ESTUARY EXPLORERS

Coastal Resilience Education Toolkit

WATERFRONT ALLIANCE

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About Waterfront Alliance

The Waterfront Alliance inspires and effects resilient, revitalized, and accessible coastlines for all communities.

Our Vision

New York Harbor and the surrounding waterways should be a shared resource for all. Our coastal communities must resolutely prepare for the reality of sea level rise and be prepared for the next big storm. Adapting to this new reality, 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 1,100 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 inquiry filled waterfront 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. We often hear from students that they've never visited their local harbor or coastline, and have no way to experience or enjoy a local waterfront nearby. Estuary Explorers not only encourages students to learn right at their local shoreline, it also engages them deeply through indoor or classroom-based activities backed by flexible, STEM lesson plans. We make all materials freely available on our website for any teacher or parent 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.

Estuary Explorers by the Numbers

As of September, 2020:

- 2,200 students have explored the estuary through our hands-on waterfront labs
- Our educators' network has grown to include 300 teachers and principals across 116 schools, all now receiving targeted Estuary Explorers materials and support
- Participating schools are located across all five New York City Boroughs, in New Jersey, and Estuary Explorers materials have been used in schools across the city of Elizabeth
- Harbor access has been newly initiated or expanded at four community waterfronts, where the first permit or permission for an educational program was earned by Waterfront Alliance and Estuary Explorers:
    - Urby's Waterfront Park (Stapleton, Staten Island, on the Upper Bay)
    - Brooklyn Bridge Beach (Lower Manhattan on the East River)
    - North 5th St. Pier (Williamsburg, Brooklyn, on the East River)
    - Bridge Park (Highbridge, the Bronx, on the Harlem River)

Experiencing the Waterfront in Person or Virtually

Estuary Explorers programs are rooted in experiential education, in which students study their community's relationship with the water by making observations on their own waterfront, using hands-on inquiry that drives both creative and critical thinking. To expand this experience, and for those who can't get to the waterfront, we're pleased to offer the activities in this guide. It may be using a tray of water indoors instead of a bucket of water at the shoreline, but we're still helping students to get their hands wet! This toolkit translates experiential goals into a library of interactive activities that support the concepts in our innovative field lab. Estuary Explorers strives to share the wonders of the estuary while helping our young people discover the facts about our urban ecosystem, ultimately building civic engagement and stewardship for a resilient future.

Coastal Resilience Education Toolkit

This toolkit of activities has multiple uses and can be utilized as-is or adapted for virtual learning and at-home teaching environments. Parents, 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' understandings 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 3 through 12, this resilience education tool kit provides teachers, students and parents with the necessary materials for meaningful environmental education in any setting. The additional multimedia resources included help teach complex topics in a virtual setting.

Overview of the Activities and their Learning Targets

The Coastal Resilience Education Toolkit guides teachers and students through seven activities that anchor a progressive exploration of our estuary and the means to protect it:

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” on an “estuary” playing board, students think critically about the role our communities play in a healthy ecosystem.

2. After establishing this ecosystem context, students will explore "The Mystery of the Disappearing Shells", an activity modeling the effects of ocean acidification, in which greenhouse gases change water chemistry and reduce shell formation, increasing the mortality of many marine creatures.

3. "Become an Ecological Engineer" gives students several hands-on examples to try for 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 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 local resilience, students will look through a more global scope with "Tallying Up Temperature Rise." This game helps students visualize the effects, however small, our choices have on the growing climate crisis and see how actions collectively affect the world around us.

6. "Water Quality Testing at Home" focuses the conversation of climate change on the water. Students construct a thermometer to test the temperature of water and a hydrometer to see how salty it is with materials that can be found in the home, By comparing results, they'll see how ocean chemistry plays a role in the New York-New Jersey Harbor Estuary.

7. The Estuary Explorers "Waterfront Field Lab Lesson Plan" takes learning outside and applies these concepts 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 supports Next Generation Science Standards and presents essential questions for connecting resilience education across the students' wider curricula. Each activity above anchors a detailed lesson plan that includes pre and post activity suggestions along with the primary investigation, and tips for flexibility and adaptations by grade level. 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 day. Each lesson plan includes:

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

- Procedures adaptable to one or more class sessions.

    - Pre-activity experiences 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.

    - Activity procedures are fully detailed as step by step instructions. Real world tips and essential explanations are provided within the relevant step of procedures for convenience.

- Post-activity experiences 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 with appropriate measures. Our team's experts can also support discussion and analysis as a post-activity experience.
- Lesson plans or data sheets in Spanish are being developed. Please contact us for further information.
- Additional materials for estuary education are available, including a presentation and workbook for students, and a pre-recorded webinar of our Introduction to Climate Change and Coastal Resilience presentation. 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.

WATERFRONT ALLIANCE

Activity 1:
The Human Impacts Game

Activity Overview

The Human Impacts Game is a curriculum aligned activity that can be done in a classroom, online, or in the comfort of a family's own home. 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 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 communties?
- What actions can I take to keep estuary clean?

