy, compacted and with a lot of oil. It has a bad smell. This mop is the one that always has less species inside. We found a lot of clam worms in it.

Reference: Resilience Paddle Sports / Data Collection Sheet

LIVING SHORELINES SUPERPOWERS

Biological Species - Highlights - February to May, 2024

Shore Shrimp

Clam

Amphipod

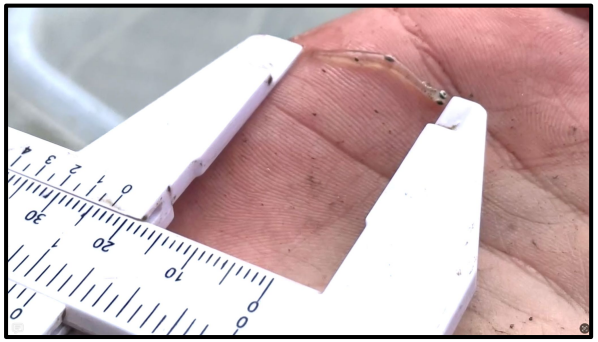
Clam Worm

Leech

Leech

LIVING SHORELINES SUPERPOWERS

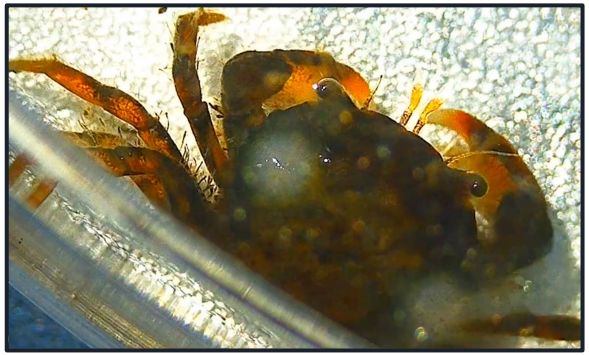
Biological Species - Highlights - February to May, 2024



Herring Larvae

Ribbed Mussel Byssus

Baby Ribbed Mussel



Mud Crab

Barnacle out of its shell or Barnacle Molt

Eel Glass (Resilience finding)

LIVING SHORELINES SUPERPOWERS - EEL MOPS COMPARISON - February to May 2024.

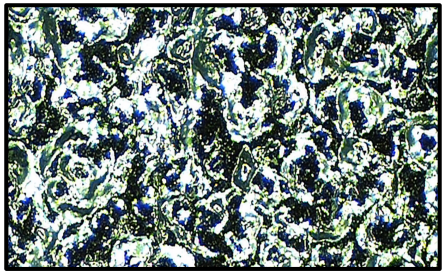
Criteria	Jute Mop	Polypropylene Mop	Coconut Mop
Supporting of Life	At first, the jute mop did good catching lots of species. It was supporting life like the other two mops. We found a species that was dead but we didn't relate it to the material because there were so many others alive. We thought it was a glass eel but, in further observation, my mentor discovered that it was another type of fish, possibly a juvenile Atlantic silverside or a type of herring. Now, I think it is an Atlantic herring larvae. We have yet to find a glass eel in my mops. By the second month, the mop peeled leaving strings in the hands and it began to support less specimens. After four months submerged in the Hudson River, the mop is decaying, and it only supported few species like amphipods, clam worms, clams and mud crabs.	Constantly, polypropylene has been supporting life, a variety and good amount of it. But also, it presented more oil than the other two mops. Its performance shows that polypropylene is a robust material to do the job correctly. It has been supporting similar life to the coconut mop. Last data collection, we found a considerable amount of oil and the number of specimens were less than in previous occasions. Overall, my observation on the polypropylene mop is that it is doing a good job supporting life. A new species it caught were two leeches.	The coconut mop has been doing a good job. It supports a lot of different species in the same amount as the polypropylene mop. It hasn't been oily or completely filled with mud giving it a rich environment and enough space for life to develop and move freely. In the last data collection, the center of the mop was muddy and small creatures were moving constantly. It was impossible to identify all of them. No other mop showed the same capacity to host life. My observation is that this mop is robust and durable, and it is doing a good job. It seems like the mop will stand until the end of this research on October 2024. We found a new species, ghost appearance, we used a microscope and we found that it was either a dead barnacle out of its shell or a barnacle molt. Unquestionably, this mop works great when supporting life, we said it is 'very popular'.
Presence of Contaminants	The jute mop is always oily and dense. We related the high presence of contaminants with the low number of specimens in it.	It has visible amount of oil in it. It didn't affect its performance.	This mop showed the least amount of oil in it. It is in good shape and doing a good performance.

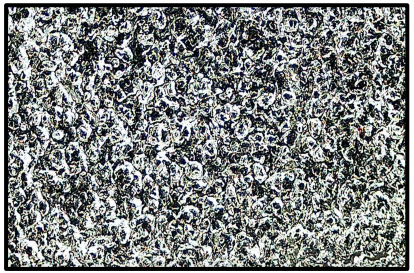
Criteria	Jute Mop	Polypropylene Mop	Coconut Mop
Durability	Jute isn't so durable. In four months, the jute material is degrading, it is continuing to peel apart and decay. The size of the mop has reduced by around 60%. In the last data collection, it was heavy, compacted, and very oily and muddy. It takes jute two to three months to degrade. The short lifespan of jute doesn't make it adequate to do this type of experiment.	Polypropylene is a synthetic fiber that is incredibly tough, making it a highly durable material. It is highly flammable and limited in its ability to withstand higher temperatures and it is also susceptible to UV degradation and oxidation. It holds up well against mold, rot, bacteria, oil, water, electricity, and high levels of physical stress. In the mops, they don't break or collapse; strings keep their shape. The smoothness and sturdiness of the material make the work easy when we do the data collection. The mop lost some strings in the river reducing slightly in size.	Coconut is durable, and it is the sturdy one between the two eco-friendly materials. It has splinted but not peeled. It is never oily or muddy. The presence of oil is low. The strings maintain their shape. Coconut coir has about 48% of linen which adds strength and elasticity to the cellulose based fiber walls. Since linen resists biodegradation, high linen content also imparts longevity for outdoors applications. Coir fiber nearly takes more than twenty years to decompose.
Shape	The jute mop isn't in good shape. It is disintegrating rapidly at the point that we are considering to retire this mop. After a month, the jute mop started to peel. By the second month, the peeling got worse leaving strings in the hands. On the third month, it became very oily and muddy. After 4 months submerged in the Hudson River, the mop is decaying, it has a bad odor, and it reduced the size by approximately 60%. The strings are getting compacted as one mass, and this material seems to absorb the oil in the environment.	The polypropylene mop is always in good shape because it is a man-made material. It is smooth, doesn't splinter, and it doesn't damage easily. It is a material that can be affected if it is exposed to sunlight, but it still can last twenty to thirty years. That means that the polypropylene string mop (plastic) can be reused for so many years of research. It was also reduced in size by around 10% to 5%, all mops lose strings in the river with a use maybe caused by strong currents, turbulence, or by being pulled out by big fish feeding on small species sheltering in it.	The coconut mop is in really good shape for a natural fiber. Coir is light and it floats. This mop managed to resist the conditions given in the experiment. It was also reduced in size by around 10% to 5%, all mops lose strings in the river with a use maybe caused by strong currents, turbulence, or by being pulled out by big fish feeding on small species sheltering in it. After four months in the river, strings show some splinters, but its texture is one of its strengths to attract life at the moment.

