ESTUARY EXPLORERS
Coastal Resilience Education Toolkit

www.waterfrontalliance.org
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Waterfront Alliance

Waterfront Alliance’s Climate Education program consists of Estuary Explorers, this Coastal Resilience Education Toolkit, and our educators, which helps teachers guide their students on the topics of climate change and coastal resilience. Through these programs, we bring students to their local waterfront to help them build a sense of connection to our waterways and to prepare for a changing world.

Together, we build, transform, revitalize, and protect accessible waterfronts for all communities.

Vision

Students, teachers, and families around the New York and New Jersey Harbor-Estuary and the surrounding waterways should be able to see the waterfront as a shared resource for all. Adapting to the new reality of climate change, we will create healthy, resilient, accessible, and equitable waterways that are alive with commerce and recreation, and exciting waterfront destinations that reflect the vitality and diversity of the communities that surround them.

What We Do

After more than a decade of leading the charge in how the New York metropolitan region views and uses its harbor, and with more than 1,000 Alliance Partners committed to bringing real change to our region’s 700+ miles of coastline, in 2019 the Waterfront Alliance stepped into a new and critical leadership role to define New York Harbor’s response to sea level rise and coastal storms. Our crucial, long-term focus on increasing waterfront accessibility for all, along with our efforts to advocate for a working waterfront that is a vital source of business activity and well-paying jobs and educating the next generation of waterfront stewards, continue as essential pillars of our work to create a well-adapted and resilient New York Harbor.
Estuary Explorers

Waterfront Alliance’s Estuary Explorers program enables young people to make hands-on and personal connections with their waterways through educational games and experiments, online video resources, and an experiential field lab. The program seeks to inspire the next generation, who will develop a passion for our region and work to ensure the New York-New Jersey Harbor Estuary is more resilient, revitalized, and accessible for all people and all communities.

The program targets high-needs areas of New York and New Jersey, where access to the waterfront is limited or unknown to communities. Estuary Explorers not only encourages students to learn at their local shoreline, the program also engages them through indoor or classroom-based activities through utilizing flexible, STEM based lesson plans. We make all materials freely available on our website for any teacher, educator or guardian to use. In addition, Waterfront Alliance educators meet many school children in their community—out at the waterfront, in their classroom, or even now, online—to provide full support and lead Estuary Explorers activities in depth.
Coastal Resilience Education Toolkit

This toolkit of activities has multiple uses. Educators and students will discover a myriad of ways to learn about the critical environmental concerns facing coastal or waterfront regions. The seven-part curriculum builds students’ understanding of an urban estuary, the effects of climate change, and what can be done to keep our local waterfronts healthy while we prepare for the future.

With detailed lesson plans, interactive activities, curated links to multimedia resources, and tips for adapting these resources across grades 4 through 12, this resilience education tool kit provides teachers and students with the necessary materials for meaningful environmental education in most settings.

Overview of the Activities and Their Learning Targets

The Waterfront Alliance Coastal Resilience Education Toolkit guides teachers and students through seven activities that anchor a progressive exploration of climate and waterfront issues and the means to protect our shorelines:

1. The unit begins with "The Human Impacts Game", a fun illustration of the interactions of humans with our harbor, customized for an urban estuary. By following game cards to remove or add “fish” to an “estuary” playing board, students think critically about the role our communities play in a healthy ecosystem.

2. Students will explore "An Investigation into Plastic", an activity exploring how plastic breaks down in the environment and what can be done to address this growing issue. Students explore just how pervasive plastics, including microplastics, are in our shorelines and waters.
3. "Become an Ecological Engineer" gives students several hands-on examples of protecting a model shoreline, guiding them to identify the benefits of green infrastructure and draw conclusions about coastal preservation and restoration. The extension links provided encourage young citizens to engage with community leaders.

4. Students evaluate their communities' qualities of resilience in the "Neighborhood Water Budget" activity. By creating a map of their community, students gain an understanding of how their neighborhood can handle flooding and begin to think of ways to improve green infrastructure around where they live.

5. After focusing in on the effects of storms and flooding, students explore how to address these issues in "Know Your Waterfront, Shape Your Waterfront." This activity helps students visualize and design climate resilient solutions in places prone to flooding.

6. "Exploring Extreme Weather" shifts the focus of the conversation of climate change to advocacy. Students develop their own public service announcement (PSA) in teams. These PSAs are a creative and engaging method to convey information about a potential extreme weather event affecting the student's community.

7. The Estuary Explorers "Waterfront Field Lab" lesson plan takes learning outside and applies concepts learned throughout the toolkit to the local waterfront. Students measure different parameters of harbor water and evaluate what can make their community more resilient in the wake of climate change.
**Toolkit Features**

The Coastal Resilience Education Toolkit utilizes Next Generation Science Standards and presents essential questions for connecting resilience education across the students’ wider curricula. Each activity in the toolkit anchors a detailed lesson plan that includes pre and post-activity suggestions along with the primary lesson plan. Teachers may choose to fully explore each lesson plan across several class sessions, or to employ our included summaries to condense the activity into one class. Each lesson plan includes:

- Overview, goals, and materials, where you’ll find helpful planning information and grade-level adaptations. Materials have been selected to be easily sourced and have been thoroughly tested.

- Instructions adaptable to one or more class sessions.
  - Pre-activity resources and questions include links to readings, media, and discussion questions for background. In addition, an informational summary is provided in case time doesn’t allow for these extra class sessions. Vocabulary is included to supplement preparation.
  - Activities are fully detailed as step-by-step instructions. Real-world tips and essential explanations are provided within the relevant steps of procedures for convenience.

- Post-activity resources and questions are suggested to encourage students to integrate and expand what they’ve learned. From research to discussion to civic engagement, they can be expanded to additional class sessions, or made optional if time doesn’t allow.

- Background for educators and extension suggestions includes additional resources for teachers, with a selection of curated links that will help those new to the topic become more familiar and prepare for any questions.
Support for Teachers

In addition to providing this toolkit, Waterfront Alliance educators are available to support our partner schools in several ways:

- One-on-one consultations for teachers can be scheduled for any questions, or for those interested in learning more about coastal resilience education and how to deploy the activities.

- Waterfront Alliance educators are available to lead this unit as a residency or lead individual activities for classes, either via live stream online, or in classrooms or school yards. Our team of experts can also support discussion and analysis as a post-activity experience.

- Our extensive network of alliance partners also enables us to make valuable recommendations to teachers seeking any specific resources for environmental education.

Please visit our website for additional materials and contact information.
Activity Overview

The Human Impacts Game is a curriculum-aligned activity that introduces the effects that humans have had on an estuarine environment. Through a simple, yet fun and engaging activity, students apply critical thinking to understand environmental and coastal systems. While this formal lesson plan provides many details, our activity is completely adaptable for multiple ages and circumstances. We welcome you to innovate and come up with your own creative takes on the game!

During this game, students will consider the consequences of actions that can change estuaries in both positive and negative ways. These actions are presented on games cards, which instruct players to add or subtract fish tokens from the shared estuary playing pot. By following the instructions on the game cards, students experience the effects that human actions can have on the environment.

This lesson plan is adaptable and best suited for students in grades 6-8.

This activity was adapted from the New Jersey Sea Grant Consortium and the NJDOT Office of Maritime Resources activity: Introduction to Estuaries, “A Day in the Life of an Estuary” simulation game.
Learning Targets

- Understand what estuaries are and why they are important to us
- Increase knowledge of the New York-New Jersey Harbor Estuary
- Connect how human actions affect an estuarine ecosystem in a positive or negative way

Key Questions

- What can I look for in an estuary that shows me how polluted it is?
- How is the New York-New Jersey Harbor Estuary affected by its surrounding communities?
- What actions can I take to keep estuaries clean?

These learning targets fulfill the following components of the Next Generation Science Standards

Science and Engineering Practices
- Analyzing and interpreting data
- Using mathematics and computational thinking

Crosscutting Concepts
- Patterns
- Cause and effect:
- Mechanism and explanation
- Stability and change
Pre-Activity Reading and Discussion

Reading

At any point before playing the game, review the pre-activity readings for background information on estuaries and human impacts. Following the readings, check that students are able to:

- Describe what an estuary is and some of its values to humans and the environment
- Identify the harbor of New York and New Jersey as an estuary

Discussion

Review any ecosystem processes that have been part of the students' studies so far. This activity will provide an introduction to estuaries, but refreshing any background on the water cycle, watersheds, or food webs will help students better apply their thinking.
Materials

Each group playing will require one set of these materials:

- Goldfish crackers, at least 50 (or other similar game markers such as bingo chips). These represent marine life in the estuary.

- Paper bowl or sheet of blue construction paper (or any placemat that can represent the estuary). You may also try to print a map of the New York-New Jersey Harbor Estuary.

- Set of game cards, provided at the end of these instructions.

Pre-activity background reading and videos through these links

- NOAA’s Introduction to Estuaries
- NOAA’s What is an Estuary?
Instructions: The Human Impacts Game

1. Prepare the materials required for the game. Game cards can be printed out and cut apart, or be read directly from the digital toolkit online.

2. Place your estuary paper, bowl, or mat onto a flat surface and split into groups (we recommend no more than five people in a playing group).

3. **Getting started:** Designate one student to be the environmental conservation officer in charge of the fish hatchery (where the extra goldfish game tokens and cards will be).

4. The student designated as the environmental conservation officer is responsible for making sure all the other students have the game materials they need and monitoring that no one takes more or less than they’re supposed to each round.

5. The conservation officer should distribute 5 starter fish to each player, and place 10 starter fish in the estuary placemat bowl or paper.

6. Place the additional crackers and the deck of game cards to the side.
Instructions: The Human Impact Game

7. Once all participants are set up, the introductory passage below should be read aloud by the teacher, a parent, or a student volunteer.