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

<u>Science and Engineering Practices</u>

- Analyzing and interpreting data
- Using mathematics and computational thinking

<u>Crosscutting Concepts</u>

- Patterns
- Cause and effect:
- Mechanism and explanation
- Stability and change

Vocabulary

Estuaries

New York-New Jersey Harbor Estuary

Ecological Resources

Salt Marsh

Pollution

Watershed

Ocean

Freshwater

Algal Bloom

Pre-Activity Reading and Discussion

Reading

At any point before playing the game, go over the pre-activity readings for background information on estuaries and human impacts. If the internet is available, the links can be opened and read from the screen by an adult or student. If internet is not available, print the text to read aloud before the game. 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.

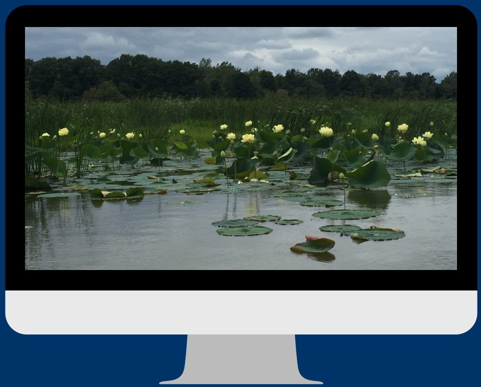
Materials

Each group playing will require one set of these materials:

- Goldfish crackers, at least 50 (or other similar game markers such as bingo chips).
- 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?



Procedures: The Human Impacts Game

1. Prepare the materials required for the game. Each group playing will need a blue bowl or a sheet of blue paper (or any placemat representing the estuary), one set of game cards, and 50 goldfish crackers (representing marine life in the estuary). Game cards can be printed out and cut apart, or be hand made by copying the template that is provided at the end of this lesson plan on to blank paper or cards. Feel free to create your own game cards based on your own actions, too. Place your estuary paper, bowl, or mat onto a flat surface.
2. 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. The fish hatchery is where the extra goldfish game tokens and cards will be. 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. The conservation officer should distribute 5 starter fish to each player, and place 10 starter fish in the estuary place mat bowl or paper. Place the additional crackers and the deck of game cards to the side.

Procedures: The Human Impact Game

4. 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!"

5. The player to the right of the conservation officer goes first, and play continues clockwise (The conservation officer may take turns and play the game, or sit aside and act as a moderator, depending on the group's size, age, and needs). 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. 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

Best for Grades 3-6, print two times if more cards are desired

A heron (a shorebird) eats a fish for lunch *Take out 1 fish*	*A dark oily liquid is found pouring into the water* *Take out 8 fish*
You and your family go on a fishing boat trip *Choose how many fish to take out*	*A shark swims into the estuary and has a snack* *Take out 3 fish*
A seal comes back to our busy harbor and needs dinner *Take out 2 fish*	*A wetland area is restored* *Add 5 fish*

Best for Grades 3-6, print two times if more cards are desired

Lawmakers have been convinced to stop the building of a shopping center on a waterfront with wetlands *Add 4 fish*	*The state fish hatchery releases fish into the estuary* *Add 5 fish*
A school of fish are caught in a power plant pipe *Take out 3 fish*	*People biking along the shoreline throw their trash in the water* *Take out 2 fish*
Somebody decides to throw their candy bar wrapper into the water and a fish chokes on it *Take out 1 fish*	*A motorboat leeks gasoline into a fish nesting site* *Take out 5 fish*

Best for Grades 3-6, print two times if more cards are desired

An egret (a shorebird) eats a fish for lunch *Take out 1 fish*	*A sewage pipe is found pouring into the water* *Take out 5 fish*
A fisherman handles his catch carelessly; the fish do not survive even though they're released back into the water *Choose how many fish to take out*	*A large storm washes trash from the mainland into the harbor* *Take out 3 fish*
A boat head (toilet) is not connected to a tank and releases sewage overboard *Take out 3 fish*	*A living dock is constructed, where the dock provides food and shelter for fish* *Add 5 fish*

Best for Grades 3-6, print two times if more cards are desired

A new waterfront development is building a wetland for fish in addition to the building for people *Add 5 fish*	*The state fish hatchery releases fish into the estuary* *Add 5 fish*
A construction site dumps debris *Take out 3 fish*	*People on the corner throw their trash in the gutter, and rain washes it into the estuary* *Take out 2 fish*
You and your family catch and release fish with the help of a park ranger, so the fish stay healthy *No fish removed*	*In winter, road salt runs off into the estuary along with the snow melt* *Take out 5 fish*

Best for Grades 7-12, print two times if more cards are desired

Invasive plants in the water make it more difficult for fish to feed *Take out 3 fish*	*A restoration project to add oyster reefs to the harbor begins* *Add 4 fish*
A farmer fertilizes her crops just before it rains and an algal bloom forms and pollutes the river *Take out 2 fish*	*Stronger environmental protections are put in place by the government* *Add 3 fish*
A local golf course fertilizes their field and causes an algal bloom in the bay *Take out 8 fish*	*A garbage clean-up effort takes place along the shoreline of the estuary* *No fish lost*