Criteria	Jute Mop	Polypropylene Mop	Coconut Mop
Environmentally Friendly	Jute is eco-friendly because jute fiber is 100% biodegradable and recyclable and thus environmentally friendly. A hectare of jute plants consumes about 15 tonnes of carbon dioxide and releases 11 tonnes of oxygen. Cultivating crop rotations enriches the fertility of the soil for the next crop. It takes jute two to three months for it to degrade.	Polypropylene is a useful substance because it's hydrophobic, meaning that it repels water, and oleophilic, meaning that it attracts oils. This might be the reason of the considerable amount of oil visible in the mop when we just pull it out from the river. This material degrades very slowly in landfills, and it takes PP about twenty to thirty years to be fully decomposed, but still shorter than other plastics like polyethylene and polystyrene, that can take over 500 years to degrade. PP can be recycled back into many different products and has a lighter carbon footprint. Additives used in plastic products may contain toxins such as lead and cadmium. As polypropylene degrades, it may release them into the water, to plants, and animals. PP exposure to high-temperature water significantly increases microplastic release.	Coconut fiber is renewable and an environmentally friendly resource that is sustainable. It is biodegradable and breaks down naturally. It is safe for wildlife since there is no plastic present to interfere with aquatic life. It can be compostable; pH neutral. Coir is water and microbial-resistant, inflexible, durable, and resistant to rotting and saltwater damage. Coir rope has been used since the ancient times for building houses and constructing boats. Coir fiber nearly takes more than twenty years to decompose. We believe our mop submerged in the Hudson River will have a lifespan of 1 to 2 years.
Investment	The jute rope was affordable. This material was the cheapest of the three. But it didn't stand to the requirements of the experiment. It will be withdrawn in future research.	Polypropylene is a cost-effective material that offers good value for money. PP is one of the least expensive and lightest thermoplastics on the market today. It offers easy processing with excellent chemical resistance and good mechanical properties. Polypropylene mops will last for years, they can be reused, but in consequence, it will reduce the cost of the research.	Coir rope is often more affordable than other natural fiber ropes, but it is more expensive than polypropylene rope, and also more expensive than jute rope. Also, it is a material that will need replacement each year or two, increasing the costs of research. In this case, it will be necessary to set priorities between the budget or the use of no pollutant material.

RIBBED MUSSELS FILTRATION TEST

Date	02/22	02/23	Observations:
Salinity PPT	18	18	I introduced 40 ml. of plankton in the tank containing 6 Gal. of Hudson River's water. Looking at a drop of water with a digital microscope 1600x, I saw some bright green areas that we assumed were plankton, brown areas of mud or sediments, and moving tiny particles in a light color. The microscope's base has an aluminum surface, giving the image an irregular black pattern. After a day, I looked again at one drop of water from the tank containing mussels. The green areas, sediments, and moving particles were reduced significantly. The water of the tank containing ribbed mussels was so clear now.
Oxygen PPM	11	11	
pH	7	7	
Nitrate	5	5	
Turbidity JTU	**70**	**0**	
Temperature	41℉ / 5℃	41℉ / 5℃	
Presence of plankton (green areas)	**Yes**	**Very little**	
Presence of microorganisms	**Yes**	**Very little**	
Presence of sediments	**Yes**	**Very little**	





Living Shorelines vs Hard Structures

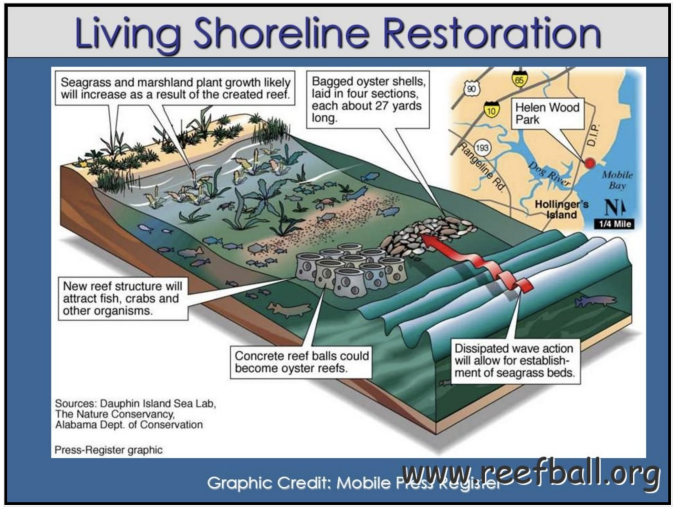
Protective structures such as seawalls and bulkheads can help save properties from erosion. But such structures, known collectively as shoreline armoring, can block the natural flow of sand and sediment down the coast and multiply the force of waves onto nearby shorelines—accelerating erosion elsewhere. Seawalls are expensive to build and maintain. And if they're allowed to degrade, they can wash into the water and hurt habitats. When the shoreline is armored, that's led to a loss of the critical shallow-water habitat that supports spawning fish, and small organisms which is at the base of the food web supporting everything else. Living shorelines reduce erosion, protect upland property, create habitat, and enhance resiliency using natural or recycled materials and strategic placement of plants and other organic materials. The reefs function in a similar fashion to rock breakwaters, dampening wave energy by inducing wave breaking as the wave trains propagate over the reef. This filtering prevents higher frequency waves from entering coastal marshes by attenuating wave energy by friction. In the face of rising sea levels and habitat destruction, many of the species that depend on New Jersey coastal ecosystems are increasingly at risk. Not only do living shorelines defend against coastal erosion, but they also restore and protect the habitats that many remarkable New Jersey species rely on.

