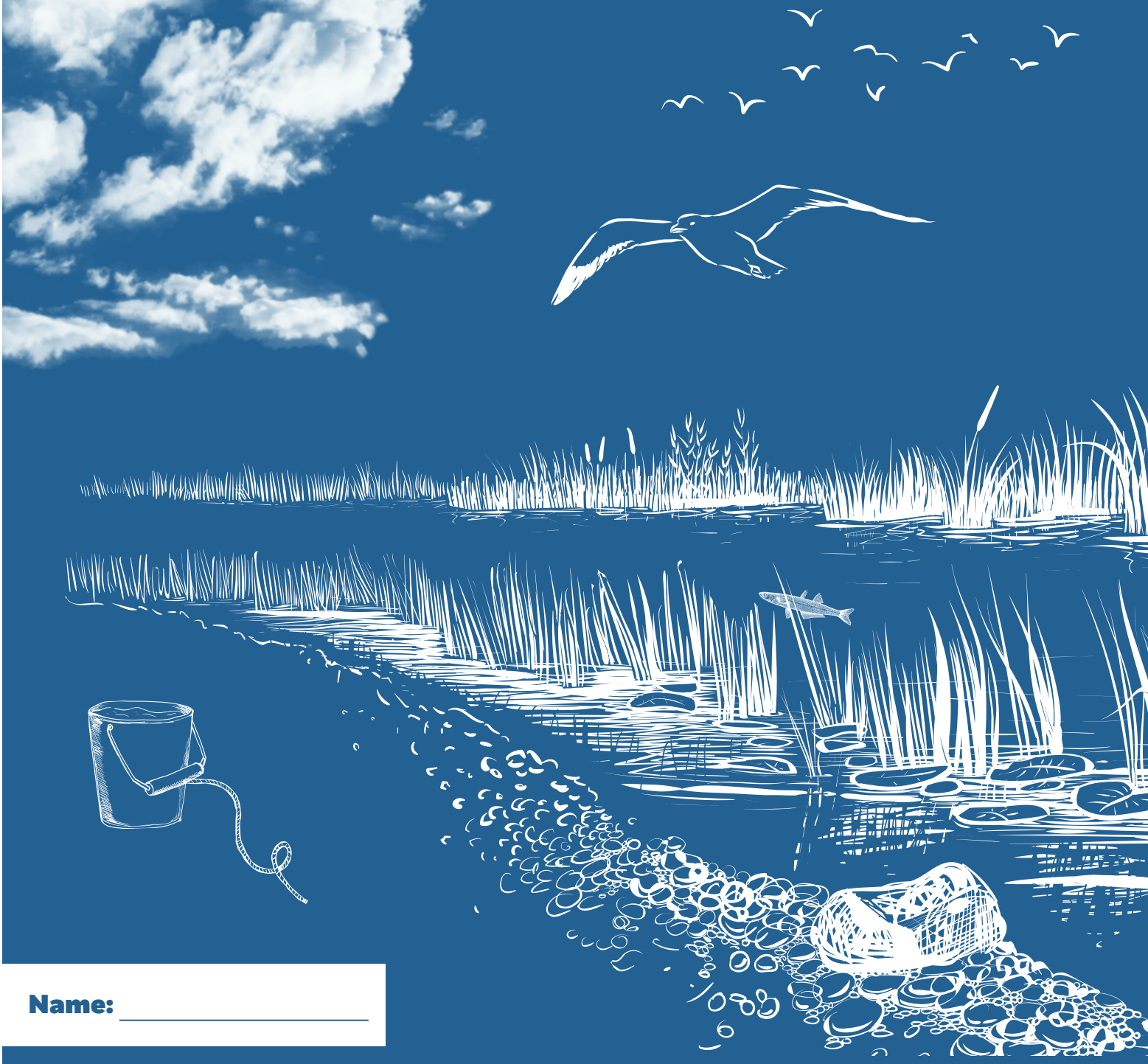