Best for Grades 7-12, print two times if more cards are desired

A farmer decides to plant native trees along the shoreline, protecting the estuary *Add 4 fish*	*The state fish hatchery has lost 3 fry (baby fish)* *Take out 3 fish*
A new road is built along the shoreline and allows road salt and oil leaks to drain into the water *Take out 3 fish*	*A new boat dock is constructed without a permit, covering a salt marsh* *Take out 2 fish*
A new ferry dock brings frequent boat traffic disturbance to a formerly quiet bay *Take out 2 fish*	*Kids hanging out along the shoreline throw their trash in the water* *Take out 3 fish*

Best for Grades 7-12, print two times if more cards are desired

Invasive crabs eat most of the algae, and our native crabs are starving *Take out 3 fish*	*A living shoreline and restored wetland are constructed to help mitigate urban runoff* *Add 4 fish*
Towns with poor sewage treatment cause nutrient pollution and algal blooms in the water *Take out 8 fish*	*Students write letters to the government calling for environmental protections* *Add 2 fish*
Past industrial pollutions, such as PCB's, are stirred up in our estuary *Take out 5 fish*	*The government budget increases funding for estuary education* *Add 2 fish*

Best for Grades 7-12, print two times if more cards are desired

A government cleanup project, such as EPA's superfund, is completed *Add 4 fish*	*Warmer waters make it harder for marine life to reproduce, and harder for fry (baby fish) to survive* *Take out 3 fish*
A highway is built along the shoreline and causes road salt and gas to go into the water *Take out 3 fish*	*An arts and music festival set up on the shoreline dumps paint into the water* *Take out 2 fish*
The harbor must be dredged (dig the bottom deeper) so that big cargo ships can bring us imported goods *Take out 3 fish*	*People at the beach let their trash blow away in the wind* *Take out 2 fish*

Activity 2: The Mystery of the Disappearing Shells

Activity Overview

The Mystery of the Disappearing Shells is a flexible lesson that can be done in a classroom, in a science lab, or in a 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

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 $CaCO_3$) 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.

Vocabulary

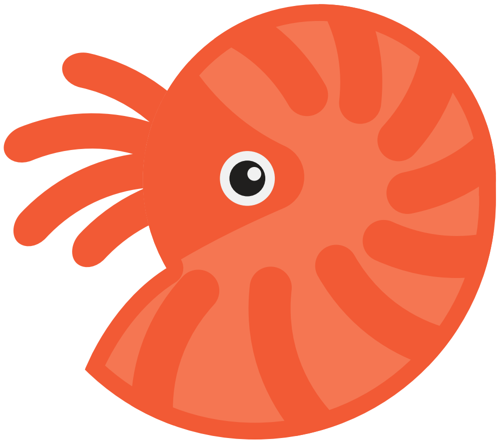
- Shell
- Reef
- Ecosystem
- Plankton
- Food Web
- Shellfish
- Calcium
- Exoskeleton
- Neutral
- Acid
- pH
- Coral Reef

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.

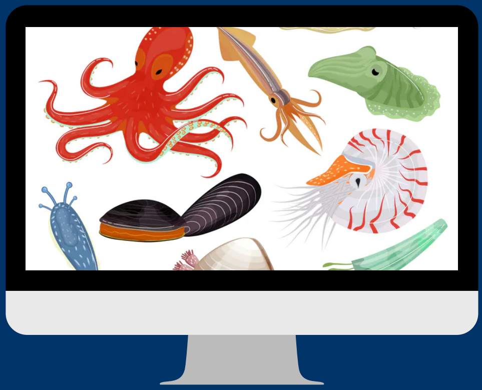
Also, review any ecosystem processes that have been part of the students' studies so far. This activity will provide an introduction to observing acidity in the environment, but refreshing any background on water quality, ecosystem interdependence, environmental reactions, or food webs will help students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



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 $CaCO_3$. 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, $CaCO_3$, is being dissolved by the acidic vinegar and creating carbon dioxide gas, CO_2. 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.

Egg Shell First Submerged

Egg Shell Halfway Dissolved

Post-Activity Questions

Printable Student Worksheet

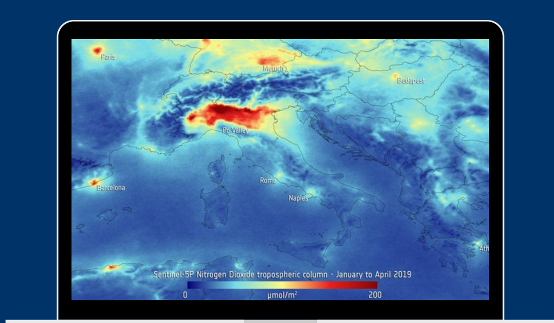
A.) How does acid get in the ocean?

B.) Why does ocean acidification matter?

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

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.



Background for Educators

- Ocean acidification education from NOAA
- Evidence of carbon emission reductions connected to pandemic from BBC News and Carbon Brief

Activity 3:
Become an Ecological Engineer

Activity Overview

Become an Ecological Engineer is a curriculum aligned activity that can be done in a classroom, or by making a lab out of a family's own kitchen. This activity 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 circumstances. We welcome you to innovate and come up with your own creative ways to explore the interactions of water and shoreline!

During this activity, students will simulate examples of different shorelines using material that can be commonly found in grocery stores or around their own homes. These mock shorelines can be constructed of household items ranging from a sponge 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.