Benefits and Disadvantages	LV	HS
Reduce shoreline erosion	✓	✓
Deflect and absorb wave energy	✓	✓
Minimal maintenance long term	✓	
Reduce storm surge and flood waters	✓	✓
Adapt to possible sea level rise	✓	
Increase recreational opportunities (fishing, wildlife viewing, potential for beach creation.)	✓	
Improve water quality	✓	
Maintain ecosystem functions (nutrient cycling, animal and plant habitat.)	✓	
Create habitat for terrestrial and aquatic species	✓	
Maintain the natural land/water connection	✓	
Multiply the force of waves onto nearby shorelines—accelerating erosion elsewhere.		✓

Wave Dissipation Test in Hoboken Cove 2/21/24

In matter, waves can lose energy through absorption, scattering, and reflection. Absorption occurs when the wave's energy is transferred to the matter, causing it to heat up or vibrate. Scattering happens when the wave is deflected in multiple directions, reducing its overall energy. Reflection is when the wave bounces off a surface, which can also result in energy loss.

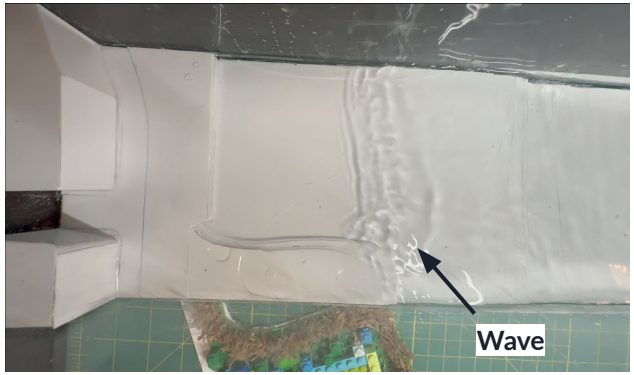
In my first experiment, I watched how the waves behave when they collided with the reef. I concluded that when the water hit the reef, the water slowed down and stopped going further inland.

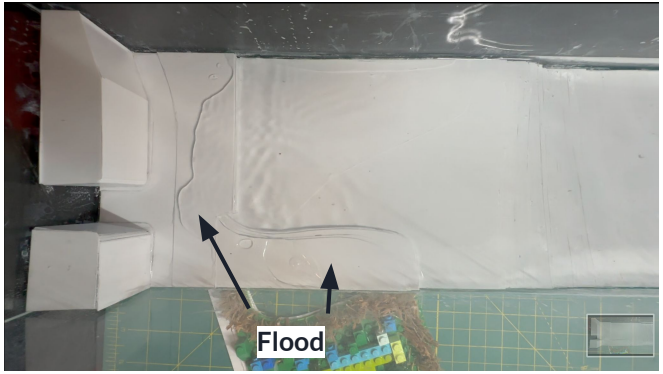


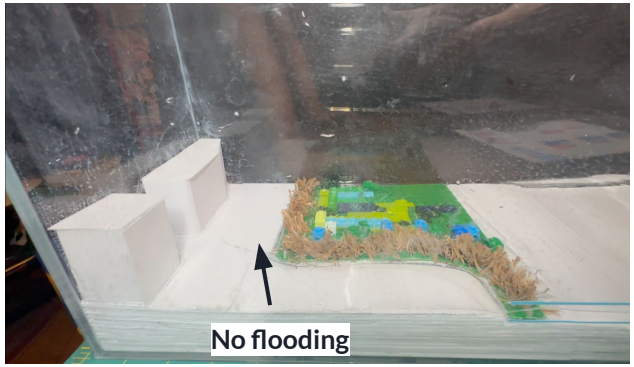
Wave Dissipation Test with a Wave Tank 6/8/24

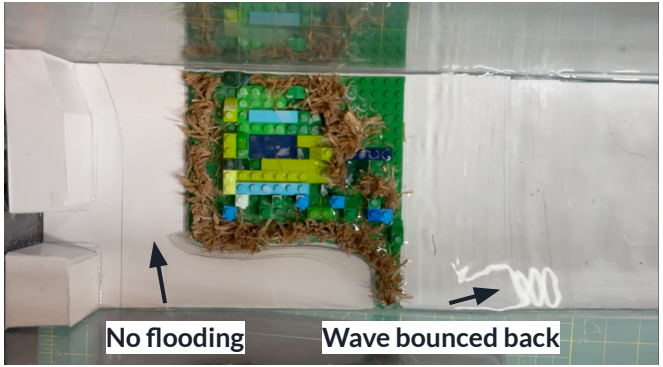
A **wave tank** is a laboratory setup for observing the behavior of surface waves. The typical wave tank is a box filled with liquid, usually water, leaving open or air-filled space on top. At one end of the tank, an actuator generates waves; the other end usually has a wave-absorbing surface.

In our experiment, we simulated the conditions of Hurricane Sandy. In these pictures, you can see how the wave approaches the shore. When it collided with the existing bulkhead wall, it resulted in flooded streets. When we introduced the living shorelines model, there wasn't any flood.









Hoboken’s Living Shoreline

Maps of the urban laboratory of the City of Hoboken show the following: A, the city plans with the elevation (New Jersey Department of Environmental Protection (NJDEP) 2002b); B, the geology; the city plans with the identification of the land use; and C, the sewer network with the outflows as implemented in SWMM (Gironás et al. 2010). The data is NAVD 88 (The City of Hoboken 2018)

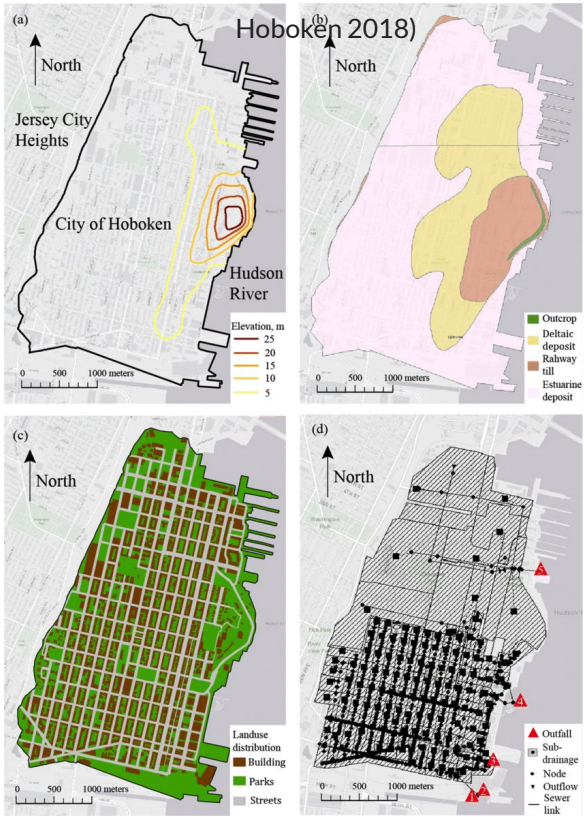
Actual Conditions.