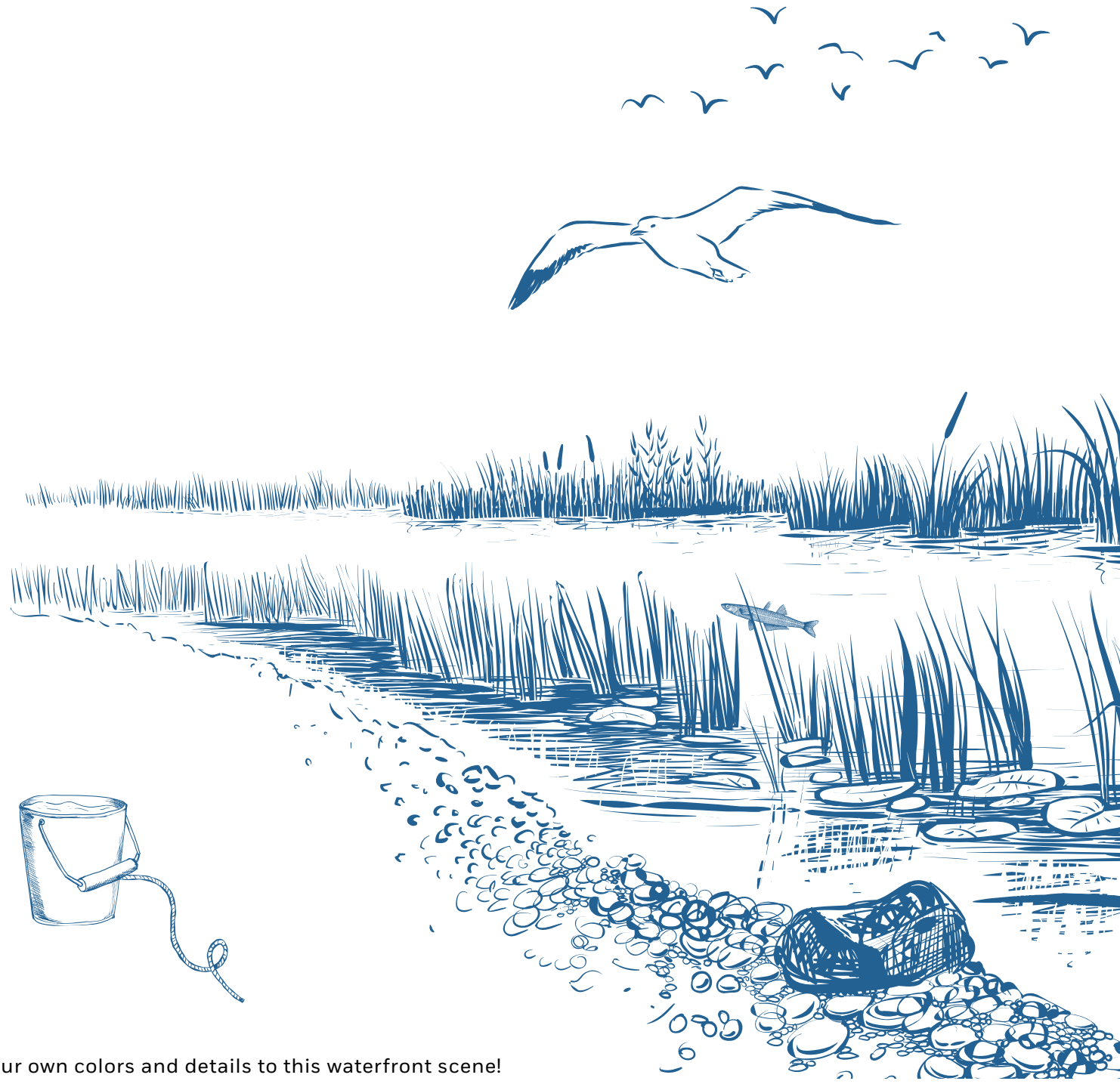
WATERFRONT ALLIANCE