"An estuary is a place where freshwater and saltwater meet. Freshwater can come from rivers, lakes, creeks, or streams, while saltwater comes from the oceans. Estuaries offer many different services to humans, from filtering water to providing habitat to the fish we love eating. Did you know that almost all types of fish that are consumed by people have passed through an estuary at least once? However, estuaries can become polluted like any other ecosystem. When an estuary becomes unbalanced or polluted, tiny floating plants called algae can overwhelm it, which can cause what is known as an algal bloom. These algal blooms can use up all the oxygen in the water, which can kill many of the fish. People, however, can clean up estuaries when they become too polluted. More importantly, people can also prevent pollution from happening in the first place. By placing environmental protections around estuaries, algal blooms can be stopped before they even happen!"

8. The player to the right of the conservation officer goes first, and play continues clockwise. Each student will draw a card from the pile, read it aloud, and add or subtract fish as directed. Fish that are removed go back to the hatchery (or can be snacked on). If a student runs out of fish, they can request 5 more from the conservation officer.

9. The game continues until all the cards have been drawn, or until the estuary is depleted of fish.
Post-Activity Discussion Questions
Printable Student Worksheet

1. What actions affect estuaries in positive ways? In negative ways?

2. What can we do to make sure estuaries are healthy and protected?

3. Did your fish population die off completely? If so, why do you think this happened? Do you think this would happen in the real world? Why?

Background for Educators

- NOAA’s Estuary Education Page
- EPA’s Exploring Estuaries
- Estuary Facts for Kids
- NYSDEC Teaching About the Hudson River Estuary
- New York–New Jersey Harbor & Estuary Program
### The Human Impacts Game Playing Cards

<table>
<thead>
<tr>
<th>Invasive plants in the water make it more difficult for fish to feed</th>
<th>A restoration project to add oyster reefs to the harbor begins</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Take out 3 fish</strong></td>
<td><strong>Add 4 fish</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A farmer fertilizes her crops just before it rains and an algal bloom forms and pollutes the river</th>
<th>Stronger environmental protections are put in place by the government</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Take out 2 fish</strong></td>
<td><strong>Add 3 fish</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A local golf course fertilizes their field and causes an algal bloom in the bay</th>
<th>A garbage clean-up effort takes place along the shoreline of the estuary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Take out 8 fish</strong></td>
<td><strong>No fish lost</strong></td>
</tr>
</tbody>
</table>
### The Human Impacts Game Playing Cards

<table>
<thead>
<tr>
<th>A farmer decides to plant native trees along the shoreline, protecting the estuary</th>
<th>The state fish hatchery has lost 3 fry (baby fish)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Add 4 fish</strong></td>
<td><strong>Take out 3 fish</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A new road is built along the shoreline and allows road salt and oil leaks to drain into the water</th>
<th>A new boat dock is constructed without a permit, covering a salt marsh</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Take out 3 fish</strong></td>
<td><strong>Take out 2 fish</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A new ferry dock brings frequent boat traffic disturbance to a formerly quiet bay</th>
<th>Kids hanging out along the shoreline throw their trash in the water</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Take out 2 fish</strong></td>
<td><strong>Take out 3 fish</strong></td>
</tr>
</tbody>
</table>
### The Human Impacts Game Playing Cards

<table>
<thead>
<tr>
<th>Invasive crabs eat most of the algae, and the native crabs are starving</th>
<th>A living shoreline and restored wetland are constructed to help mitigate urban runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Take out 3 fish</em></td>
<td><em>Add 4 fish</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Towns with poor sewage treatment cause nutrient pollution and algal blooms in the water</th>
<th>Students write letters to the government calling for environmental protections</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Take out 8 fish</em></td>
<td><em>Add 2 fish</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Past industrial pollutions, such as PCB’s, are stirred up in our estuary</th>
<th>The government budget increases funding for estuary education</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Take out 5 fish</em></td>
<td><em>Add 2 fish</em></td>
</tr>
<tr>
<td><strong>The Human Impacts Game Playing Cards</strong></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>A government cleanup project, such as EPA's superfund, is completed</strong></td>
<td><strong>Warmer waters make it harder for marine life to reproduce, and harder for fry (baby fish) to survive</strong></td>
</tr>
<tr>
<td>Add 4 fish</td>
<td>Take out 3 fish</td>
</tr>
<tr>
<td><strong>A highway is built along the shoreline and causes road salt and gas to go into the water</strong></td>
<td><strong>An arts and music festival set up on the shoreline dumps paint into the water</strong></td>
</tr>
<tr>
<td>Take out 3 fish</td>
<td>Take out 2 fish</td>
</tr>
<tr>
<td><strong>The harbor must be dredged (dig the bottom deeper) so that big cargo ships can bring us imported goods</strong></td>
<td><strong>People at the beach let their trash blow away in the wind</strong></td>
</tr>
<tr>
<td>Take out 3 fish</td>
<td>Take out 2 fish</td>
</tr>
</tbody>
</table>
Answer Guide

The Human Impacts Game

1. What actions affect estuaries in positive ways? In negative ways?

Actions that affect estuaries in positive ways include community shoreline clean ups, planting trees to reduce erosion, not flushing pharmaceuticals or trash, etc. Actions that affect estuaries in negative ways include dumping of debris or harmful chemicals into the water, over harvesting of fish, runoff, CSO's, etc. Learn more about the good being done to help estuaries and what threatens them at these websites brought to you by NOAA.

2. What can we do to make sure estuaries are healthy and protected?

Implementing new laws and policies targeted at environmental regulation and protection, educating people about the value of estuaries, conducting a home waste audit, etc. Learn about what you can do as an individual to help preserve and protect estuaries at the EPA's and NOAA's websites.

3. Did your fish population die off completely? If so, why do you think this happened? Do you think this would happen in the real world? Why?

Refer to your own results and to the links provided in the lesson plan.
Engaging your parent / guardian in the conversation!

Students: Watch the following video and have your parents ask you these questions when you get home

New York State’s Department of Environmental Conservation’s Video of “What is an Estuary”

1. How can you positively and negatively impact an estuary?

2. In what ways can we protect our estuaries?

3. How can fish populations in the estuary be impacted by our actions?
Activity 2: An Investigation into Plastic

Activity Overview

"An Investigation into Plastic" introduces the ways in which plastic breaks down in our natural and built environments. By looking at a pre-made mixture of sand and different types of plastic degrading, students will separate out the broken-down pieces of plastic to better understand the ways in which these plastic pieces degrade.

Throughout the activity students will ask questions such as:

- Why such a large amount of plastics have been introduced into the environment?
- What are the most commonly found forms of plastic?
- How our own actions and the collective actions of society are part of plastic pollution?
- What can be done to address this growing problem?

This lesson plan is adaptable and best suited for students in grades 6-12.
Learning Targets

- Understand the effects plastic has on the natural world
- Explore how plastic breaks down in the environment
- Understand how everyday actions can drive plastic pollution
- Find ways to address the growing problem of plastic pollution

Key Questions

- What are the negative effects plastic has on living things?
- Why is there a plastic crisis?
- How do our own actions impact plastic pollution?
- How can we turn the tide of plastic pollution?

These learning targets fulfill the following components of the Next Generation Science Standards

Science and Engineering Practices
- Developing and using models
- Analyzing and interpreting data

Crosscutting Concepts
- Cause and effect: mechanism and explanation
Vocabulary

Plastic
Single Use Plastics
Photodegradable Plastics
Microplastics
Marine Debris
Entanglement
Degradation
Water Quality
Bioaccumulation
Phthalates
Bisphenols

Pre-Activity Reading and Discussion

Reading

Before the activity, go over the 5 resources provided for information on plastics. Following the readings, look to see that students are able to:

- Identify the differences between macro and microplastics
- Understand the scope of the plastic crisis
- Comprehend the impacts plastics have on our oceans

Discussion

Go over any subjects relating to waste, impact of pollution on the environment, or marine science that you’ve already discussed with your students in previous classes. Any knowledge on how pollution impacts marine life is especially helpful.
Pre-Activity Questions
Printable Student Worksheet

1. What are the types of plastic we find in our waterways and along our shorelines?

2. How long do you think it takes for plastic to break down?

3. Name 3 examples of plastic waste commonly found in your community.
Materials

Use one set of materials for either a group of no more than 4 students or per person.

- 1 Clear tub of water per group.
- Paper
- Pencil
- A sample of sand polluted with plastic and other waste (any local beach should have this embedded in their sand)
- Magnifying lenses

Pre-activity background reading and videos through these links

- Microplastics
- What Are Microplastics?
- Single Use Plastics
- Ocean Plastics Pollution
- Plastic Pollution and You
Instructions: An Investigation into Plastic

1. Gather all materials and split students into groups of no more than 4.
2. Prepare each sand mixture in the tubs by filling the tub with sand.
3. Distribute each of the tubs to your groups of students along with the magnifying glass, a pencil, and a sheet of paper.
4. Have each group take their magnifying glass and examine the sand samples. Have your students determine if they can find any plastic waste in the sample.
5. Discuss where the students think the fragments come from.
6. Each group should record down observations about the plastics they found in their mixture along with size, color, texture, and any other notes about what they found.
Post-Activity Questions
Printable Student Worksheet

A.) What are three actions we can take to prevent plastic pollution?

B.) What are the hazards of microplastics?

C.) What is the difference between a primary microplastic and a secondary microplastic?
Primary microplastics are tiny particles designed for commercial use, such as cosmetics, as well as microfibers shed from clothing and other textiles, such as fishing nets.

Secondary microplastics are particles that result from the breakdown of larger plastic items, such as water bottles.

An Investigation into Plastic

1. What are three actions we can take to prevent plastic pollution?

Examples of actions that we can take to prevent plastic pollution include: reducing our use of items such as plastic bags, straws, and disposable cutlery; properly recycling and disposing of waste to avoid litter accumulating in the street and in public places; supporting bans on plastic such as plastic bag bans in stores or legislation on holding large producers and users of plastic accountable for the waste they create.