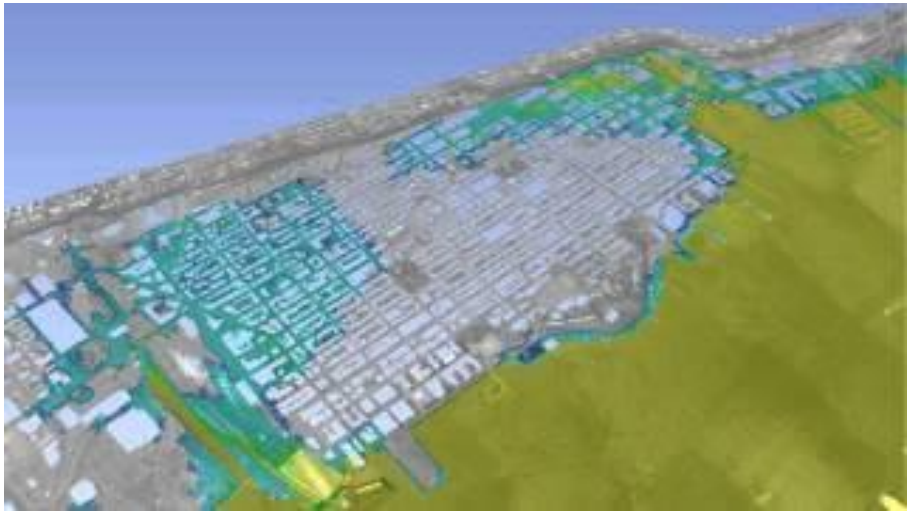
Hoboken's Topography

Hoboken's Flood Map

Hoboken's Green Areas

Hoboken's Sewer System





Hurricane Sandy
Flood Simulation in Hoboken

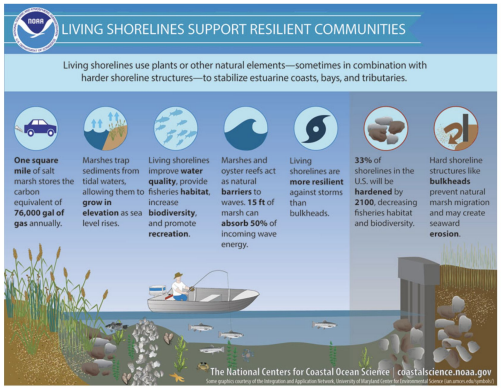
Solution.

Proposal for a new park in the former ferry's dry dock. The new marshes in this project are an excellent example of how we can reintroduce natural habitats to our shore. My idea is to do more living shorelines like this project along Hoboken and New Jersey coastlines on the Hudson River.

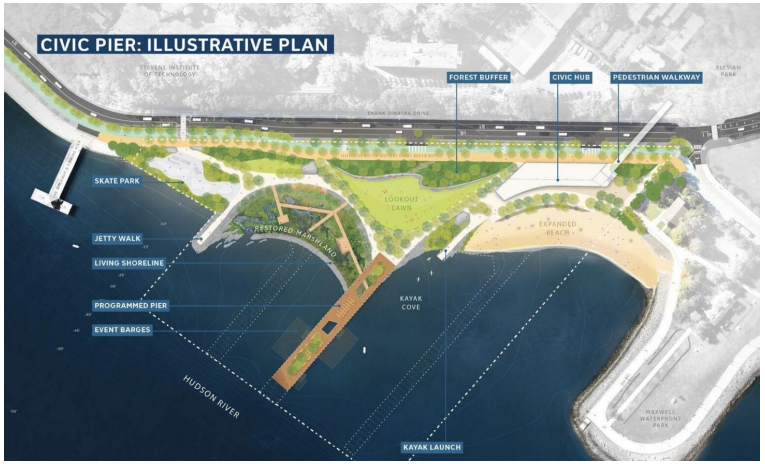
http://www.reefball.org/album/alabama/slides/Living%2BShoreline%2BRestoration.html

https://www.fisheries.noaa.gov/insight/understanding-living-shorelines

https://jerseydigs.com/maritime-park-hoboken



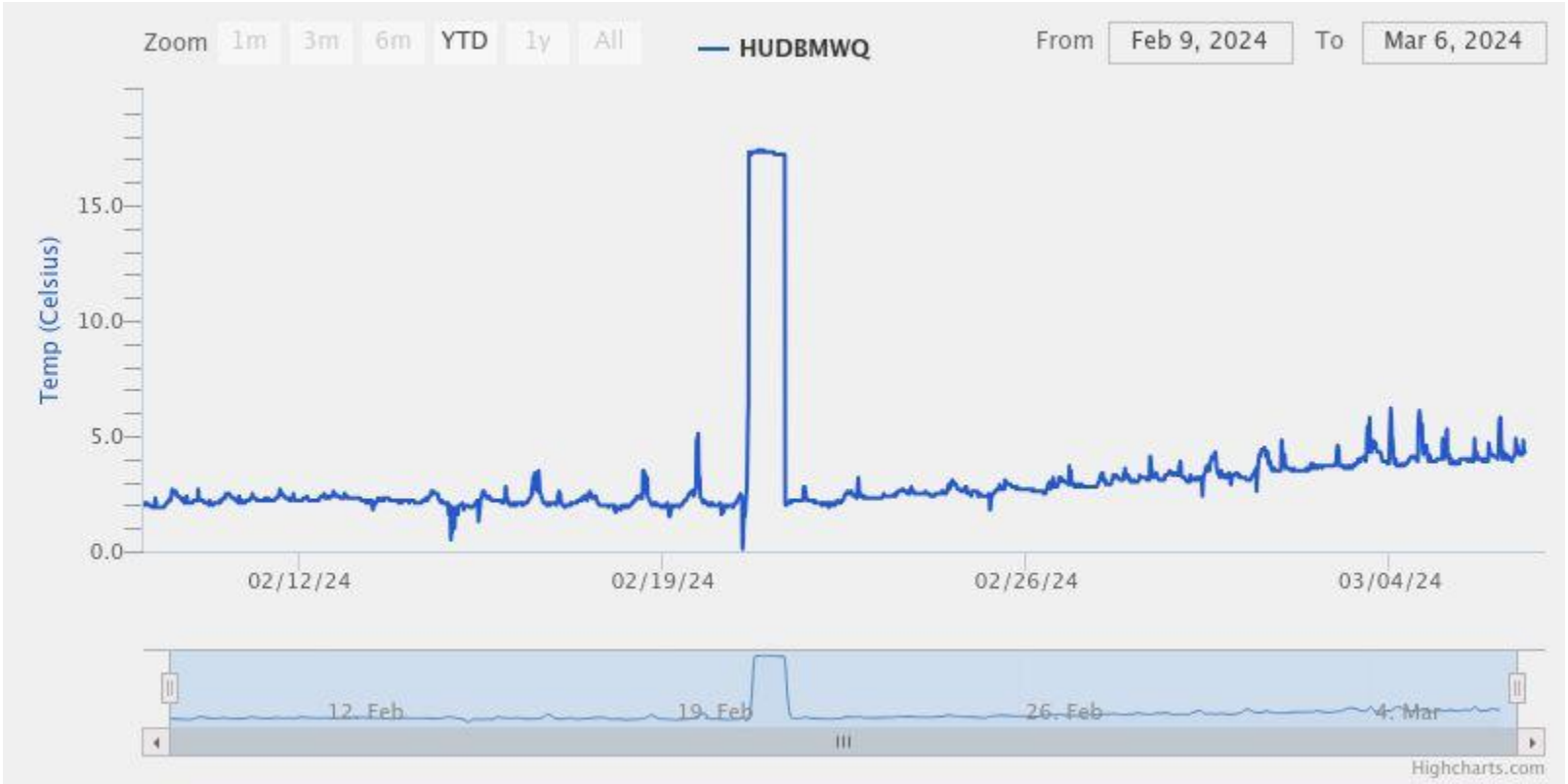
Living shorelines use plants or other natural elements to stabilize estuarine coasts, bays, or tributaries. Infographic Text