ESTUARY EXPLORERS

Exploring Our Waterfront: Estuary Explorers Workbook



Name: _____



Add your own colors and details to this waterfront scene!

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Waterfront Alliance



Our Vision

The New York-New Jersey Harbor Estuary and the surrounding waterways should be a shared resource for all. We strive to create healthy, resilient, accessible, and equitable waterways that are alive with commerce and recreation, and reflect the vitality and diversity of the communities that surround them.

Estuary Explorers



Waterfront Alliance's premier climate change education programming is STEM-based and grounded in experiential learning at the waterfront. Through our hands-on field labs, multi-week residency programs, and teacher trainings, students and educators alike learn about the scientific method and how they can apply it to their classrooms and local shorelines.

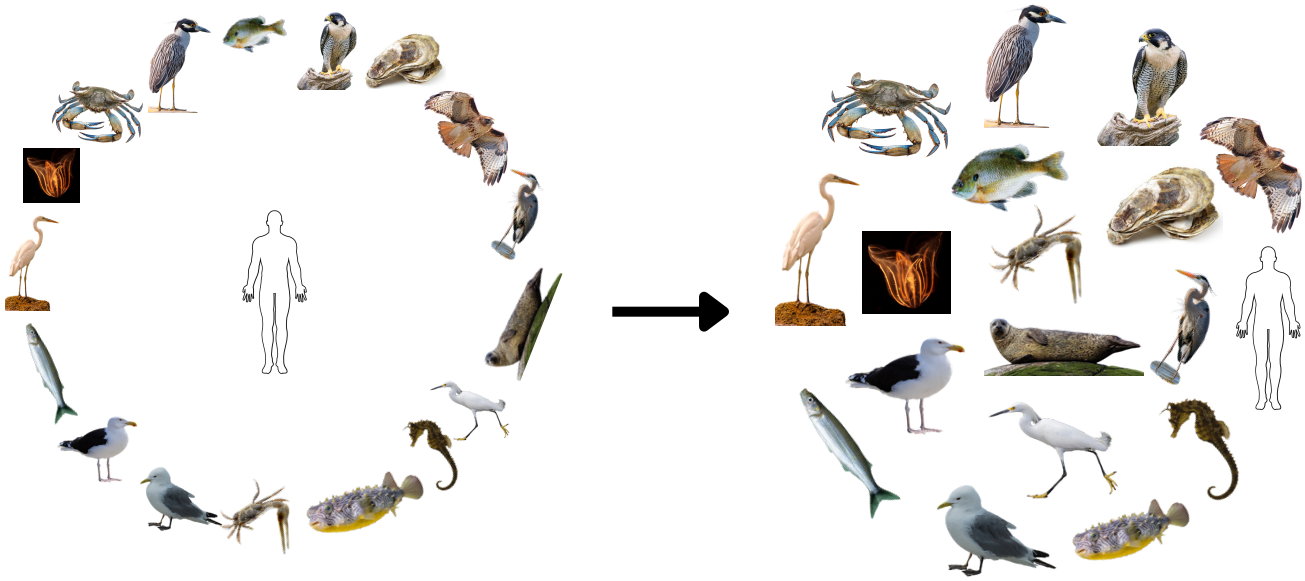
WATERFRONT ALLIANCE | ESTUARY EXPLORERS

Learn more about Estuary Explorers here:

#OurWaterfront @waterfrontalliance

The Story of Our Waterfront

Hello, Estuary Explorers! Let's take some time to learn about the area we call home here in the New York-New Jersey Harbor Estuary. The original people who lived around and used the waterfront of this region were the Lenape, whose name translates to "people." The area where we live now was referred to as Lenapehoking or the "region of the Lenape." Since the 1600's, there are and have been many different people from all over the world who have lived here on the land of the Lenape.



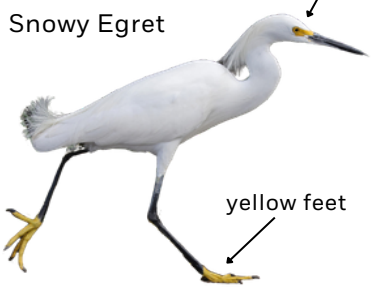
But are humans the only ones that live and rely on the waterfront? No! There are many different plants and animals that make our waterfront unique. Without each of these plants and animals, our shorelines would be a different place. Humans are not the only ones that add (or take away) value from our ecosystem; each living thing has an impact. Through this workbook, we hope that you are able to learn more about the history of our waterfront, what makes it unique today, and what is awaiting us in the future.

Think about a waterfront (a pier, park along the river, beach, etc.) that you live near. How do you feel about it? Is it a place you can access easily? Do you feel a connection to it?

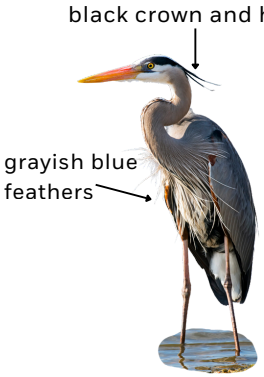
The Characters of Our Story: Birds

This region is home to many plant and animal species, including more than 200 types of fish, 19 kinds of rare birds and 140 rare plants [1]

Herons



Both male and female snowy egrets take turns incubating their eggs and taking care of their young when they hatch.