2. What are the hazards of microplastics?

Hazards posed by microplastics include: Being mistaken for food by marine animals and then are ingested. They block the digestive system of animals and result in low levels of oxygen and consequently result in reduced energy levels. Some plastics are so tiny that they embed in the animal tissues.

Microplastics also act as a sponge for harmful chemicals in the environment and are passed across the food chain, and some find their way to humans. Microplastics find their way to humans through ingestion or respiration.

3. What is the difference between a primary microplastic and a secondary microplastic?

- Primary microplastics are tiny particles designed for commercial use, such as cosmetics, as well as microfibers shed from clothing and other textiles, such as fishing nets.
- Secondary microplastics are particles that result from the breakdown of larger plastic items, such as water bottles.
Engaging your parent / guardian in the conversation!

Students: Watch the following video with your parents and discuss the following questions

[QR Code]

The Problem with Microplastics Video

1. Where do microplastics come from?

2. Why are microplastics dangerous?

3. What can we do to reduce the amount of plastic in our waterways?
Activity 3: 
Become an Ecological Engineer

Activity Overview

"Become an Ecological Engineer" will engage students in the skills of visualizing, constructing, and analyzing a simplified model of a shoreline to learn more about coastal resiliency and green infrastructure. While this formal lesson plan provides many details, our activity is completely adaptable for multiple ages, and we welcome you to innovate and come up with your own creative ways to explore the interactions of water and land.

During this activity, students will simulate examples of different shorelines using materials that can be commonly found in grocery stores or around the classroom. These mock shorelines can be constructed using household items such as sponges to rice. By experimenting with different materials, students will begin to understand how choices of raw material when constructing shorelines can have different effects on the coastal resilience and quality of life of a community.

This lesson plan is adaptable and best suited for students in grades 4-12.
Learning Targets

Observe how different shorelines respond to events such as flooding waves

Recognize the relationship between natural and developed areas and the impact human activities have on the shoreline

Draw conclusions about what students can do to make their communities more resilient

Key Questions

What types of shorelines promote both coastal resilience and healthy communities?

How can shoreline alterations positively or negatively affect a community?

What are some ways that you, as a community member, can help promote stable shorelines?

These learning targets fulfill the following components of the Next Generation Science Standards

Science and Engineering Practices
- Developing and using models
- Analyzing and interpreting data
- Using mathematics and computational thinking

Crosscutting Concepts
- Cause and effect: mechanism and explanation
- Scale, proportion, and quantity
- Systems and system models
Materials

Use one set of materials per person, or take turns in a cooperative group sharing a set of these materials:

- 1 rectangular tray – An aluminum tray, baking pan, roasting pan, or glass dish, approximately 8 inches by 12 inches or larger.
- 1 empty, single-serve bottle – An aluminum or plastic water bottle works well.
- Material to make landfill – If available, sand is the best option, otherwise rice can be used as the shoreline. You’ll need enough to spread a pile across one side of the tray.
- Materials to model waterfront protective infrastructure – As many as you can find, including 1-2 kitchen sponges (as marshland), eggshell halves (as artificial reefs), a rock collection (as riprap, or stabilizing stones on the shore), a shell collection (as natural reefs), or a brick (as a seawall).
- Water and a pitcher or measuring cup for pouring water into the tray.
- A camera or notebook for recording observations.
- A towel for wiping up any drips.

Pre-activity background reading and videos through these links

- Green Infrastructure
- What is Coastal Resilience?
Quick Fact!

Green infrastructure maximizes the benefits of natural processes in our built environment. This type of infrastructure can be inland or on the waterfront. When it comes to coastal resilience, this means that our waterfront and communities are prepared for a changing climate to be less affected by unusually high water or strong waves, and to recover easily from hazardous events!
Pre-Activity Reading, Video, and Discussion

Reading

Before starting this activity, go over the pre-activity readings for background and context information on green infrastructure and coastal resilience. We highly recommend the video provided below, as it will provide a great insight into the ways coastal resilience is being modeled in this activity.

Video

![QR Code](image-url)

Click here to watch more about Coastal Resilience

Discussion

This activity will provide an introduction to shoreline types and coastal resilience, but refreshing any background on the water cycle, watersheds, ecosystems will help students better apply their learning.
Instructions: Become an Ecological Engineer

1. Place your tray on a flat surface. Choose which landfill material you will use and prepare enough to fill \( \frac{1}{4} \) to \( \frac{1}{3} \) of the tray.
2. Set the landfill material across one narrow end of the tray, about \( \frac{1}{4} \) to \( \frac{1}{3} \) filling the tray. Make sure to densely pack your material to whichever side of the tray you have placed it.
3. Add water so that the tray is filled to about \( \frac{1}{2} \) the height of your landfill.
4. Hold your bottle horizontally and place it at the end of the tray opposite the landfill. Move the bottle gently up and down in the water to make waves to test the stability of your landfill shoreline. You do not need to push the water towards the landfill. Observe what happens to your shoreline as the severity of the wave action increases.
5. Take a photo or video or record your observations of your first shoreline test in a notebook.
6. One at a time, add your infrastructure materials to protect your landfill shoreline, and make waves again to test them. Layer or insert the protective infrastructure where the landfill meets the water’s edge. Repeat generating waves by moving the bottle up and down in the opposite end of the tray.
7. Observe and record what happens to your newly protected shoreline as the severity of the wave action increases.
8. Reset, rebuild landfill, and evaluate different infrastructure protections as many times as you like. Try any materials, but be sure to make a connection to what kind of infrastructure the material represents, and to record your observations.
9. Sort your waterfront infrastructure materials into hardening protections (like a brick/seawall and rocks/riprap) or green infrastructure (like shell/reefs or sponges/marshland).
Post-Activity Projects
Printable Student Worksheet

1. Which materials protected your landfill the best?

2. Which materials bring co-benefits, meaning they’re good for wildlife as well as for people?

Background for Educators

- NOAA’s Green Infrastructure Animation
- NOAA’s Providing Green Infrastructure for Coastal Resilience PowerPoint
- EPA’s Green Infrastructure for Climate Resilience Infographic
Answer Guide

Become an Ecological Engineer

1. Which materials protected your landfill the best?

_Green, natural surfaces help absorb water and are permeable. Hard concrete surfaces do not help manage water and are impermeable. Think about which surfaces are permeable and impermeable._

2. Which materials bring co-benefits, meaning they’re good for wildlife as well as for people?

_Green and blue infrastructure include habitats involved in nature-based solutions are tidal salt marshes, mangroves, maritime forests, coral and shellfish reefs, beaches, and dunes. In addition to buffering storm effects, these habitats also provide other community benefits (called ecosystem services) related to recreation, water quality, local fisheries, and climate change mitigation._
Engaging your parent / guardian in the conversation!

Students: Watch the following video with your parents and discuss the following questions.

1. What is coastal resilience?
2. What kind of infrastructure works best to promote healthy ecosystems while also protecting communities?
3. What can you do to learn more about coastal resilience in your area?

[Click here to watch more about Coastal Resilience]
Activity 4: Neighborhood Water Budget

Activity Overview

By applying observations of their neighborhood to a map, students evaluate the resilient qualities of urban infrastructure as a real-world problem. Learn about and compare permeable and non-permeable surfaces, and think of creative ways to increase green infrastructure and resilience in your community!

Start by printing or drawing a map of the area around your home, school, or waterfront. Go out to observe the area or use your memory to identify the kinds of surfaces that absorb water (permeable) or don’t absorb water (impermeable). Record that analysis on your map and use it to calculate how the infrastructure in your neighborhood can handle or contribute to flooding. Learn more about ways to manage water and think about how to increase green infrastructure in your community.

This lesson plan is adaptable and best suited for students in grades 7-12.
Learning Targets

- Understand how green infrastructure contributes to neighborhood resilience
- Determine possibilities for increasing green infrastructure in your community
- Recognize the value of natural processes and ecosystem services in an urban setting

Key Questions

- How do natural processes work in an urban environment?
- How does green infrastructure enable the ecosystem to help us?
- What can be done to increase resilience in my community?

These learning targets fulfill the following components of the Next Generation Science Standards

- Science and Engineering Practices
  - Analyzing and interpreting data
  - Using mathematics and computational thinking

- Crosscutting Concepts
  - Patterns
  - Cause and effect:
    - mechanism and explanation
  - Stability and change
Materials

One set of materials for each participant is recommended, but if needed, a group can share one set and work together:

- Pen or pencil
- Paper
- Ruler
- Crayons, markers, or colored pencils in several different colors.
- Optional: graph paper, calculator
- Optional for outdoor observations: tote bag, clipboard
- Pre-activity materials as described below
Pre-Activity Reading and Discussion

Reading

Take a look at how water moves through our urban environment with NYC H2O’s Urban Water Cycle Story Map (click here or scan the QR code below). The same types of water systems are used in New York and New Jersey.

Discussion

How do you know that different surfaces absorb water differently? What does it mean to be permeable or impermeable, and how do you identify it? Inside, compare watering a plant to pouring water in a bowl. Outside, compare water absorption (also called infiltration) on pavement, grass, sand, or anywhere else. If it’s helpful, add a pre-activity to go outside, pour the same amount of water on different surfaces, and observe what happens.
Instructions: Neighborhood Water Budget

1. Prepare a base map
   a. Select your area to study for the project. Focus on your school or on a few square blocks in your community (home, school or waterfront). The activity will be considering features like tree pits and driveways, so you’ll want a small enough study area to be able to identify those on a map. It can be one or a few blocks, and can be printed (for example, Google Maps) or drawn. The scale should enable students to color in or mark the built, paved, and natural areas.
   b. Prepare a simple outline of the major features of your study area and focus on identifying the street, buildings, parks, and landmarks that are most significant in size and help orient you.