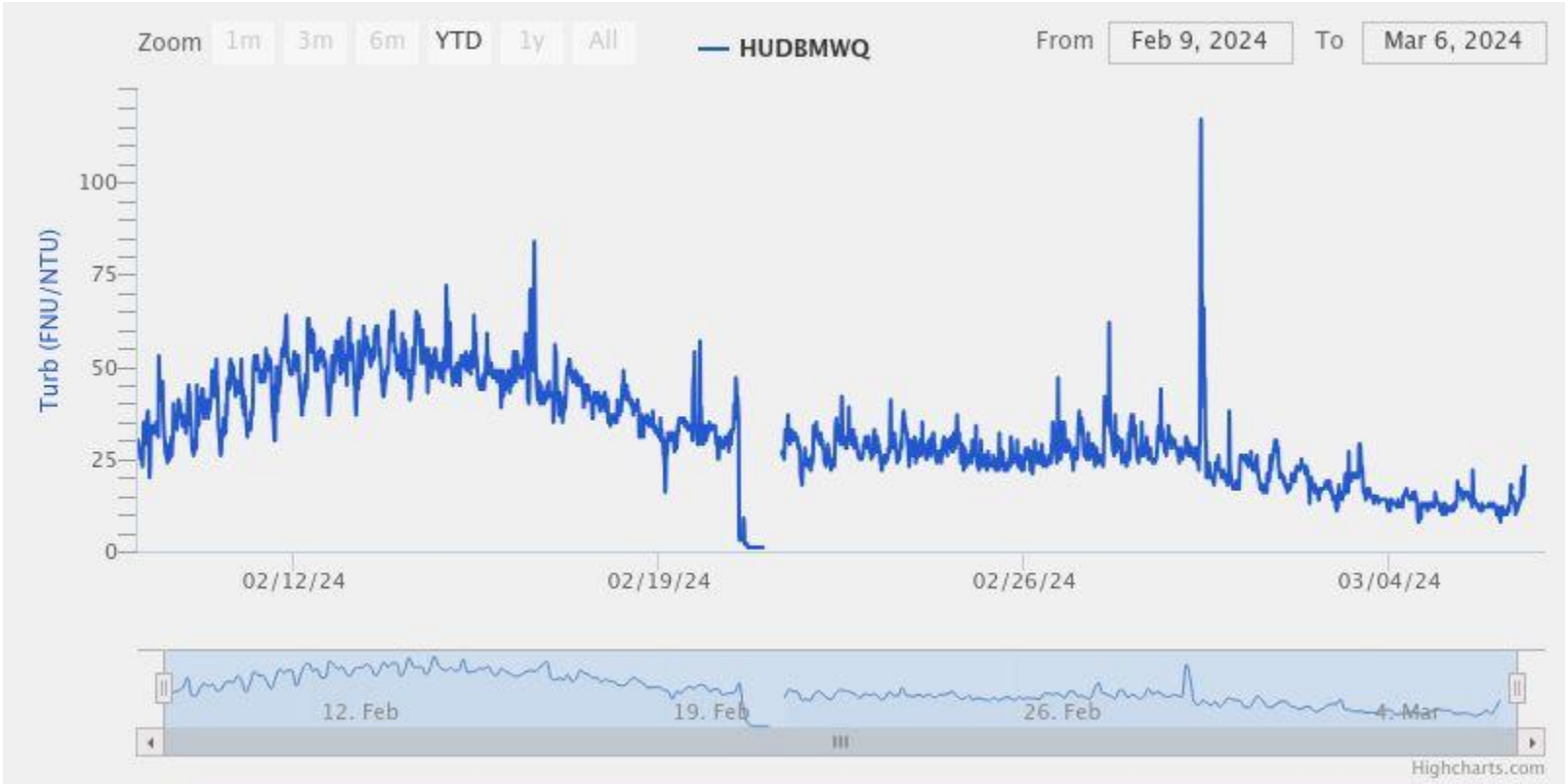
Examples.