Learning Targets

- Observing 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 mathematical 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 – such as an aluminum tray, baking pan, roasting pan, or glass or corning ware dish, approximately 8 inches by 12 inches or larger. Many sizes or types of trays could work, as long as the bottle below fits inside across the narrow end.
- 1 empty, single serve bottle - an aluminum or plastic water bottle works well, but even an empty soda bottle or can will work.
- Material to make landfill – such as rice, beans or cornmeal. Sand is a very good option, if available. You'll need enough to spread a pile across one narrow side to the tray, a generous cup will work in an 8x12 tray. For cornmeal, check the Procedures section below for additional materials and instructions.
- Materials to model waterfront protective infrastructure - as many as you can find, including 1-2 kitchen sponges (as marshland), egg shell 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). Try your own ideas too!
- 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?

Vocabulary

- Shoreline
- Erosion
- Infrastructure
- Coastal Resilience
- Green Infrastructure
- Wetland
- Salt Marsh
- Seawall
- Jetties
- Groins

Vocabulary

- Rip Rap
- Living Shoreline
- Climate Change
- Storm Surge
- Hurricane Sandy
- Permeable
- Impermeable

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

Discussion

Review any ecosystem processes that have played a part of the students' studies so far. 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.

Procedures: Become an Ecological Engineer

1. Place your tray on a flat surface. Choose which landfill material you will use and prepare enough to fill ¼ to ⅓ of the tray:
    a. Rice or beans will work dry right out of the bag or box.
    b. Sand is excellent, though not always easy to find.
    c. Cornmeal will make a great model shoreline, but takes more preparation, and you will need enough to empty and refill your tray, or make two trays to start. Boil anywhere from 2-4 cups of water. Once close to a rolling boil, stir in a ½ cup to 1 cup of cornmeal (depending on how many cups of water you used). Stir and let it thicken up. Once thickened up, have potholders handy to carefully transfer the mixture and cool it for about 30 minutes, with two options:
        i. Option 1. Transfer all the cornmeal to a storage container and place it in the refrigerator. Monitor as it cools so you can remove it when it's the consistency of clay.
        ii. Option 2. Divide the cornmeal by pouring it into two trays or into one tray and one storage container. In the tray, use utensils to push it into one side as described below. Place it all in the refrigerator and monitor as it cools so you can remove it when it's the consistency of clay.
2. Set the landfill material across one narrow end of the tray, about ¼ to ⅓ 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 ½ the height of your landfill.
4. Hold your bottle horizontally and place it in 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. Allow the up and down motion on the opposite side to generate waves that travel across the water to the shoreline, Change the frequency or force in moving the bottle up and down to create more or larger waves. Observe what happens to your shoreline as the severity of the wave action increases.

Procedures: Become an Ecological Engineer

5. Take a photo or video or record your observations of your first shoreline test in a notebook.
6. Rebuild the landfill to reset your tray. Remove the bottle. For rice, beans or sand, push them back into place on one end of the tray. For cornmeal, you may pour it out and start with new cornmeal.
7. 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.
Observe and record what happens to your newly protected shoreline as the severity of the wave action increases. 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. You can also try a version with the protective materials, such as shell reefs, placed a little away from the landfill, modeling offshore protections. The more tests the better!

Procedures: Become an Ecological Engineer

8. To conclude, sort your waterfront infrastructure materials into hardening protections (like a brick/seawall and rocks/riprap) or green infrastructure (like shell/reefs or sponges/marshland)

   a. *Which infrastructure materials protected your landfill the best?*
   b. *Which infrastructure materials bring co-benefits, meaning they're good for wildlife as well as for people?*
   c. *Which types of infrastructure would you like to live next to? Why?*
   d. *How do your results compare to any real world circumstances you've seen in the past?*

9. Clean up by rinsing everything before you put it away and fully washing any dishes or utensils that you also use for eating. Throw out wet beans, rice, or cornmeal, which is no longer good to eat.

Post-Activity Projects
Printable Student Worksheet

Research Waterfront Infrastructure in Your Community

Many kinds of research can help you understand what the waterfront in your community is like. Start by picking a waterfront area you've visited in the past, or would want to visit in the future.

1. Use your personal knowledge. Think about the last time you visited your waterfront, or look up pictures of the waterfront you'd like to visit. Pay attention to what's made of concrete, or what's natural. Draw a picture or make a list in the space below that identifies what is concrete or hard and what you see that is natural or green. In general, green natural surfaces help absorb any extra water, and are called permeable. On the other hand, hard concrete surfaces do not help manage water and are called impermeable. How would strong waves or heavy rain behave on this waterfront?

Post-Activity Projects

Printable Student Worksheet

Research Waterfront Infrastructure in Your Community

1. Speak with others. Ask your parents or any family members what they know about permeable surfaces and green infrastructure. Share your drawing or list. What could be done to have more permeable surfaces on this waterfront to help manage flood water?

2. Research on the internet. Sometimes it's not easy to see green infrastructure. Use the links below to learn more, and add new ideas about green infrastructure to your drawing or list.