2. Identify the surfaces in your map’s study area.

3. Make a grid on your map that creates 10 small boxes across it. You can fold your paper with the creases making a grid, or draw lines on your map.
   a. To hand sketch a simple grid draw a line lengthwise to make two halves. Draw four lines across that perpendicularly and evenly spaced, to create a 2x5 grid.

4. Analyze the amount of permeable or impermeable surfaces on your community map. Look at the colors in each box of the grid, and assign a numeric value between 0 and 10 to that box, with 0 being all impermeable and 10 being all permeable.
   a. Add up the points and figure out how to express them as the percentage of permeable surface in your study area. (each of the small grid boxes is worth 10 permeability points, making a total of 100 for your map).

5. Discuss your results and draw conclusions from your analysis.

6. If you’d like, create a new map showing how and where you’d add green infrastructure in your community.
“When there are a lot of impermeable surfaces in a community, rain or snow is blocked from being absorbed into the environment, so there are more ways for flooding to occur. When we create more permeable surfaces in our communities, we are encouraging nature to help us manage extra water. When humans build ways for the processes of nature to manage flooding, heat or other concerns it’s called green infrastructure. Let’s use our maps to think about how our neighborhood does this, and after, we’ll learn more about green infrastructure.”

1. What do our maps show about impermeable surfaces in our area?
2. What green infrastructure do we have?

“There are many kinds of green infrastructure in addition to parks, gardens, and tree pits. One is permeable pavers, which means that bricks or small patches of concrete are installed with small spaces between them. The space allows water to absorb into the earth below, making a sidewalk or parking lot much more permeable. Green roofs, where grass or gardens are planted on top of a building, also help absorb rain. At the waterfront, green infrastructure includes marshes or wetlands, sand dunes, and oyster reefs.
Post-Activity Discussion Questions
Printable Student Worksheet

1. How does green infrastructure help communities? What kinds of green infrastructure would you like to have in your community, and why?

2. List examples of 3 things that you as an individual can do to help maintain the green infrastructure in your community, or to add more. If helpful, do more research or ask an adult to help you inquire with your local community board or city council member.

3. To learn more about guidelines that communities around New York are using to add green infrastructure, check out Waterfront Alliance’s own WEDG® (Waterfront Edge Design Guidelines). Go to this link (or scan the QR code below) of WEDG sites, pick the project that you like the most, and explain why.

With precipitation, the water not absorbed is called runoff. The U.S. Geological Survey provides a scientific summary and data records for better understanding runoff and predicting potential floods.

Storm water runoff makes combined sewer overflow (CSO) worse. Learn more about this related concern on the SWIM coalition website.
1. How does green infrastructure help communities? What kinds of green infrastructure would you like to have in your community, and why?

Rain gardens, green roofs, permeable pavers, street trees, beaches, wetlands, and marshes are all good examples of green infrastructure. For additional information, the links below from the University of Colorado include a presentation with many photographs of green infrastructure and a matching script explaining how they work.

[Green Infrastructure Presentation](#)  [Green Infrastructure Script](#)

2. List examples of 3 things that you as an individual can do to help maintain the green infrastructure in your community, or to add more. If helpful, do more research or ask an adult to help you inquire with your local community board or city council member.

Sometimes green infrastructure can cost more to build at first. But since green infrastructure reduces costly problems like flooding or extreme heat, it can save money over time. A number of simulation and world building games allow students to experiment with building green infrastructure as apart of the overall community.

[The Alliance for the Chesapeake Bay’s Stormwater Sentries Online Game](#)
3. To learn more about guidelines that communities around New York are using to add green infrastructure, check out Waterfront Alliance’s own WEDG ® (Waterfront Edge Design Guidelines). Go to this link (or scan the QR code below) of WEDG sites, pick the project that you like the most, and explain why.

*Waterfront Alliance has developed Waterfront Edge Design Guidelines, or WEDG, a set of recommendations for building at the shoreline that maximizes green infrastructure, resilience, and community engagement. People do not have to be experts themselves, they can just ask that decisions about the waterfront follow WEDG. Many community boards in New York have made official resolutions that WEDG should be consulted for projects, has yours?*
Engaging your parent / guardian in the conversation!

Students: Watch the following video with your parents and discuss the following questions

1. What is green infrastructure and how does it help our communities?
2. What are various types of green infrastructure?
3. What can we do to bring more green infrastructure into our neighborhoods?

Click here to watch more about Green Infrastructure
Activity Overview

"Know Your Waterfront, Shape Your Waterfront" is a curriculum aligned activity that engages students skills in decision making and design. Students will learn about the different types of waterfront features used in restoration and resilience projects. They will also learn about the obstacles that designers, landscape architects, urban planners, and engineers face in these developments.

During this activity, students will be given a worksheet with a drawing of the waterfront slated for construction (or reconstruction). Based on the worksheet, students will draw their own version with features described in the lesson. While drawing out their own version, students will need to be cognizant of things like feature placement and project cost and community input since they have a limited budget for the project and many of these features have different costs, while also balancing the needs and expectations of the local community. Additionally, students will need to consider permitting and land ownership and various landscape features such as the grade, propensity for flooding, etc.

This lesson plan is adaptable and best suited for students in grades 9-12.
Learning Targets

- Model the construction or reconstruction of a waterfront
- Explore the landscape features and planning complexities that are used in designing waterfronts
- Draw conclusions about the problems that often face design professionals when building on the waterfront

Key Questions

- What are the main considerations facing design professionals?
- How can we address budgetary constraints when building waterfront projects?
- What should be prioritized in the design of new projects when limited by budget and other factors?

These learning targets fulfill the following components of the Next Generation Science Standards

Science and Engineering Practices
- Developing and using models
- Analyzing and interpreting data

Crosscutting Concepts
- Cause and effect: mechanism and explanations
- System and system models
Materials

Use one set of materials for either a group of no more than 4 students or per person:

- 1 Pencil
- 1 Sheet of Paper
- 1 Waterfront Redesign Worksheet
Vocabulary

Riprap
Seawall
Jetties
Groins
Wetland
Living Shoreline
Salt Marsh
Storm Surge
Urban Planners
Engineers
Landscape Architects
Resilience
Infrastructure

Pre-Activity Questions

Draw lines to connect the correct words with the images below
Instructions: Know Your Waterfront, Shape Your Waterfront

1. Gather materials and split your students into groups of no more than 4 if you want your class to work in teams. Distribute the model shoreline worksheet to each student or group and have each group study the features on the worksheet.

2. Each group will be allocated a budget of $5 million to redo the waterfront from the image as they see fit. They will need to consider what they feel is important when it comes to spaces like waterfronts – is accessibility more important than resiliency? Is ecology more important than ease of transportation? Should it look welcoming or is that not important?

3. There will be four main features the students will consider when designing this waterfront, and each feature has a different financial cost associated with it.
   a. Concrete Sea-Wall = $750,000
   b. Living Shoreline = $1.5 million
   c. Riprap = $1 million
   d. Highway Removal = $1.75 million

4. Each group will take 20 minutes to draw their waterfront with the design choices they feel would work best for their waterfront and fits within their budget.

5. After each group has finished, go around the room and have them present their design to the class. They should be able to explain why they chose the features that they did as well as the challenges they faced in designing their waterfront.

6. After each group has presented, have the class vote on which waterfront they feel is the most resilient and is the best use of their funds.
Post-Activity Discussion Questions
Printable Student Worksheet

1. What are the types of waterfront features you found to be most important when designing your waterfront?

2. List 3 challenges design professionals face when trying to build and create more resilient waterfronts.

3. Can you think of anything else not brought up in this activity that you think could be important to the resiliency of the waterfront?

Background for Educators

- Create a City
- Waterfront Resilience Family Activities and Learning | SF Port
- Billion Oyster Project - Digital Platform (bopuiprod.azurewebsites.net)
- Education (lacoast.gov)
Climate change - Climate change is one of the biggest challenges that design professionals face when trying to build and create more resilient waterfronts. The effects of climate change such as sea-level rise, increased storm intensity, and flooding can cause significant damage to waterfront infrastructure.

Limited funding - Design professionals often face limited funding when trying to build and create more resilient waterfronts. This can make it difficult to implement the necessary infrastructure changes needed to make waterfronts more resilient.

Limited space - Design professionals also face limited space when trying to build and create more resilient waterfronts. This can make it difficult to implement the necessary infrastructure changes needed to make waterfronts more resilient.

**Answer Guide**

**Know Your Waterfront, Shape Your Waterfront**

1. What are the types of waterfront features you found to be most important when designing your waterfront?
   
   Coastal and shore protection structures help define and protect ports and harbors. Common waterfront elements are piers, wharves, bulkheads, dry docks, breakwaters, boat ramps, and marinas.

2. List 3 challenges design professionals face when trying to build and create more resilient waterfronts.
   
   a. Climate change - Climate change is one of the biggest challenges that design professionals face when trying to build and create more resilient waterfronts. The effects of climate change such as sea-level rise, increased storm intensity, and flooding can cause significant damage to waterfront infrastructure.
   
   b. Limited funding - Design professionals often face limited funding when trying to build and create more resilient waterfronts. This can make it difficult to implement the necessary infrastructure changes needed to make waterfronts more resilient.
   
   c. Limited space - Design professionals also face limited space when trying to build and create more resilient waterfronts. This can make it difficult to implement the necessary infrastructure changes needed to make waterfronts more resilient.

3. Can you think of anything else not brought up in this activity that you think could be important to the resiliency of the waterfront?
   
   a. Community Awareness - Educate residents about the risks and benefits of waterfront living, and involve them in resilience planning.
   
   b. Emergency Preparedness - Implement effective early warning systems for storms, floods, and other emergencies and develop evacuation
Engaging your parent / guardian in the conversation!

Students: Watch the following video with your parents and discuss the following questions

1. What is a resilient waterfront and why is it important?
2. What are some of the obstacles to creating a resilient waterfront?
3. What are some examples of resilient waterfronts?