Other Data

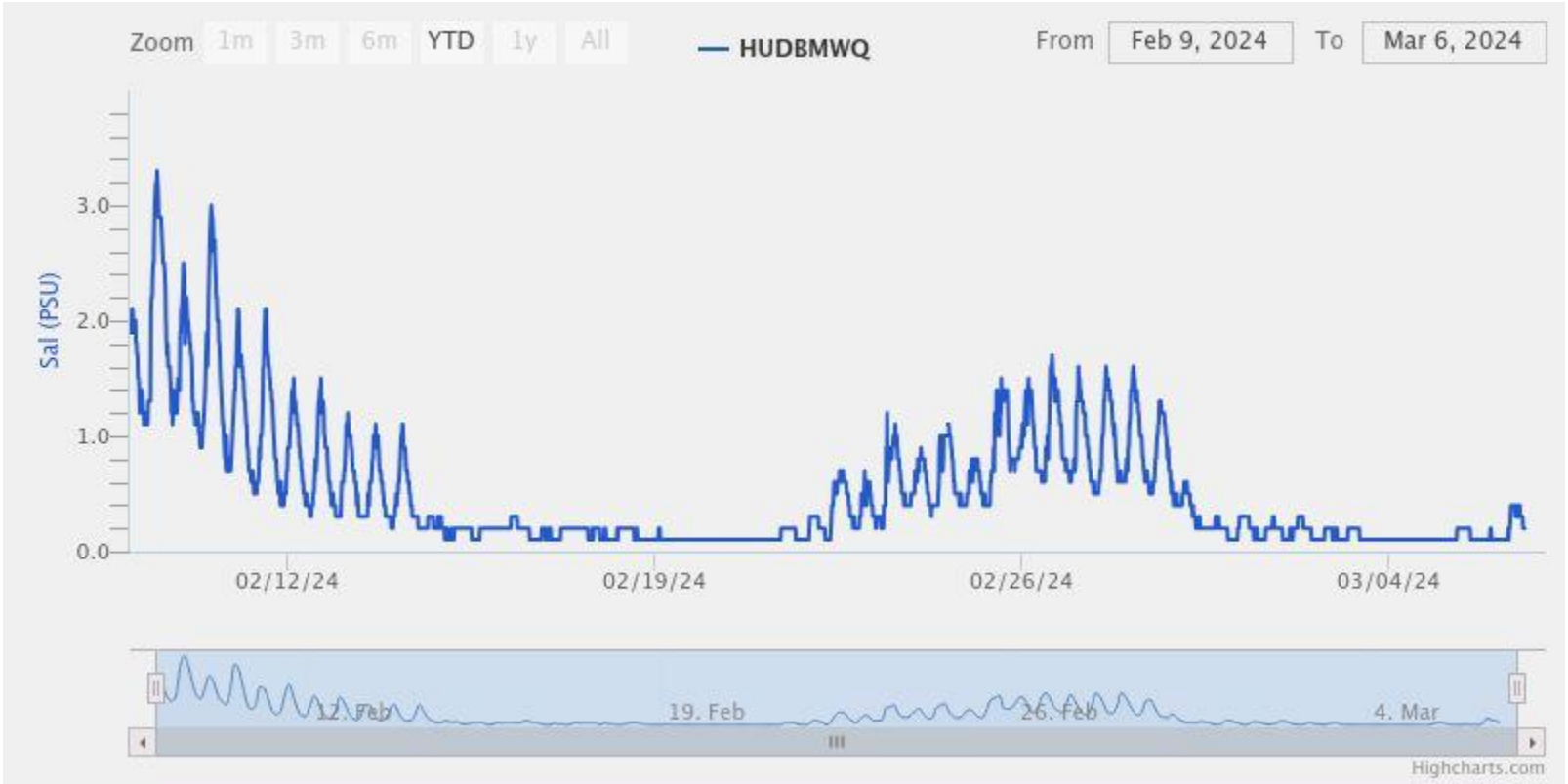
NOAA Temperature Data 02/09 to 03/06



NOAA Turbidity Data 02/09 to 03/06



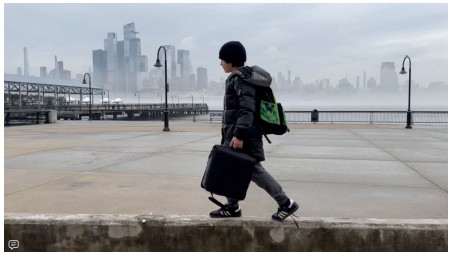
NOAA Salinity Data 02/09 to 03/06



Record

Record

Follow my experiment in a series of mini-documentaries in my project's website



Meet Resilience Team. Data collection at Pier 12. January 25, 2024.

Hoboken Cove, Data Collection. February 8, 2024.

Living Shorelines Superpowers, oyster cages, and eel mops deployment. Pier 12, February 9, 2024.

Living Shorelines Superpowers, water analysis test. Pier 12. February 9, 2024.

Living Shorelines Superpowers, oyster cages, and eel mops data collection. Pier 12. February 21, 2024.

Living Shorelines Superpowers, reef bed, and wave dissipation. Hoboken Cove. February 21, 2024.

Living Shorelines Superpowers, ribbed mussels filter feeders. Pier 12. February 22 and 23, 2024.

Living Shorelines Superpowers, oyster cages, and eel mops data collection. Pier 12. March 4, 2024.

Record

Follow my experiment in a series of mini-documentaries in my project's website

Billion Oyster Project, Basic Oyster Research Station Training. Williamsburg, Brooklyn. March 15 and 16, 2024.

Living Shorelines Superpowers, oyster cages, and eel mops data collection. Pier 12. April 23, 2024.

Living Shorelines Superpowers, oyster cages, and eel mops data collection. Pier 12. May 16, 2024.

Billion Oyster Project 10th Student Symposium. Governors Island. May 31, 2024.

Living Shorelines Superpowers, wave dissipation with a wave tank Hoboken, May 16, 2024.

How To Make

What do you need?

An eel mop is designed to hold juvenile (glass) eels. The eel mop mimics a suitable habitat for glass eels, leading eels to swim inside for a haven from the open waters. Eel mops are used to monitor the presence or absence of eels in a body of water.

What do you need?

7” by 7” Ceramic Tamer.
20 ft length of Coconut Coir Fiber Rope.
20 ft length of Jute Rope.
20 ft length of brown Polypropylene Rope.
Plastic ties.
Elastic bands.
½ ” - 100 ft Yellow polypropylene rope.
½” hole yellow fishing buoys.

Important To deploy an eel mop, you must first have a scientific collection permit from the NYC/NJ Department of Environmental Conservation.

How to do it?

Cut the ropes every 20”. Unfurl the rope completely, until each fiber is separated. After each bundle of rope is unfurled, fold the bunch of rope in half and rubber band it so that there is a loop at the top. Use a plastic tie to tie the bunch of rope to the tile, using the ceramic tile holes, and evenly distribute the bunches of rope. Keep attaching the fibers until you have all attached to the tile. You may remove the rubber bands once they are all firmly zip tied to the tile. Attach yellow rope to the tile using any hole. Make sure you make it long enough to tie it in your research station. Size of rope will vary depending on where you plan to deploy your mop. Use the buoy to signal the location of your mop, it will give itself visibility and prevent other passing boats from running over.