Post-Activity Projects

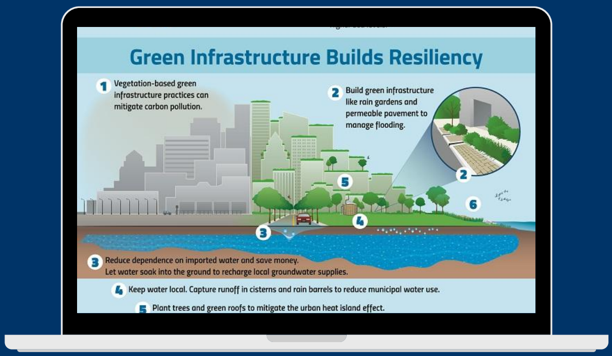
Printable Student Worksheet

Civic Engagement

1. Every neighborhood has representatives in government. You can advocate for a more sustainable waterfront by reaching out to contact your local government representative, either by calling them directly or by emailing them. Share your research from above, ask what's being done to help make your waterfront resilient, and ask if there are any projects being planned to help restore natural protections for the waterfront.

2. Think about what you have learned from your representative or from your research and write down examples of 3 things that you as an individual can do to help improve the condition of your local waterfront.

3. For grades 7-12: To learn more about the guidelines that communities around New York are using to revitalize their waterfronts, check out Waterfront Alliance's own WEDG ® (Waterfront Edge Design Guidelines).



Background for Educators

- NOAA's Green Infrastructure Animation
- NOAA's Providing Green Infrastructure for Coastal Resilience PowerPoint
- EPA's Green Infrastructure for Climate Resiliencey Infographic

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. Compare and compute 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 activity was adapted from Cary Institute of Ecosystem Studies, "Our Runoff"

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:

- The procedures below will guide you to make a map of the area around your home, school, or waterfront. 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 the built, paved, and natural areas. A paper map is easiest, though with enough digital expertise, there could be a way to complete the activity electronically. Read through these instructions then select the map materials you prefer.
- The procedures below will also guide you to make a grid overlay for your map. You can draw lines directly on the map with a marker and ruler, or lay or glue yarn across it, or use craft wax sticks. If a transparency sheet is available, you can use that to make the grid a separate layer. Kitchen plastic wrap is also an option for a transparent layer, though it can be hard to handle. Read through these instructions then select the grid materials you prefer.
- Pen or pencil
- Paper
- Ruler
- Crayons, markers, or colored pencils in several different colors. You will be
- color coding your map, so select colors that would be most readable. Permanent markers are especially good for writing on computer printouts, transparencies, or plastic.
- Optional: graph paper, calculator
- Optional for outdoor observations: tote bag, clipboard
- Pre-activity materials as described below

Vocabulary

- Ecosystem
- Green Infrastructure
- Permeable
- Impermeable
- Infiltrate
- Runoff
- Combined Sewer Overflows (CSOs)
- Tide
- Current
- Resilience
- Ecosystem Services

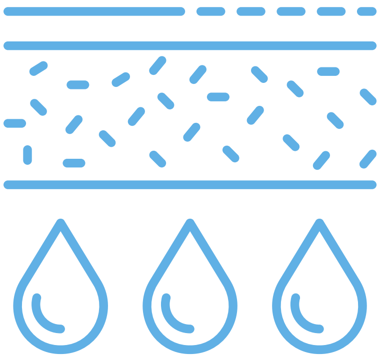
Pre-Activity Reading and Discussion

Reading

Take a look at how water moves through our urban environment with NYC H2O's Urban Water Cycle story map. 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.



Procedures: Neighborhood Water Budget

1. Prepare a base map
   a. Select your neighborhood area to study for the project. You can focus on the block of your home or school, on a few square blocks, or on a short length of waterfront. The activity will be considering features like gardens or driveways, so you'll want a small enough study area to be able to identify those on a map.
   b. Prepare a simple, outline map of your study area. You can print a map from the computer or draw your own. Show the street, buildings, park or landmarks that help orient you. Keep the color simple, we'll color code it later. Try to keep your study area in the center and try to fill the page out to the edges. Your map doesn't have to be perfect for this activity. But if you'd like to incorporate more mathematical thinking, use a ruler or graph paper, or create a scale, and go for it!
   c. Make a legend. Choose one color that will be used to mark permeable, or absorbing, surfaces on your map and a different color for impermeable, or not absorbing, surfaces. Make a legend for these colors on your map or on scrap paper. Feel free to use age appropriate vocabulary, and if you're not sure of these definitions, refer back to the pre activity discussion above.
2. Identify the surfaces in your study area.
   a. Make a list of all the types of surfaces that are rained on in your neighborhood, such as concrete, roofs, grass, dirt. For each one, indicate if it would be permeable or impermeable.
   b. Color the features on your map according to your legend and your observations of how those surfaces absorb water or not. If you can go outside, take your map to your study area to add details and color code it. If you can't go outside, color code your map from memory or from visuals on line. If you are using a transparency for your grid in the next step, you can also layer it on your map at this stage and color onto the transparency sheet instead.