Click here to watch more about resilient waterfronts
Activity Overview

Public Service Announcements (PSA’s) are an important way for governments and community organizations to convey information about an emergency event. As super-storms like hurricanes, wildfires, and floods are more frequently occurring and continue to get worse, communities and public entities need effective ways to communicate important information to ensure public well-being and safety.

In this activity, students will learn why PSA’s are important, how to convey them, and how to draft their own. Students will create their own PSA on an assigned issue, will draft a script of their own PSA, and will present and act out their PSA.

This activity is best suited for students in grades 6 through 12.
These learning targets fulfill the following components of the Next Generation Science Standards

**Disciplinary Core Ideas:**
- The roles of water in Earth’s surface processes
- Weather and Climate
- Global Climate Change

**Science and Engineering Practices:**
- Analyzing and Interpreting data
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence

**Crosscutting Concepts:**
- Cause and Effect
- Stability and Change
- Human Impacts on Earth Systems
Materials

Use one set of materials for either a group of no more than 4 students or per person:

- Pen or Pencil
- Sheet of Paper
- Computer or Smartphone

Pre-activity background reading through these links:

- Extreme Weather Factsheet
- Climate Resilience Literacy Handbook
- Student Tools for Emergency Planning Program (STEP)
Pre-Activity Videos and Questions

Videos

Take a look at the PSA's below to get a sense of how topics around plastic pollution are conveyed:

- Kindergartners Version of a Public Service Announcement
- End Plastic Pollution
- FEMA Accessible: Hurricane Florence Preparedness PSA
- CleanSeas Break-Up PSA

Questions

1. What is the difference between a PSA and a general emergency message?
2. What messages were the PSA's trying to convey?
3. How are the PSA's trying to convey their message in a digestible way for the public?
Instructions: Exploring Extreme Weather

1. Split your students into groups of no more than 4 and make sure all materials are gathered.
2. As a class, watch the recommended PSA videos to ensure students have a clear understanding of what a PSA is.
3. Each group will take 15 minutes to brainstorm a topic related to an extreme weather event. Have the groups come up with three questions related to their topic to ensure they fully understand the root of the problem:
   a. What is the issue?
   b. Why is it a problem?
   c. How can this problem be addressed?
4. Using a laptop or smartphone, students will choose a picture to use when drafting their PSA. This picture should be informative about what the issue is and hold people’s attention when going over their PSA.
5. Have the students take 20 to 30 minutes to draft a script for their PSA. It’s important to remember that the PSA is meant to be informative and change the viewers behavior when it comes to the topic discussed.
6. While drafting the script, students should also come up with a catchy slogan that helps keep people’s attention.
7. Once the students have chosen an image, have come up with a slogan, and drafted a script, each group should take 5 to 10 minutes to rehearse their PSA. Each group will then present their PSA to the class on their topic.
Post-Activity Discussion Questions
Printable Student Worksheet

1. Check off the supplies you have in Ready’s Emergency Supply List and list off below which supplies you still need to be prepared for an emergency event.

2. Develop a plan to get 3 people in your community to sign up for Notify NYC.

Background for Educators

- Games and Activities on Extreme Weather - Kids Discover
- Exploring extreme weather - lesson plan - Met Office
- Investigating Extreme Weather Events with Interactive Activities — Beyond Weather & The Water Cycle (osu.edu)
- Hurricane Tracker
Post-Activity Resources

A.) Go to NYC Emergency Management’s Get Prepared and Ready’s Build a Kit page and learn about the steps you need to take to build your own disaster supply kit.

B.) Go to Notify NYC and sign up to stay informed about emergency alerts and important city services throughout New York City.

C.) Check out Waterfront Alliance's Exploring Extreme Weather StoryMap for a more visual experience on what extreme weather events are and how to be prepared for them.

Expand Your Learning!

Click on this link or scan the QR code below to explore extreme weather using a StoryMap!

Background for Educators

- FEMA’s Youth Emergency Preparedness Curriculum
  - Grades 3-5
  - Grades 6-8
  - Grades 9-12
Engaging your parent / guardian in the conversation!

Students: Share your PSA with your parents / guardian and ask them the following questions

1. What is extreme weather?

2. How extreme weather related to climate change?

3. What are some ways to be prepared for extreme weather?

Click here to watch more about extreme weather
Activity 7: Waterfront Field Lab Lesson Plan

Unit Overview

The Estuary Explorers Waterfront Field Lab Lesson Plan is a curriculum-aligned field lab offered at your local waterfront (for example a park or marina). Through a simple, yet impactful program, students apply STEM skills to the real world challenge of environmental analysis and coastal protection on a waterfront near their school community.

By making observations of permeable and non-permeable areas; observing the low and high tide; and taking measurements of pH, salinity, and water temperature, students collect and analyze data that informs their community's response to the climate crisis.

This lesson plan is adaptable and best suited for students in grades 6-12.
Learning Targets

- Increase knowledge of the local estuary ecosystem, water quality, and climate resiliency on the waterfront
- Apply STEM skills from the classroom during a field lab on the community waterfront
- Make connections on why these studies matter and how young people can advocate for their community

Key Questions

- What types of shorelines promote both coastal resilience and healthy shoreline communities?
- How can shoreline alterations positively or negatively affect a community?
- What are some of the ways that you can help promote stable shorelines?

These learning targets fulfill the following components of the Next Generation Science Standards

- Science and Engineering Practices
  - Developing and using models
  - Analyzing and interpreting data
  - Using mathematics and computational thinking
- Crosscutting Concepts
  - Asking questions and defining problems
  - Planning and carrying out investigations
Materials

If possible, bring two or three of each measuring tool below to give more opportunities for hands on exploration, and to shorten wait times for groups of students

- Three buckets total (With at least one having a rope attached)
- Aquarium thermometer
- Aquarium hydrometer
- pH strip kit
- Small trash bag
- Student data sheets, clipboards, and pens
- Yard stick to measure predicted high water levels (best at a beach)
- Sea-level rise predictions from the NYC Panel on Climate Change 2019 report.

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Pre-activity background reading and videos through these links

- The New York State Education Department's Engage NY Website
- NYC Waterfront Access Map
Pre-Activity Discussion

Discussion

Review skills in measurement as this field lab utilizes measuring skills to make observations of pH temperature and salinity. Also review any ecosystem processes that have been part of the students' studies so far. The waterfront lab will provide understanding about estuaries, but refreshing any background on the water cycle, watersheds, or food webs will help students better apply their learning. We will also be placemaking on the waterfront, so a grade level appropriate review of the local community geography would be helpful. Measurement review can include:

- Standard Units
- Increments
- Comparison

During these series of activities, students will apply mental math to extrapolate unlabeled marks on the scale, which is helpful to practice in advance if needed. For example, if the measurement falls between 40 and 50, and there are 5 little spaces, count by twos for each space.
Instructions: Waterfront Field Lab

1. Placemake on the local waterfront, naming local waterbodies, and defining an estuary (10 minutes)

2. Split students into 3 groups, each led by an adult (classroom teacher, environmental educator, chaperone). They will rotate through one test activity at a time (5-10 minutes per activity x3 rotations = 20-30 minutes) working as a team to collect data. Follow the instructions on the student data sheet for each activity, and record measurements on the same data sheet.
   a. Temperature
   b. pH
   c. Salinity

3. Reconvene as one group to focus on coastal resilience components (10 minutes)
   a. If at a natural shoreline, use a yard stick to show the predicted high water levels. See chart below.
   b. Discuss permeable and non-permeable surfaces, and how green infrastructure supports resilience.
   c. Observe and discuss the waterfront you’re at, consider what would happen if the area floods.

4. Analyze today’s data, compare the measurements to pre-existing estuary parameters, and discuss why differences occur. Explain how these measurements connect to climate change (10 minutes)

5. pH strips can be disposed of in the trash bag. After dismissing students, rinse all measuring tools with freshwater.
Post-Activity Discussion Questions

Civic Engagement

Students may write letters to the elected officials in their community, expressing what they learned about the waterfront and what they hope the local, state, and federal government can do to make their community more resilient. This citizenship brainstorm encourages self-exploration of the qualities of citizenship and civic engagement. Find your city council member or congressional and state representative below.
Post-Activity Discussion Questions
Printable Student Worksheet

1. What helpful services are provided by local government specifically related to our urban environment? What services could the government improve?

2. Who is in charge of taking care of the waterfront?

3. How can we ask for help or improvements for the waterfront in our community?

Background for Educators

- NOAA's climate education page
- NASA's videos on oceans and climate change
- International Union for Conservation of Nature's ocean warming brief
- NOAA resources on pH and ocean acidification
Answer Guide

Waterfront Field Lab Lesson Plan

1. What helpful services are provided by city government, particularly related to our urban environment? What services could the government improve?

The New York City Department of Environmental Protection manages both the drinking water and sewer systems in the City of New York. At a higher level, the New York State Department of Environmental Conservation oversees statewide efforts. In New Jersey, the state Department of Environmental Protection oversees the water regulations for towns and cities, who make their own plans. Many communities have private companies running their water and services. Planning and Land Use Departments also have an impact on the waterfront.

NYCDEP Resources for Educators

2. Who is in charge of taking care of the waterfront?

This is a tricky question, as dozens of agencies have some kind of jurisdiction over some of the waterfront, and some waterfront is privately owned. The New York City Department of City Planning creates zoning guidelines for the waterfront. Other major responsibilities fall under the New York City Department of Parks and Recreation, Economic Development Corporation, or Department of Transportation.
3. Students may write letters to the elected officials in their community, expressing what they learned about the waterfront and what they hope the local, state, and federal government can do to make their community more resilient. This citizenship brainstorm encourages self-exploration of the qualities of citizenship and civic engagement. Find your city council member or congressional and state representative below.

Find additional water access sites in your community on the New York City Department of City Planning Waterfront Access Map. The Explorable Places link shows many nonprofit organizations with field labs.
Engaging your parent / guardian in the conversation!