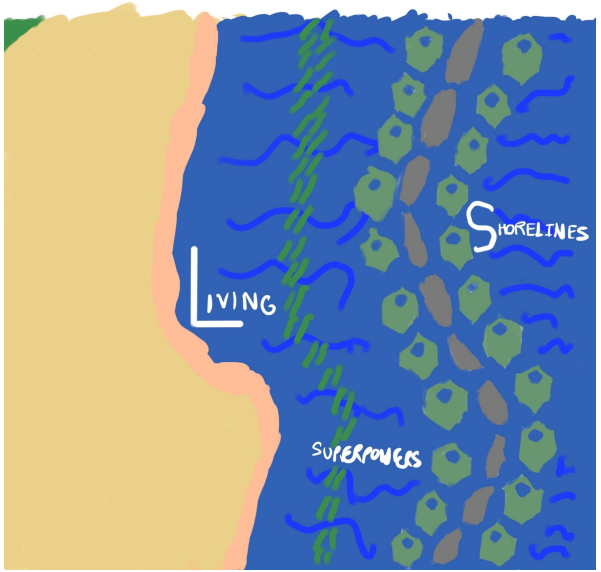
Conclusions

Monitoring species using eco-friendly mops and oyster cages has been successful. It is still cold and early in the year, but we saw fantastic specimens. The mops and cages mimic the natural habitat the animals will find on a living shoreline. If we help restore their habitats, they will come to live here, and the species' population will increase and become very diverse. I am excited to see what I will find when the weather gets warmer. I hope I find the next glass eel alive. Updated on 6/9/24. We have been doing data collections during springtime, and it's better to do it when it's warmer because it's easy for me to work on the dock and because there are more species. We still haven't found a glass eel. We thought we did, but it was either an Atlantic silverside or a herring larvae. In May, Resilience found 2 glass eels in their mops in the Weehawken Cove. We have already found our first baby ribbed mussel, which was just one millimeter in width. This means there are more in the mops and cages, and we will soon be looking for spats and oysters. For five months, I have been observing the three eel mops. I compared them on how they support life, how durable and good they are at keeping their shape, they are environmentally friendly, if there is the presence of contaminants, and the investment. Of the two eco-friendly options, coconut and jute fibers, the coconut mop in a ceramic tile seems very robust, and it is still doing a great job; it has been equally or even more effective in supporting life than the typical material used by scientists, polypropylene, but without polluting the river. I am proud to bring innovation to this field. The jute material had shown to be inadequate for an eel mop, and after 3 months of use, it is decaying and hosting only a few specimens like mud crabs and clam worms.

Ribbed Mussels showed us they can efficiently clean the water by filtration. And because people don't like to eat them, no one will eat the pollutants they filter. We should give them a try to promote their growth on our coast. I would love to live in a healthy place with a clean river and land.

After I did all my experiments, I found wave dissipation very interesting. My findings will be positive in my subsequent trial, proving how effective reefs can mitigate floods. In June, there is a science fair at my school. I will continue my studies on this topic and present a new proposal. Updated 6/9/24: In my first experiment, the results were inconclusive. The reef bed I tested at Hoboken Cove was small. Between May and June, I built a wave tank with the topography of Hoboken and the Hudson River for the school science fair. I simulated the conditions of Hurricane Sandy with and without living shorelines. Without the living shoreline, Hoboken got flooded, but with it, the living shoreline stopped the water from flooding Hoboken. I concluded that the living shoreline did better at wave dissipation.

Living shorelines are better because they reduce soil erosion, need minimal maintenance in the long term, reduce storm surge and flood waters, create habitats for terrestrial and aquatic species, improve water quality, increase recreational opportunities, and so much more.



Jacob Tennenbaum. 5th Grade, Hoboken Charter School. March 11 and June 9, 2024.

What is Next: This research began in January 2024, and was first presented in the 66th Annual Jersey City Medical Center / RWJBarnabas Health STEM Showcase at the Liberty Science Center on March 11, 2024. I continue monitoring the mops and cages, and I will carry on with it until Fall. I am working in a wave tank with the topography of Hoboken Cove where I will try my reef. I will like to do a giant cage to bring to the cove next time. On March 15 and 16, I participated in the Basic Oyster Research Station (ORS) Training, organized by the Billion Oyster Project. On, May 31, I will participate in the Billion Oyster Project Students Symposium, and on June 11, I will participate in the Science Fair of my school. I will continue learning about our environment and volunteering for Resilience in other exciting projects. Updated 6/9/24: I received an Exemplary Project award at the Billion Oyster Project symposium for this project. My project has been used for data collections for the student biologists at the New Jersey City University. I am going to be introduced and exchange data with the organizers of the Eel Project in New York City. I will continue doing networking with other scientists and changing our views and information.

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I want to thank Mr. Keeler, my teacher, and our school coordinator for the JCSS STEM Showcase. Thank you for giving us the opportunity to participate in this experience.

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Research and Keywords

Oyster History in NY/NJ Harbor

Native Americans and Oysters: Because shellfish such as the Eastern Oyster provided a valuable source of protein that didn't require much energy, they became a staple of the Native American diet. The accessible intercostal islands of Manhattan served as ideal harvesting grounds for tribes such as the Lenape, Algonquin, and Narragansett further to the north. Massive shell middens were found in places such as the Damariscotta River in Maine, which peaked over 10 meters deep in some areas. Anthropologists have also found intact oyster shells inside of fire pits, which indicate that the Native Americans would have consumed them raw and also fire-roasted and steamed them inside of seaweed wraps. Given their sustainable harvesting practices and relative lack of population, Native Americans could enjoy this resource seemingly without worrying about running out. That is why when European settlers, such as the Pilgrims and Dutch, first arrived in the 17th century, the Natives utilized one of their most abundant resources as a bargaining chip for trade.

Oysters Boom: On the East Coast, oysters became a keystone of the American diet. The Eastern Oyster created one of the most abundant occupations, employing 52,805 persons by 1880. Some flocked to the docks and became watermen, while others found steady work in the shucking and canning houses. Although harvesting had begun with traditional techniques, such as hand picking and tonguing, these methods gave way to the newest technologies, such as dredges and steam engines. As harvesting became more aggressive, so did sales, and between 1880 and 1910, America managed to harvest 160 million oyster meats per year.

By the early 1920s, Eastern American cities realized that the same waters they were harvesting oysters from where they were dumping their raw, untreated sewage. In bays like the Chesapeake, by 1920, three-quarters of the life-giving reef necessary for oyster survival was destroyed by dredging. By the second half of the 20th century, nearly all that remained were eradicated by disease, pollution, and continued overharvesting.

Oysters Come Back: This species has come back into existence from the brink of extinction through sustainable farming practices and other reef restoration projects to New York Harbor. The implications of this resurgence are huge, considering a single Eastern Oyster can filter up to 50 gallons of water a day. Oyster reefs provide habitat for hundreds of species and can protect our cities from storm damage — softening the blow of large waves, reducing flooding, and preventing erosion along the shorelines.

New Jersey Regulations

The conditions for permitting oyster restoration are much more difficult in the New Jersey waters of NY/NJ Harbor. In 2010, the New Jersey Department of Environmental Protection banned oyster restoration activities in waters closed to harvest due to concerns about human consumption of contaminated oysters. The ban required NY/NJ Baykeeper to remove oysters from the water in Keyport Harbor and end their oyster gardening program, destroying over 50,000 oysters. In January 2016, the NJ State Legislature passed a bill requiring the governor to review and revise the ban (A3944/S2617), although then-Governor Chris Christie never took these actions. A review of state regulations commissioned by NY/NJ Baykeeper and TNC of New Jersey found that New Jersey's regulations were the strictest in the United States (Gibson 2017).

Because of this strict regulatory environment, restoration organizations in both states have attempted to site restoration projects in locations with greater security or closed to the public. NY/NJ Baykeeper now conducts most of its restoration activities at Naval Weapons Station Earle, a United States Navy base in Sandy Hook Bay that is closed to the public. BOP has restored oysters at Head of Bay in Jamaica Bay, close to the John F. Kennedy International Airport security zone.