Procedures: Neighborhood Water Budget

3. Make a grid overlay for your map that creates 10 small boxes across it. You can draw directly on your map or on a transparency to lay over your map.
    a. To hand sketch a simple grid, draw a line lengthwise to make two long halves. Draw four lines across that perpendicularly, evenly spaced, to create a 2x5 grid.
    b. To make an even grid, use your ruler to divide the short side of the paper or transparency into two and the long side of the paper into five. First use the ruler to make small marks along the edges of the paper; next use the ruler to make a straight line connecting your measurements.
    c. You can also glue yarn or apply wax craft sticks to your map to create the 2x5 grid.
4. Compute the amount of permeable or impermeable surfaces on your map. Look at the colors in each box of the grid, and assign a numeric value to them according to your legend of permeable or impermeable. Keep track by writing directly on your map or transparency or keep a list on scrap paper. Use the tips below to add up your estimate of how much of your study area is permeable and how much is impermeable.
    a. Applying basic math, each of the small grid boxes is worth 10 permeability points, making a total of 100 for your map. Estimate how much of each box is permeable or impermeable and assign points accordingly to each category, such as three permeable and seven impermeable. Add up the points and figure how to express them as the percentage of permeable or impermeable surface in your study area.
    b. Younger Students: With very young students, you can simply identify more or less permeability per box or in your map as a whole. Students can round up by the majority color in each box, and sum whole boxes that have been rounded, or can apply fractions.
    c. Older students: For higher level math, adapt examples from the Cary Institute of Ecosystem Studies' worksheet that incorporates precipitation calculations in the activity.

Procedures: Neighborhood Water Budget

5. Discuss your results and draw conclusions from your analysis. Read aloud or share the starter below, consider these questions, and read aloud or share the conclusion to help frame the discussion.

   a. *Discussion starter: "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."*

   b. *What do our maps show about impermeable surfaces in our area?*

   c. *What green infrastructure do we have?*

   d. *Discussion conclusion: "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.*

   e. *What green infrastructure could we add in our community?*

   f. *What additional benefits does green infrastructure bring to how you live, work, or play? Does it provide recreation, or benefits for wildlife?*

6. If you'd like, create a new map showing how and where you'd add green infrastructure in your community. Display everyone's maps together in a mural.

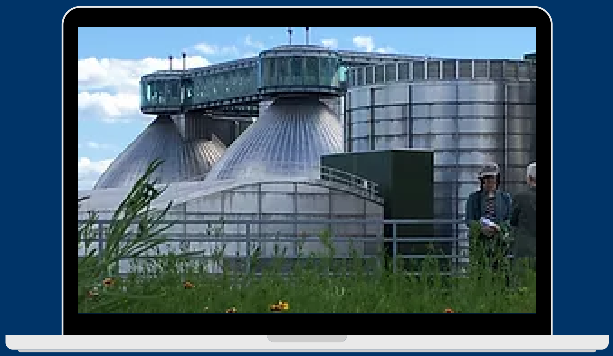
Post-Activity Discussion Questions

Printable Student Worksheet

1. What kind of green infrastructure can help communities?

2. Think about what you have learned from your representative or from your research and write down examples of 3 things that you as an individual can do to help improve the condition of your local waterfront.

3. To learn more about the guidelines that communities around New York are using to revitalize their waterfronts, check out Waterfront Alliance's own WEDG ® (Waterfront Edge Design Guidelines). Go to this link to pick the project that stands out most to you and explain why you chose it.



Background for Educators

- 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.

Activity 5:
Tallying Up Temperature Rise

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 student or children!

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 climate change

Key Questions

- How are people affecting the climate?
- Why is climate change important?
- 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

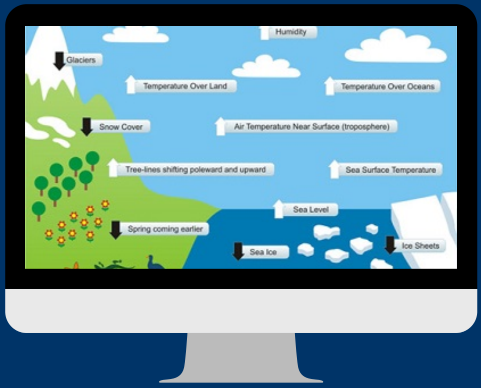
Use one set of materials

- 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?



Vocabulary

Climate Change

Sea-Level Rise

Temperature

Fahrenheit

Carbon

Fossil Fuels

Coastal Resilience

Hurricanes

Pre-Activity Reading and Discussion

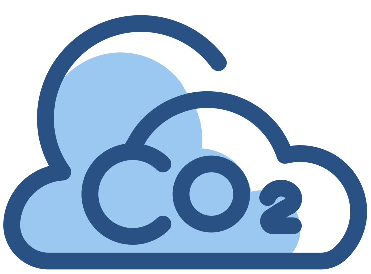
Reading

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 region

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 better help students comprehend the scale of the issue of climate change.



Procedures: Tallying Up Temperature Rise

1. Prepare the materials required for the game and split the 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 (temp rise, same, lower).
3. 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 chart. 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 in fact no carbon neutral activities and that all answers should be either positive or negative. This should become more apparent to students as the game progresses.
4. 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:

Procedures: Tallying Up Temperature Rise

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.