Birds have hollow bones, which make their bodies lighter so they can fly. Even though the Great Blue Heron is a large bird, it only weighs 5-6 pounds.



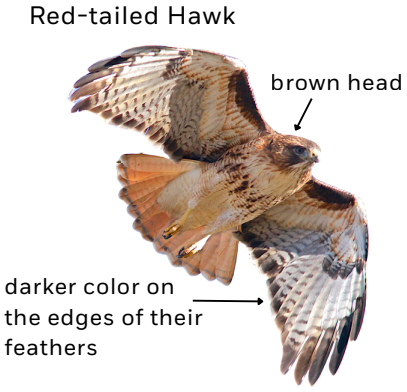
Great egrets hunt by standing still or wading through wetlands to catch fish with their sharp bills.



This herons main diet is crustaceans such as crabs and crayfish, which they hunt for both day and night.

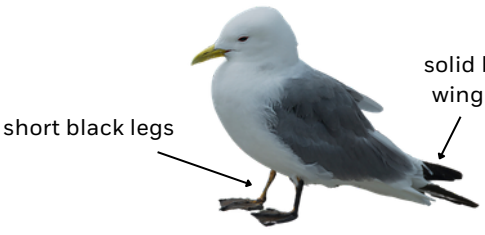


Peregrine falcons were almost eradicated by pesticide poisoning. While their populations have recovered overall, they are still an endangered species in NY State. [2]



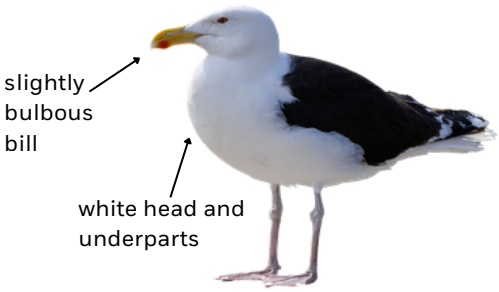
The most common hawk in North America. They have a unique, shrill cry.

Gulls



Black-legged Kittiwake

Kittiwakes are found in the oceans of the northern hemisphere, and spend their entire lives on the open ocean, only coming to land to nest.

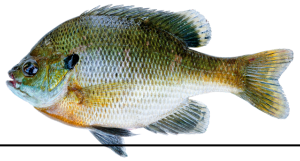


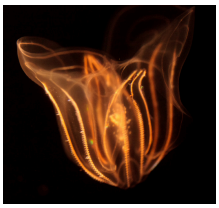
Great Black-backed Gull

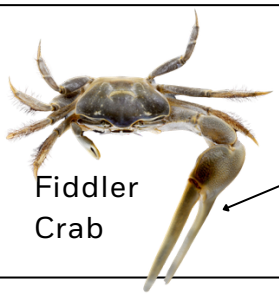
The “king” of the Atlantic waterfront, they are the largest gull in the world. In the 1800's they were threatened because their feathers were used in the fashion trade.

1. The Nature Conservancy https://www.nature.org/en-us/about-us/where-we-work/united-states/new-york/stories-in-new-york/eny-animals-of-the-hudson/
2. NYSDEC https://dec.ny.gov/nature/animals-fish-plants/peregrine-falcon
3. All About Birds https://www.allaboutbirds.org/news/

The Characters of Our Story: Marine Animals

	Rainbow Smelt [1]	Bluegill Sunfish [2]	Striped Burrfish [3]
			
temperature range	-1.8°~20°C (28.8°~68°F)	18°~26.7°C (65-80°F)	22°~25°C (71.6-77°F)
salinity range	anadromous (they spend portions of their life in both fresh and salt water)	mostly live in freshwater but can tolerate salinity up to 18 ppt	7-47 ppt
pH range	greater than 6	6.5-8.5	8.1-8.4

	 Eastern Oyster [4][5]	 Comb Jelly [6][7]	Lined Seahorse  [8]
temperature range	20°~30°C (68-86°F)	0°~32°C (32°-89.6°F)	22°~25°C (71.6-77°F)
salinity range	15-30 ppt	around 30 ppt	26~33 ppt
pH range	6.75-8.75	8.1-8.4	8.1-8.4

	 Blue Crab [9]	 Fiddler Crab [10]
temperature range	15°~33°C (59-91°F)	23.3°~26.7°C (74-80°F)
salinity range	3-15 ppt	6.6-15.9 ppt
pH range	6-8	8-8.3

Male fiddler crabs have one claw that is much larger than the other, which makes them look like they're playing a fiddle!)