In 2017, BOP struggled to receive permits for a community reef in Coney Island Creek in Brooklyn. These waters are notoriously polluted, receiving at least 57 million gallons of combined sewer water and stormwater from combined sewer overflow events during rainstorms in 2015 (Waterfront Alliance 2017) and additional pollution from other illicit sources. The New York state regulators deemed these waters were too contaminated to allow oyster restoration activities. In 2018, BOP compromised with New York state, in which oysters will be removed from the site before they reach "market size."

Estuary

“Estuaries are bodies of water and their surrounding coastal habitats are typically found where rivers meet the sea. Estuaries harbor unique plant and animal communities because their waters are brackish — a mixture of fresh water draining from the land and salty seawater.

Estuaries are some of the most productive ecosystems in the world. Many animal species rely on estuaries for food and as places to nest and breed. Human communities also rely on estuaries for food, recreation, and jobs.

Of the 32 largest cities in the world, 22 are located on estuaries. Not surprisingly, human activities have led to a decline in the health of estuaries, making them one of the most threatened ecosystems on Earth. NOAA's National Estuarine Research Reserve System (NERRS), in partnership with coastal states, monitors the health of estuaries, educates the public about these ecosystems, and helps communities manage their coastal resources.

New York City, with a population of over eight million people, is located at the mouth of the Hudson River Estuary which stretches 153 miles inland from the Atlantic Ocean and includes a wide range of wetland habitats. Home to more than 200 species of fish, the Hudson River Estuary serves as a nursery ground for sturgeon, striped bass, and American shad. It also supports an abundance of other river-dependent wildlife, especially birds.”

The Hudson River

The Hudson River is 315 miles long, starting from its source at Lake Tear of the Clouds near the base of Mt. Marcy, in the Adirondack Mountain Range and empties into the New York Harbor leading to the Atlantic Ocean.

Living Shorelines

Living Shorelines Support Resilient Communities

Living shorelines use plants or other natural elements — sometimes in combination with harder shoreline structures — to stabilize estuarine coasts, bays, and tributaries.

- One square mile of salt marsh stores the carbon equivalent of 76,000 gal of gas annually.
- Marshes trap sediments from tidal waters, allowing them to grow in elevation as the sea level rises.
- Living shorelines improve water quality, provide fisheries habitat, increase biodiversity, and promote recreation.
- Marshes and oyster reefs act as natural barriers to waves. 15 ft of marsh can absorb 50% of incoming wave energy.
- Living shorelines are more resilient against storms than bulkheads.
- 33% of shorelines in the U.S. will be hardened by 2100, decreasing fisheries habitat and biodiversity.
- Hard shoreline structures like bulkheads prevent natural marsh migration and may create seaward erosion.

Wetlands

Wetlands are lands consisting of marshes and swamps. They are vital because they protect and improve water quality, provide fish and wildlife habitats, store floodwaters, and maintain surface water flow during dry periods. Wetlands are highly productive and biologically diverse systems that enhance water quality, control erosion, maintain stream flows, sequester carbon, and provide a home to at least one-third of all threatened and endangered species. **Marshes are vibrant ecosystems brimming with life. They serve as nurseries for many species of fish and shellfish, offering shelter and ample feeding opportunities. The vegetation in marshes provides a home for nesting birds and acts as a refuge for small mammals. As we restore and create marshlands, we're not just defending our shorelines, but also bolstering these critical habitats, supporting the intricate web of life that depends on them.**

Salinity ppt

Salinity is the measure of the amount of dissolved salts in water. It is usually expressed in parts per thousand (ppt) or percentage (%). Freshwater from rivers has a salinity value of 0.5ppt or less. Within the estuary, salinity levels are referred to as oligohaline (0.5-5.0 ppt), mesohaline (5.0-18.0 ppt), or polyhaline (18.0-30.0 ppt). Near the connection with the open sea, estuarine waters may be euryhaline, where salinity levels are the same as the ocean at more than 30.0 ppt.

Filter Feeders

Oysters can filter up to 50 gallons of water daily, and sediment and nitrogen cause problems in bay waters. Though nitrogen is an essential nutrient for plants and animals, too much of it—often from fertilizer runoff and septic tanks—boosts algae growth, which overwhelms water bodies and ultimately reduces oxygen levels.

Oysters, clams, and other shellfish help remove excess nitrogen from water by incorporating it into their shells and tissue as they grow. Oysters also filter these pollutants by consuming them or shaping them into small packets deposited on the bottom of the sea where they are not harmful.

Glass Eel (American Eel - Anguilla Rostrata)

The glass eel (Anguilla Rostrata) lives in estuaries, oceans, and rivers on the Atlantic Coast of America. All glass eels hatch in the Sargasso Sea, along with 33 other species of eel. At their life stage, they are also known as leptocephali. One big fact about glass eels is that overtime, it migrates to a different species, different name, and different color. In the Hudson and its tributaries, the glass eel (transparent) would first transform into elvers (brown) which would then, transfer into yellow eels (yellow green). Once mature, eels return to the Sargasso Sea to spawn.

Ribbed Mussels (Geukensia demissa)

Atlantic Ribbed mussels (Geukensia Demissa) live in freshwater lakes, streams, creeks, and estuaries. They can be found in all nearby waters, even in extreme places like deep-sea depths in hydrothermal vents. The mussel has a shell like all other bivalves, mollusks, and shellfish, but the mussel shell is more oblong than an oval structure, and its color is darker with green, purple, blue, or brown hues. The ribbed mussel shell is different, having a triangular structure and dark grooved ribs similar to corduroy pants. One interesting thing is that ribbed mussels are edible but challenging to eat because the meat is rubbery and hard to chew, so you must be starving to eat one. Yet, the qualities that make ribbed mussels so difficult to eat are the perfect indigents to improve water quality. When the water rises with the tide, the ribbed mussel opens its shell slightly to draw the water in. Ribbed mussels would mainly feed on algae and other particles like sediment and nitrogen because they're filter feeders.

Amphipods

Marine amphipods have been found at depths of more than 9,100 m (30,000 ft). The amphipod is likely to be mistaken for tiny shrimp, which they resemble. They are food for many fishes, invertebrates, penguins, shore birds, small cetaceans, and pinnipeds. Amphipods feed on mostly benthic organic matter but since they're omnivores, they can scavenge and search on other animals when possible. And the amphipods' habitat is in the sea, lakes, rivers, sand beaches, caves, and moist habitats on many tropical islands. Amphipod means "both feet". Lastly, how they filtrate is that it can tolerate lower oxygen conditions found in deep water when the lake is thermally stratified in the summer.

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