Students: Watch the following video with your parents and discuss the following questions with them.

Click here or scan the QR code above to watch more about the impact of climate change on our oceans.

1. What are some of the issues facing our water systems?

2. What are 3 ways that we can monitor our local water quality?

3. How can we begin to protect our waterways from a changing climate?
Glossary

**Acid:** Any substance that in a water solution tastes sour, changes the color of certain indicators, reacts with some metals to liberate hydrogen, reacts with bases to form salts, and promotes certain chemical reactions.

**Algal Bloom:** A rapid growth of microscopic algae or cyanobacteria in water, often resulting in colored scum on the surface.

**Bioaccumulation:** When chemicals are taken up by a plant or animal directly from exposure to contamination or by eating food containing the chemical.

**Bisphenols:** Chemicals used in plastic manufacturing to make the material more durable and heat resistant, that can mimic estrogen in the human body and can raise health concerns.

**Borough:** A town or district, which is an administrative unit.

**Brackish Water:** Slightly salty water, consisting of a mixture of river water and saltwater.

**Combined Sewer Overflows (CSOs):** An event that occurs as a result of heavy rainstorms, where combined sewers receive higher than normal flows. Treatment plants cannot handle flows, leading to a mix of stormwater and untreated sewage directly discharging into the waterways.

**Calcium:** The chemical element of atomic number 20.

**Carbon:** The chemical element of atomic number 6; the shortened version of carbon dioxide, a common greenhouse gas contributing to climate change.

**Celsius:** Denoting a scale of temperature on which water freezes at 0° and boils at 100° under standard conditions.
Glossary

Climate Change: Significant changes in temperature, precipitation, wind, or other global or regional climate patterns that occur over several decades or longer.

Coastal Resilience: The building of the ability of a community to rebound after hazardous events such as hurricanes, coastal storms, or flooding.

Coral Reef: An underwater ecosystem characterized by reef-building corals.

Current: A body of water moving in a definite direction.

Degradation: The physical, chemical, or biological processes that cause the reduction in size and strength of plastic.

Density: The degree of compactness of a substance.

Ecological Resources: A natural resource that plays a vital role in the keeping of balance of an ecosystem.

Ecosystem: A biological community of interacting organisms and their physical environment.

Ecosystem Services: The direct and indirect contributions of ecosystems to human well-being.

Entanglement: Plastics that have loops pose the risk of choking animals, leading to drownings, infections, and limiting their ability to eat or move.

Engineers: A professional who applies scientific principles and mathematics to build and design machines or public works.

Erosion: The process of being eroded by wind, water, or other natural causes.
Glossary

**Estuary**: Bodies of brackish water where freshwater rivers meet the sea (such as a bay, mouth of a river, salt marsh, lagoon).

**Evacuation Route**: Routes designed for the movement of persons to safety in the event of an emergency and or natural disaster.

**Exoskeleton**: A rigid external covering for the body in some invertebrate animals, especially arthropods, providing both support and protection.

**Exposure**: The presence of people, livelihoods, species, or ecosystems in places and settings that could be adversely affected.

**Fahrenheit**: Denoting a scale of temperature on which water freezes at 32° and boils at 212° under standard conditions.

**Food Web**: A system of interlocking and interdependent food chains.

**Fossil Fuels**: A natural fuel such as coal or gas, formed in the geological past from the remains of living organisms.

**Freshwater**: Water that has no appreciable salinity, commonly defined as less than 0.5 parts per thousand dissolved salts.

**Green Infrastructure**: Natural systems including forests, floodplains, wetlands, and soils that provide additional benefits for human well-being, such as flood protection and climate regulation.

**Groin**: Fingerlike-shaped barriers built perpendicular or at an angle to the shoreline that reduces currents. These lower currents help prevent erosion and encourage sediment deposition.
**Glossary**

**Hurricane**: A tropical cyclone in the Atlantic, Caribbean Sea, Gulf of Mexico, or eastern Pacific in which the maximum 1-minute sustained surface wind is 64 knots (74 mph) or greater.

**Hurricane Sandy**: The 18th named tropical cyclone of the 2012 Atlantic hurricane season hitting the east coast of the United States and causing record amounts of damage, especially in New York and New Jersey due to it making landfall during high tide.

**Hydrometer**: An instrument for measuring the salinity of liquids.

**Impermeable**: Not allowing fluids to pass through.

**Infiltrate**: Permeate by filtration when referring to a liquid.

**Infrastructure**: The basic physical and organizational structures and facilities, such as buildings and roads, needed for the operation of a society.

**Jetty**: A long, narrow structure that protects a coastline from the currents and tides - typically made of wood, earth, stone, or concrete.

**Landscape Architects**: Professionals who design and plan functional and environmentally friendly outdoor spaces.

**Living Shoreline**: A technique using native vegetation alone (or in combination with low structures that run parallel to the coast) to stabilize the shoreline.

**Local Government**: The administration of a particular town, county, or district, with representatives elected by those who live there.

**Marine Debris**: Any manufactured material disposed of in our oceans or waterbodies.
Glossary

**Microplastics**: Small pieces of plastics less than 5 millimeters in size that breakdown from larger pieces of plastics or shed from synthetic materials.

**Neutral**: Neither acidic nor basic; Having a pH of 7.

**New York-New Jersey Harbor Estuary**: The end of New York’s and New Jersey’s largest waterways, including the Hudson, Hackensack, Passaic, Rahway, Shrewsbury, Navesink, and Raritan rivers.

**Ocean**: A very large expanse of sea, in particular, each of the main areas into which the sea is divided geographically.

**Percent**: One part in every hundred.

**Permeable**: Allowing liquids or gases to pass through it.

**Photodegradable Plastics**: Plastics that breakdown into smaller pieces when exposed to sunlight.

**Plankton**: Small and microscopic organisms drifting or floating in the sea or freshwater.

**Plastics**: Synthetic or manmade materials derived from petroleum that can be shaped into things like water bottles and toys.

**Pollution**: The presence in or introduction into the environment of a substance or thing that has harmful or poisonous effects.

**Phthalates**: A group of chemicals used to make plastics more durable and flexible, that are known to affect hormones and have the potential to cause cancer.
Glossary

Public Service Announcement (PSA): A short message or ad to inform, educate, or raise awareness about a specific issue.

Reef: A ridge of jagged rock, coral, or sand just above or below the surface of the sea

Resilience: A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.

Riprap: Layer of large stones used to protect soil from erosion in areas of heavy runoff and are often located on steep, unstable slopes.

River: A large natural stream of water flowing in a channel to the sea, a lake, or another stream.

Runoff: The draining away of water (or substances carried in it) from the surface of an area of land or structure.

Salinity: The quality or degree of being saline or salty

Salt Marsh: Coastal wetlands that form transition zones between land and sea. They provide valuable habitat for wildlife, serve as nurseries for fish and shellfish, store floodwaters, and protect our shorelines against damage from storm surges.

Sea-Level Rise: An increase in the level of the world's oceans due to the effects of climate change. It is caused primarily by two factors related to global warming: the added water from melting ice sheets and glaciers as well as the expansion of seawater as it warms.
Glossary

Seawall: A wall or embankment erected to prevent the sea from encroaching on or eroding an area of land.

Shell: The hard protective outer case of a mollusk or crustacean.

Shellfish: An aquatic shelled mollusk, such as an oyster, or crustacean, such as a blue crab, especially one that is edible.

Single-Use Plastics: Plastic items that are designed for one-time use and thrown away, contributing to large amounts of waste.

Shoreline: The line along which a large body of water meets the land.

Storm Surge: A rise in coastal water level associated with a hurricane or other strong coastal storm above the level associated with normal tides. The storm surge height is the difference between the observed storm tide and the normal tide.

Temperature: The degree or intensity of heat present in a substance or object.

Thermometer: An instrument for measuring and indicating temperature.

Tide: The alternate rising and falling of the sea, usually twice in each lunar day due to the attraction of the moon and sun.

Tropical Storm: A tropical cyclone that has maximum sustained winds of 74 mph (64 knots) or greater.

Urban Planners: Professionals who develop land use plans and specialize in the development and design of cities, towns, and communities.
Glossary

**Watershed**: A land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean.

**Water Quality**: The physical, chemical, and biological characteristics that are measured to determine the health and usability of water.

**Wetland**: A type of environment that is seasonally or annually flooded by water, and is characterized by saturated soil, known for their high levels of biodiversity, similar to coral reefs.

**pH**: A figure expressing the acidity or alkalinity (how basic something is) of a solution on a logarithmic scale on which 7 is neutral, lower values are more acidic, and higher values more alkaline.

**100-Year Flood**: A flood or storm that has a 1% probability of occurring in any given year - the 100-year flood zone is the extent of the area of a flood that has a 1% chance of occurring or being exceeded in a given year.

**500-Year Flood**: A flood that has a 0.2% chance (or 1 in 500 chance) of occurring in a given year.
Thanks for learning with us!
ESTUARY EXPLORERS
Coastal Resilience Education Toolkit
Extra Lessons
Activity Overview

The Mystery of the Disappearing Shells is a flexible lesson that can be done in a classroom or kitchen. Through a simple activity that models ocean acidification, students will learn about a chain reaction generated by climate change that can severely affect our coastal ecosystem. This formal lesson plan shows that the environmental processes behind ocean acidification can be investigated in complex detail, but it also offers simplified language and explanations for younger students, so that children of any age can discover more about resilient ecosystems together.

By observing an eggshell placed in vinegar, students will see what effects ocean acidification has on marine life, specifically those that have shells. While the details of the particular chemical reactions can be complex, watching the eggshell disappear is simple and powerful to observe. With the additional resources provided here, students will explore why this happens and what can be done to protect our coastal environment from further damage. When combined with our Estuary Explorers waterfront field lab, students can test for acidity on their own waterfronts, to expand these studies with their own, local data.
Learning Targets

- Model the ecosystem effects of ocean acidification
- Draw conclusions about coastal preservation and restoration
- Explore green and blue infrastructure solutions for restoring our coasts and waters

Key Questions

- How are people affecting the marine ecosystem?
- Why do things out in the ocean matter?
- How can new waterfront construction help restore our estuary?