Harbor Seal [11]



Harbor seals are one of the most common marine mammals that live on the east coast, often spotted in this "banana-like" position. They can live in either freshwater or saltwater.

So FUN FACT

Crustaceans are animals that have a hard exoskeleton (outer shell) such as crabs, lobsters, crayfish, and shrimp. Mollusks are soft-bodied animals, some which are protected by a hard outer shell. Snails, slugs, clams, mussels, oysters, squids, and octopus are all mollusks. Shellfish is a term some people use to refer to a group of animals including crustaceans and mollusks.

1. https://nas.er.usgs.gov/queries/factsheet.aspxSpeciesID=796#:~:text=Native%20Range%3A%20Atlantic%20drainages%20from,to%20Vancouver%20Island%2C%20British%20Columbia.
2. https://dnr.maryland.gov/ccs/Documents/education/Biology-of-Bluegill.pdf
3. https://sta.uwi.edu/fst/lifesciences/sites/default/files/lifesciences/documents/ogatt/Chilomycterus_schoepfii%20-%20Striped%20Burrfish.pdf
4. https://coastal.la.gov/wp-content/uploads/2017/04/Attachment-C3-12_FINAL_02.20.2019.pdf
5. https://spo.nmfs.noaa.gov/sites/default/files/TMSPO88.pdf
6. https://narrowriver.org/ctenophora/
7. https://www.aquariumkeeping.co.uk/blogs/reef-keeping/ctenophores-the-comb-jelly-wonders
8. https://www.algaebarn.com/blog/captive-bred-fish/bizarre-and-beautiful-the-lined-seahorse-hippocampus-erectus/
9. https://www.vims.edu/cbnerr/_docs/education_docs/StakeholderMeetingPart2.pdf
10. https://www.aquariumsource.com/fiddler-crab/, https://aquaticsunlimited.com/fiddler-crab-guide/#:~:text=As%20mentioned%20above%2C%20fiddler%20crabs,salinity%20between%201.005%20and%201.012.
11. https://www.fisheries.noaa.gov/species/harbor-seal

The Characters of Our Story: Plants



Hudson River Water Nymph

The only place in the world where you can find this plant is in the shallow waters of the lower Hudson River. It is categorized as an endangered species by NY State. [1]



Salt Marsh Grass (Smooth Cordgrass)

Densely growing plants that can be seen on shorelines and in coastal wetlands. It can live in waters with a salinity range of 8-33 ppt, and a pH range of 3.7-7.9. [2]



Water Celery

Native to Eastern North America, this plant has long ribbon-like leaves that stay underwater to provide shelter and nutrients for aquatic life. [3]



Saltmeadow Cordgrass (Salt Marsh Hay)

This plant is used to protect shorelines and to stabilize loose sand. It grows in salty and brackish waters. It also provides food and cover for different animals. [4]

An invasive species is a species that is not native to the region, that can often grow and spread very quickly. Invasive species can be harmful because they can change the habitat itself, harm other species, and affect the overall health of the habitat. [5]



Asian Shore Crab

Asian shore crabs eat invertebrates such as blue mussels, snails, barnacles, as well as algae. They also compete with native species for shelter and food.

1. NYNHP https://guides.nynhp.org/hudson-river-water-nymph/
2. https://www.nrcs.usda.gov/plantmaterials/njpmcpg13933.pdf
3. https://www.caryinstitute.org/sites/default/files/public/downloads/lesson-plans/water_celery_2-2_0.pdf
4. https://plants.usda.gov/DocumentLibrary/factsheet/pdf/fs_sppa.pdf
5. https://dec.ny.gov/nature/invasive-species

Activity: Find that Flora and Fauna!