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 y-axis 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

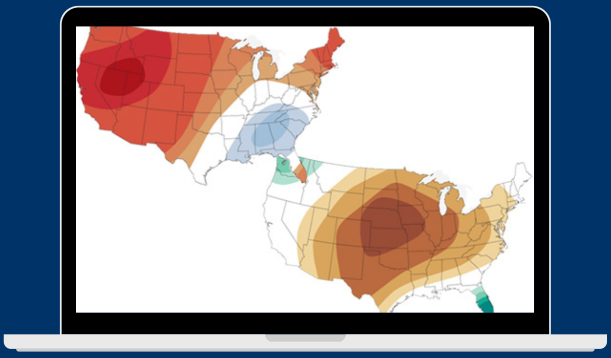
1. Climate change is not only affecting the temperature of the air, but also of our oceans. How do rising ocean temperatures impact the New York-New Jersey Harbor Estuary?

2. New York City, along with New Jersey and New York State, 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, by remote learning, 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 or children!

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:

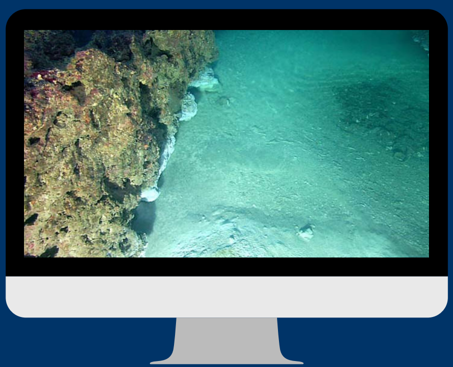
- Salt
- Scissors
- Lighter
- Modeling Clay (Or a hot glue gun)
- Tall Glass
- Small Metal Nails (Or anything small that can fit through the end of a straw that is heavy)

For the thermometer:

- Small Spray Bottle (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

Vocabulary

Salinity

Temperature

Thermometer

Hydrometer

Density

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

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

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. 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 correlation 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?**

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.

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, at least one with a rope
- Aquarium thermometer
- Aquarium hydrometer
- pH strip kit
- Small trash bag
- Student data sheets, clipboards, 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.

Sea-Level Rise baseline (2000-2004)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
2020s	+2 in.	+4-8 in.	+10 in.
2050s	+8 in.	+11-21 in.	+30 in.
2080s	+13 in.	+18-39 in.	+58 in.
2100	+15 in.	+22-50 in.	+75 in.

Pre-activity background reading and videos through these links

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

Vocabulary

Fahrenheit

Celsius

Percent

Salinity

Freshwater

Brackish Water

River

Ocean

Watershed

Borough

Local Government

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.

Procedures: Waterfront Field Lab - On the Waterfront Led by a Waterfront Alliance Environmental Educator

1. Introduction: placemaking 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. Conclusion: 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. Clean up: pH strips can be disposed of in the trash bag. After dismissing students, rinse all measuring tools with freshwater.

Post-Activity Discussion Questions

Printable Student Worksheet

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.

- Locate the City Council Member who represents your home or school
- Locate Congressional and State representatives
- Contact your local community board

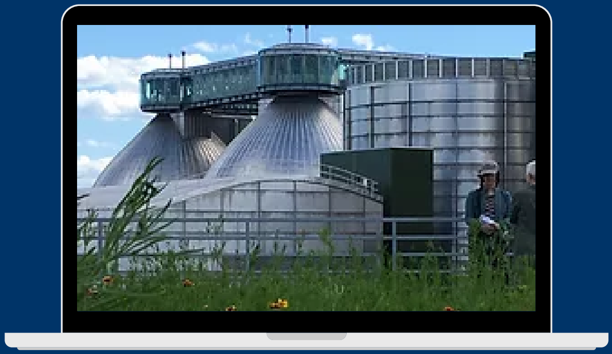
Post-Activity Discussion Questions

Printable Student Worksheet

1. What helpful services are provided by city government, particularly 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 city?



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

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.

Managing, Protecting, and Restoring Estuaries
Human Disturbances to Estuaries

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.

What You Can Do to Help Protect Our Coastal Watersheds and Estuaries
Do Your Part: Help Protect Our Estuaries
Ten Ways to Protect Estuaries

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 previous questions.

Answer Guide

The Mystery of the Disappearing Shells

1. How does acid get in the ocean?

Many human activities, such as using petroleum fuels, have led to increases of a gas called carbon dioxide on our planet, including in the ocean. The carbon dioxide makes the ocean more acidic, which is making it harder for marine creatures to build their shells.

NOAA's Graphic of the Reaction Behind Acidification
NOAA's Video on Ocean Acidification

2. Why does ocean acidification matter?

All living things are connected through sharing the ecosystem. One example of this is the food web, and if all shelled creatures can't survive in the ocean, we will eventually see a collapse of food webs and fewer fish for us to eat. Also, coral reefs and oyster reefs are constructed of calcium carbonate and serve as storm protectors for nearby islands and shores. If the reefs fail, more communities will have more severe damage from big storms. What other connections can you think of?

NEEF Big Picture on Ocean Acidification
Yale Climate Solutions Covering Ocean Acidification

Answer Guide

The Mystery of the Disappearing Shells

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

People around the world are using more renewable energy, which does not release carbon dioxide to impact the ocean. We can also build piers and waterfronts that are designed to improve the water environment called living docks, or living shorelines, including using special building materials that help balance the pH of the water.