These learning targets fulfill the following components of the Next Generation Science Standards:

Science and Engineering Practices
- Analyzing and interpreting data
- Using mathematics and computational thinking

Crosscutting Concepts
- Patterns
- Cause and effect: mechanism and explanation
- Stability and change
## Pre-Activity Reading and Discussion

### Discussion

Before immersing the eggshell in the vinegar, ensure the students have developmentally appropriate pre-activity discussion. A short reading is on the previous page, but if the internet is available, the links included on the following page provide more context.

Also, review any ecosystem processes that have been part of the students’ studies so far. This activity will provide an introduction to observing acidity in the environment, but refreshing any background on water quality, ecosystem interdependence, environmental reactions, or food webs will help students better apply their learning.
Pre-Activity Reading and Discussion

Reading

At a minimum, share this reading below or its equivalent preparation

"Though some acids are normal in life, like in your stomach, you’ve probably heard in the movies or on TV that acids can harm people. But it’s not just people to be concerned about, all kinds of living things can be injured by too much acid. Acids are measured by pH (say the letter p then the letter H), which is studied more in high school, but anyone can make a simple observation about acid pollution in the water. The ocean normally measures a pH of about 8. This is close to the middle of the pH scale at 7, called neutral. pH numbers lower than 7 are acidic, and the lower the number the stronger the acid. We don’t want to see pH measurements that are getting lower for our ocean and coastal waters, because that means they’re getting more acidic. Many marine animals have shells (made of a mineral called calcium carbonate, written as CaCO3) that can’t grow strong when the water is acidic. Think what it would be like to have a problem growing your bones or skin! Acid is making the water ecosystem unlivable for the creatures in it. Here’s an activity that shows what acidification in our estuary is like, The Mystery of the Disappearing Shells."

Following the introduction of age appropriate background, check that students are able to:

- Identify pH as indicating acidic or neutral. You may recall the scale also includes basic, which is a concept best explored with older students.
- Inquire how the acidity of coastal water affects our shared ecosystems.
Materials

For each lab group sharing a counter:

- A clean, dry glass jar with a clean, dry lid. Remove the label to see better.
- A rinsed, dry piece of eggshell, about a half of the eggshell. Brown eggs offer more contrast, but white eggs will also work.
- White vinegar, enough to cover the eggshell in the jar. Be careful with the vinegar!
- A temporary storage spot to leave your jar at least overnight, or up to a few days. Make sure to keep your jar out of direct sunlight and away from sources of heat.
- If working with multiple variables or groups, use a marker or tape to label the jars.
- A lab notebook, drawing sheet, or camera to record observations of the jar over time.
- In some school settings, goggles, and gloves may be considered appropriate when using household vinegar in an experiment. Check your school's instructions.
- If lighting or visual contrast may be a concern due to room or the special needs of students, keep a white or a black sheet of paper handy to hold up near the jar to enhance observations through contrast.

Pre-activity background reading and videos through these links

- The Conversation's How Do Shells Get Made?
- Ducksters Science pH Scale
- Woods Hole Oceanographic Institution The pH Scale
Procedures: The Mystery of the Disappearing Shells

1. Prepare the materials listed above. Each lab counter or group will need a clean glass jar and lid, a half piece of eggshell, and white vinegar to submerge the eggshell. Be careful with vinegar, it is a mild acid, and children may require supervision. Do not touch your face or eyes when handling vinegar and wash your hands after using it. Even though vinegar is commonly found in kitchens, some administrations may have procedures requiring goggles and/or gloves when using it with students. Don’t forget to clear a spot to leave the jar for a few days, where you don’t have to worry about sun or heat or accidents.

2. If labeling is helpful, do that on the jar or lid first.

3. Use the reading above or lead a brief review to activate student background knowledge about why acidification in the water is of concern. Instruct students that the eggshell is made of the same mineral as seashells, calcium carbonate or CaCO3. Add that vinegar is a mild acid, representing acid pollution in the ocean. Clarify that by putting the eggshell in vinegar, you are modeling what happens to shelled creatures in the ocean.

4. Gently place the eggshell in the empty jar and add just enough vinegar to submerge it by a half inch or so. Children should be as hands on as possible, but according to age and stage, adult supervision should be active. Expect soft bubbling reactions to begin within the jar immediately, and to continue for some time. There is usually some odor, but there is no reason to be concerned about fumes.

5. Take a few minutes to observe the immediate reactions within the jar with the eggshell and vinegar. Allow time or structure turns for all to have a close look, while still not getting vinegar on their faces. If there is good self-control, leave the lid off the jar for these first few minutes for the best observations. White vinegar is clear, and while the bubbling is always noticeable, it may be comparatively soft and small. Try to keep the jar still for the best effect. If children haven’t mastered impulse control, cap the jar immediately, before making observations, to prevent spilling vinegar. If the light doesn’t facilitate good contrast, hold the capped jar in front of light or dark paper or backgrounds for contrast.
Procedures: The Mystery of the Disappearing Shells

6. A simplified explanation of what’s happening in the jar is that the calcium carbonate shell, CaCO₃, is being dissolved by the acidic vinegar and creating carbon dioxide gas, CO₂. When the ocean is full of carbon dioxide, an acidic reaction also takes place, and the calcium carbonate is also not able to form shells.

7. Take a photograph of the jar or encourage children to record their observations in a lab notebook or through drawing. Transition to leaving the jar capped and storing it in a spot where you can check it again. There may be soft hissing from the cap because of the carbon dioxide. It’s best to not allow children to open the jar on their own.

8. Leaving the cap on, view the jar again in several hours, and/or regularly over the next two days, to observe how acid in the ocean makes shells weak. Continue to photograph or record these observations. Within about five hours, you should see that some of the eggshell has dissolved. Within two days, you should see only bits of eggshell left. The eggshell shape will want to float over time, but will dissolve more quickly when shaken back down fully into the vinegar. Children, under supervision, may choose to quicken or slow the effects by occasionally shaking the jar or not. Egg shells have a membrane inside the shell, which is usually not all rinsed out. You may see that the soft, white membrane stays floating in the vinegar. The difference is more obvious with brown eggs, where the brown shell will dissolve leaving the white membrane behind.

9. Leaving the cap on the jar allows you to contain the activity well. The reactions in the jar will cause some pressure, and the combination of vinegar and egg will cause some odor. You will not ruin the activity or be exposed to any unusual risk to open the lid on the jar at any time, but point away from anything sensitive just in case. Expect a little sigh or pop of pressure, and mild odor. Continue observations either way.
Procedures: The Mystery of the Disappearing Shells

10. Wait at least a day, or up to three, then invite students to share their observations and conclusions. Ensure the connection that acidification prevents the building of shells is made at an appropriate level for the student. The additional resources below will help explain the particulars of the chemical reaction behind ocean acidification and explore further questions. To summarize what happens in the ocean, extra carbon dioxide dissolves in the salt water, where it forms ions that turn the water more acidic, which turns the shell building blocks of calcium carbonate into a different, unusable mineral salt called bicarbonate.

11. For clean-up, dispose of the eggshell remnants and vinegar by pouring it outside on the grass or pavement away from other people. You can also pour it down the toilet and flush. The empty jar can be recycled.
Expand Your Learning!

If you have a seashell collection, you can try submerging a seashell in vinegar to model these reactions too (Note that seashells bought in stores may have a varnish applied, which will not work well). Thinner eggshells gives more immediate observations.

Post-Activity Questions
Printable Student Worksheet

A.) How does acid get in the ocean?

B.) Why does ocean acidification matter?

C.) What can people do to prevent more damage from ocean acidification?

Background for Educators

- Ocean acidification education from NOAA
- Evidence of carbon emission reductions connected to the COVID-19 pandemic from BBC News and Carbon Brief
Activity Overview

Tallying Up Temperature Rise is a curriculum aligned lesson plan that can be done in the classroom, in remote learning settings, or at home. In this interactive game, students visualize the causes and effects of climate change on a large scale and are introduced to concepts such as temperature and sea-level rise. This lesson plan is adaptable for students in grades 3-12 and we invite you to come up with your own versions to suit the needs of your students!

During this activity, participants consider the effects of their own actions in terms of carbon emissions and climate change. By writing down an activity they did the previous weekend and letting it be apart of a larger game, students can better visualize how those actions affect the larger environment they're apart of and how they compare and relate to the actions of others.
Learning Targets

- Recognize the relationship between the cause of carbon emissions and a rise of temperature in the air and oceans
- Understand that climate change is caused by, and affects, everyone, not just one group
- Raise awareness about what students can do to help mitigate and adapt to climate change

Key Questions

- How are people affecting the climate?
- Why is climate change important to learn about?
- How can we address climate change and rising carbon emissions?

These learning targets fulfill the following components of the Next Generation Science Standards

- **Science and Engineering Practices**
  - Analyzing and interpreting data
  - Using mathematics and computational thinking
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information

- **Crosscutting Concepts**
  - Patterns
  - Cause and effect
  - Mechanism and explanation
  - Stability and change
  - Scale, proportion, and quantity
Materials

Use one set of materials

- Bowls for however many groups there are
- A sheet of paper to cut into slips, with one slip per student
- A board – a chalkboard, dry erase board, large sheet of paper, or just a way to visualize groups and scores
- Pen or pencil, at least one per group
- Scissors
- Pre activity video below:

Video

Pre-activity background reading and videos through these links

- NYSDEC Impacts of Climate Change in New York State
- NASA’s Causes and Effects of Climate Change
- NASA’s What is Happening in the Ocean?
Pre-Activity Reading and Discussion

Reading

Before starting the activity, go through the provided pre-activity readings and video for more information on climate change and its causes and effects. Following the readings, check that students:

- Understand what is causing the climate to change so rapidly and what effects that will have on communities
- Can visualize some of the effect's climate change has already had around the New York metropolitan area

Discussion

Review any concepts on weather or climate that the students may have gone over already. There is a link on the differences between weather and climate provided, but emphasizing their differences will help students better understand the scale of the issue of climate change.
Procedures: Tallying Up Temperature Rise

1. Prepare the materials required for the game and split students into multiple groups with no more than 4 to 5 per group. Each group can either name themselves or be assigned the name of a fictional "city" which will act as the community they live in. Each participating “city” will need 2 to 3 sheets of paper, scissors to cut the paper into small slips, a pen or pencil, and a bowl to place the slips of paper into.