NRDC Ways to Reduce Ocean Acidification
ECOncrete Innovations to Build Living Shorelines

Answer Guide

Become an Ecological Engineer

Research Waterfront Infrastructure in Your Community

1. Green, natural surfaces help absorb water and are permeable. Hard concrete surfaces do not help manage water and are called impermeable.

2. Think about which surfaces are permeable and impermeable.

3. Use links provided in Background for Educators as a starting point for research

Civic Engagement

1. Research local projects on your waterfront.

Contact Your New York City Council Member
Contact the Town Mayors of New Jersey

2. Examples of waterfront improvements that can be done individually include leading a trash pick up, participating in volunteer events that help plant or maintain green space around the waterfront and around street drains, informing your friends and family about waterfront issues in your community, etc.

Answer Guide

Neighborhood Water Budget

1. What additional kinds of green infrastructure can help communities?

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. If it's so great, why don't we have more green infrastructure already?

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

Answer Guide

Neighborhood Water Budget

3. How can we ask for more green infrastructure in our neighborhood?

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?

Waterfront Alliance's Waterfront Edge Design Guidelines Examples
Contact Your Community Board and See if They've Made a WEDG Pledge Resolution

Answer Guide

Tallying Up Temperature Rise

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?

Refer to NASA's What is Happening in the Oceans link provided. Answers could be along the lines of stronger hurricanes or rising sea-levels and marine life die off.

NASA's What is Happening in the Oceans

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

Refer to the NYSDEC Impacts of Climate Change in New York State. Acceptable answers could be, but are not limited to, warmer temperatures, more precipitation, or sea-level rise.

NYSDEC Impacts of Climate Change in New York State

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 is 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

Think not only about what the activities were, but what form of transportation you took to that activity, what you ate while you were doing it, etc.

Answer Guide

Water Quality Testing at Home

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

In general, the more salty the water is, the more dense it is. Colder water is also more dense then warmer water, In water bodies, colder and more salty water will slide to form a layer under warmer and less salty water. This layering happens in the real world, but the layers can also be mixed by currents and winds.

In your experiment, look for the changes in density by comparing the two glasses of water. Experiment with adding salt to both hot and cold water and notice the changes with your hydrometer. Refer to pre and post-activity links as well.

2. What effects do you think higher ocean temperatures will have on the New York-New Jersey Harbor Estuary in the next 50 years?

Think about effects on not only humans, but on the ecosystems of the harbor as well. More severe weather and fewer fish are among the consequences.

NOAA's Climate Change: Ocean Heat Content

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?

In New York City, the Department of Environmental Protection manages both the drinking water and sewer systems. At a higher level, the New York State Department of Environmental Conservation oversees these 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. Learn more about these agencies and efforts:
NYCDEP Resources for Educators
New York City Panel on Climate Change

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

This is a tricky question, as dozens of agencies shave 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. To discover who is specifically responsible for your local waterfront spaces, use the NYC OASIS online map. Note that is a sophisticated and date heavy application, which may respond slowly depending on your system. Zoom in to the property boundary level, click the area, then click the location report tab for specifics.

Oasis Online Map

Answer Guide

Waterfront Field Lab Lesson Plan

1. How can we ask for help or improvements for the waterfront in our city?

In addition to contacting the government, local organizations leading stewardship in our communities can be located on the New York City STEW-MAP. 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.

New York City STEW-MAP
New York City Department of City Planning Waterfront Access Map
Explorable Places

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 a colored scum on the surface

Borough: A town or district which is an administrative unit

Brackish Water: Slightly salty water, consisting of a mixture of river water and salt water

Combined Sewer Overflows (CSOs): The discharge from a combined sewer system that is caused by snowmelt or stormwater runoff

Calcium: The chemical element of atomic number 20

Carbon: The chemical element of atomic number 6; 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

Climate Change: A change in global or regional climate patterns attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels

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

Coral Reef: A ridge of rock in the sea formed by the growth and deposit of coral

Current: A body of water moving in a definite direction

Glossary

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

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

Estuary: A partially enclosed, coastal water body where freshwater from rivers and streams mixes with salt water from the ocean

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

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: Found in water not of the sea

Green Infrastructure: A resilient approach to managing wet weather events by working with nature and providing community benefits

Glossary

Groin: A low wall or sturdy barrier built out into the sea from a beach to check erosion and drifting

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

Hurricane: A storm with violent winds, in particular, a tropical cyclone formed in the Caribbean

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 landing stage or small pier at which boats can dock or be moored

Living Shoreline: A protected and stabilized shoreline that is made of natural materials such as plants, sand, or rock

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

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

Glossary

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

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

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

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

Resilience: The capacity to recover quickly from difficulties

Rip Rap: Loose stone used to form a foundation for a breakwater or other structure

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: An area of coastal grassland that is regularly flooded by seawater

Glossary

Sea-Level Rise: An increase in the level of the world's oceans due to the effects of climate change

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

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

Storm Surge: A rising of the sea as a result of atmospheric pressure changes and wind associated with a storm

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

Watershed: An area of ridge of land that separates waters flowing to two different rivers, basins, or seas

Wetland: Land consisting of marshes or swamps; Saturated land

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

WATERFRONT ALLIANCE