2. Have students in each group write down a single activity they did the weekend prior to them playing this game. Once drawn, each piece of paper will be determined by the group what effect it will have on the global temperature (Raising it, keeping it where it is, or lowering it). The group should use pre-activity reading material as a base to make educated guesses on what the outcome of their actions are. Once the students determine the effect, have the author of the action label their slip of paper with that determination (temperature rises, remains the same, or it lowers).

3. As the educator, make a large table with the rows representing an increase in temperature, maintaining of temperature, or lowering of temperature. The columns will be of each name of the “cities,” and tallies will be placed in the sections lining up to group names. The tallies represent an increase or decrease of 1°F and show the actual predicted scenarios of global temperature increase:

   a. If the tallies add up to less than 4, than an optimistic goal of mitigating temperature rise has been met – optimistic means that policies that reduce carbon emissions have been put in place and renewable energy technologies have been greatly improved upon.
   b. If the tallies add up between 5 and 8, then the expected goal of mitigating temperature rise has been met – expected is the path we're on with current policies and minimal technological improvements.
   c. If you have tallies that add up to greater than 9, then you have reached the worst-case scenario goal for the planet – worst-case is if we remove the policies and laws that are currently put in place and have no technological improvements in the future.
Procedures: Tallying Up Temperature Rise

4. Rotate through groups alphabetically and draw a single slip of paper from the bowl per turn. Have the group report if the activity is carbon positive, carbon neutral, or carbon negative. If you as the educator agree with them, place a tally in the appropriate section of the table. If you disagree with the outcome, lead the students in a quick, constructive discussion about what you believe the correct answer to be. It should be noted that there are no carbon neutral activities and that all answers should be either positive or negative. This becomes more apparent to students as the game progresses.
5. Once all of the slips have been drawn, add up the tallies of each “city” and make a bar graph on the board. Have the y-axis labeled temperature (in Fahrenheit) with the top being at 10°F and the bottom at 0°F. Have the x-axis labeled with each of the “city” names. The group with the lowest number is the winner, but as a surprise, average all the numbers together to determine what the global average temperature increase is. Read aloud the passage below.

“Climate change is a global issue that no individual city, state, or country can solve alone. While often times it comes down to individuals making choices that are good or bad for the environment, it is when large groups work together implementing policy changes and improvements in technology, can real progress be made.”
Post-Activity Discussion Questions
Printable Student Worksheet

1. Climate change is not only affecting the temperature of the air, but also of our oceans. How do rising ocean temperatures impact the New York-New Jersey Harbor Estuary?

2. New York and New Jersey, have already begun to see the effects of climate change. What are three effects that the region has seen in the past 150 years?

3. How did your group do in the activity? Was the action you wrote on the slip of paper carbon positive or carbon negative?
   a. If it was positive, what's one way you could make it more climate friendly?
   b. If it was negative, think of another activity you do in your free time and write down one way you could make it more climate friendly?

Background for Educators
- NOAA's Climate Website
- NYCDEP Climate Change Education Module
- NYSDEC Climate Change Information
- NEA's Climate Change Education: Essential Information for Educators
- Waterfront Alliance’s Climate Change and Coastal Resilience Presentation
Activity 6: Water Quality Testing at Home

Activity Overview

Water Quality Testing at Home is a curriculum aligned lesson plan that can be done in the classroom, virtually, or at home. In this activity, students use hands on skills to construct tools and measure parameters scientists would use to track the health of an estuary. This lesson plan is adaptable for students in grades 3-12 and we invite you to come up with your own versions to suit the needs of your students!

This lesson plan guides students in constructing a thermometer and a hydrometer (a tool that measures salinity) with materials found in the home or easily brought into the classroom. Throughout the activity, students will utilize skills in design and critical thinking while making observations of the ranges of salinity and temperature in an aquatic environment. Once the students have constructed both tools, they can explore how salinity and temperature interact, modeling real conditions in the New York-New Jersey Harbor Estuary.

*This activity was partially adapted from the Billion Oyster Project's online video How to Make a DIY Hydrometer*
Learning Targets

- Look at the relationship between salinity, temperature, and density
- Utilize hands-on skills in constructing scientific tools
- Understand how scientists use tool to make real-world assessments about the environment

Key Questions

- How do temperature and salinity affect one another?
- Why do temperature and salinity matter for an ecosystem?
- Do you think temperature and salinity affect more than just the density of water?

These learning targets fulfill the following components of the Next Generation Science Standards

- Science and Engineering Practices
- Asking questions and defining problems
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Crosscutting Concepts
- Patterns
- Cause and effect: mechanism and explanation
- Structure and function
- Energy and matter: Flows, cycles, and conservation
**Materials**

One set of materials for each participant is recommended, but if needed, a group can share one set and work together

For the hydrometer:
- Salt
- Scissors
- Modeling Clay (Or a hot glue gun)
- Tall Glass
- Small Metal Nails (Or anything small that can fit through the end of a straw that is heavy)

For the thermometer:
- Small Spray Bottle (A glasses cleaner bottle works well)
- Rubbing Alcohol
- Food Coloring
- Modeling Clay
- Eye Dropper Bottle (x2)
- Small Bowl Filled with Water and Ice

For both:
- Clear Plastic Drinking Straw
- Water
- Sharpie Marker
- Tape Measure (Or ruler)

Pre-activity background reading through these links:
- Why is the Ocean Salty?
- Ocean Temperature
- Water Quality Parameters Information Sheet
  - Read about salinity and temperature
Pre-Activity Reading and Discussion

Reading

Before starting the activity, go through the provided pre-activity readings for more information on temperature and salinity. Following the readings, check that students:

- Visualize the relationship between temperature and salinity and how thermometers and hydrometers are useful tools for scientists to measure these parameters
- Learn why salinity and temperature are two critical components in maintaining equilibrium in the New York-New Jersey Harbor Estuary

Discussion

Review any concepts on oceans, estuaries, water chemistry, salt, or temperature that the students may have already gone over. It is important to emphasize that in any environment, including an aquatic one, disrupting one metric can have drastic effects on another, as well as the environment as a whole.
Procedures: Water Quality Testing at Home

1. Prepare the materials required for the activity.
2. For the hydrometer, lay out all necessary materials
   a. Use modeling clay (or a hot glue gun) to seal the straw. Make sure one end of the straw is sealed with something that will not dissolve in water.
   b. Take the straw out of the paper and trim some of the end off.
   c. Put two metal nails into the straw (or any objects small and dense enough to weigh the straw down). This keeps your straw weighted.
   d. Fill a glass (the taller and thinner, the better) with tap water and insert the straw gently into the water with the sealed side facing down.
   e. Take your measuring tape or ruler and measure the distance from the top of the water to the top of the glass. Record this number on a separate sheet of paper. Remove your hydrometer from the water.
   f. Measure out that same length from the top of the straw and mark with your marker. Insert your hydrometer back into the water. The markings should line up. This is your baseline for water density.
   g. Add salt to your water. Different amounts will raise your marking up due to salinity affecting the density of water. For reference, 8-28 parts per thousand (PPT) is the range for New York Harbor.

Video

Watch on YouTube
Procedures: Water Quality Testing at Home

3. For the thermometer, lay out all necessary materials
   a. Mark your straw at ½ cm intervals
   b. Make a flattened ball of clay and press your marked straw through it. Be sure to remove any clay inside the straw once it is pushed through.
   c. Pour rubbing alcohol into one of your small eye dropper bottles and fill it up to the halfway point. Add food coloring and mix. Fill up your other eye dropper bottle about ⅓ of the way up.
   d. Take your straw and clay combination and place the clay part on the bottle, ensuring that the straw does not touch the bottom of the bottle and that the seal over the bottle is airtight.
   e. Take your eye dropper filled with liquid and pour it into the straw. Notice that the liquid builds up in the straw.
   f. Fill up a bowl with water and ice and place your newly constructed thermometer into the ice bath. Notice that the level of the liquid drops. Mark where the liquid drops to on your straw with your marker.
   g. Take your thermometer out of the ice bath and hold the bottle portion with your hands to warm it up. Notice that the liquid rises.

Video

![Constructing a Thermometer in Your Kitchen](image-url)
Procedures: Water Quality Testing at Home

4. Once your hydrometer and thermometer are constructed, lay them out in front of you
   a. Add hot water to two glasses and measure the temperature to be the same. Add salt to one glass and measure the salinity of both with your hydrometer. Observe which one is denser and which one is less dense.

5. Play around with temperature and salinity in the water and explore the different ways temperature and salinity affect the density of water! If you feel like you’re not seeing significant differences, don’t be afraid to add a lot of salt.
Post-Activity Questions
Printable Student Worksheet

1. Do you see any trends or correlations between salinity and temperature? What are they and why do you think they relate this way?

2. What effects, either on the living organisms that call the estuary home, or on the people that live around it, do you think higher ocean temperatures will have on the New York-New Jersey Harbor Estuary in the next 50 years?

Background for Educators

- NYSDEC Hudson River Estuary
- Density, Temperature, and Salinity
- EPA Climate Adaption and Estuaries
- NOAA How Does the Ocean Affect Climate and Weather on Land?