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Black-legged Kittiwake	Blue Crab	Bluegill Sunfish
Comb Jelly	Eastern Oyster	Fiddler Crab
Great Black-backed Gull	Great Blue Heron	Great Egret
Harbor Seal	Hudson River Water Nymph	Lined Seahorse
Peregrine Falcon	Rainbow Smelt	Red-tailed Hawk
Salt Marsh Grass	Salt Marsh Hay	Snowy Egret
Striped Burrfish	Water Celery	Yellow-crowned Night Heron

What is a Waterfront? - Seawall and Riprap

A waterfront is where land meets water! There are many different types of waterfronts, each with unique characteristics that provide pros and cons for the area. Next time you are near a body of water, check to see what kind of waterfront it has!

Seawall



A seawall, or bulkhead, is a solid, vertical structure used to make the land more stable, to stop it from sliding into the water. It protects the land from heavy waves, and in places with smaller waves, it separates the land from the water.

Seawalls can be made from many different materials such as:



Gabions



Metal Sheets



Concrete Blocks

Riprap



Riprap is a layer of large stones used to protect soil from erosion in areas of concentrated runoff. Riprap can also be used on slopes that are unstable as a result of seepage problems.

What is Erosion?
Erosion is when natural forces such as wind or water cause land to wear away over time, similar to how a cookie will crumble if you leave it in milk for too long!

While they can be helpful, sea level rise may mean that seawalls that already exist will not remain effective.

What is a Waterfront? - Beaches



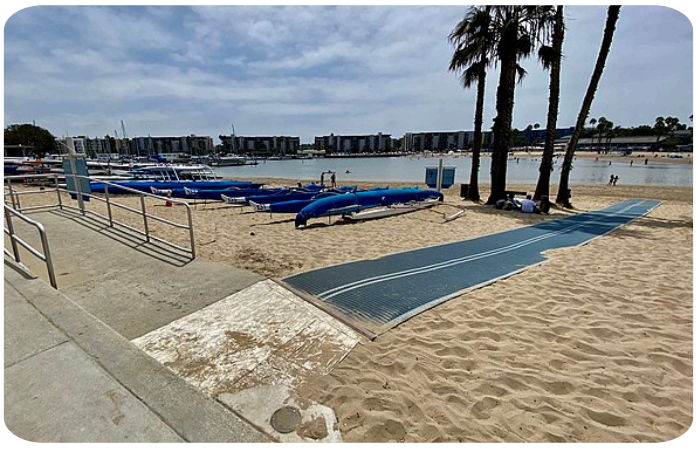
A beach is a natural shoreline that extends towards land from a low water line to where there is a marked change in the landform and vegetation.

A get-down is a structure that provides direct access to the water's edge and allows people to enter or touch the water.



Beaches and get-downs make it possible for people to access and interact with the water in a safe way. Being able to touch and enter the water can help improve our mental health, and encourage us to form a sense of stewardship, or a feeling of responsibility to take care of the waterfront. Beaches and get-downs also provide us with many different activities and learning experiences such as fishing, launching boats, observing wildlife, and swimming!

Accessible waterfronts are important for any community that lives near water. What are some ways that you can act as a steward for your communities waterfront?



Beaches are for everyone, and there are many ways to make beaches more accessible for all. For example, by adding ramps that lead onto beaches, and laying beach mats in the sand that lead to the water, wheelchair users can enjoy the waterfront too!

What is a Waterfront? - Wetlands

Wetlands are areas where the land is either covered in water all year round or during different times of the year. Wetlands are one of the most productive ecosystems and are home to many different plants and animals. Coastal wetlands are especially valuable because they protect inland areas from floods, prevent erosion of coastlines, filter chemicals and sediment out of the water, and have the ability to absorb and store carbon. Here are some different types of wetlands:



Swamp

Swamps are wetlands that are dominated by woody plants. Swamps have nutrient-rich soil, and because of this, many swamps have been cleared for agriculture and other development.



Fen

Fens get their nutrients from surrounding soil or groundwater. Fens are less acidic and have higher nutrient levels than bogs, which means they can support more biodiversity.



Bog

Bogs have spongy peat (partially decomposed organic material) deposits, acidic waters, and are covered by moss. Bogs reduce flooding in downstream areas by absorbing precipitation.



Marsh

Marshes are wetlands that are always flooded with water, and special plants that can survive in these conditions. Marshes control waterflow by providing water to streams.

← Find out more about wetlands in our region here.

https://www.epa.gov/wetlands/what-wetland

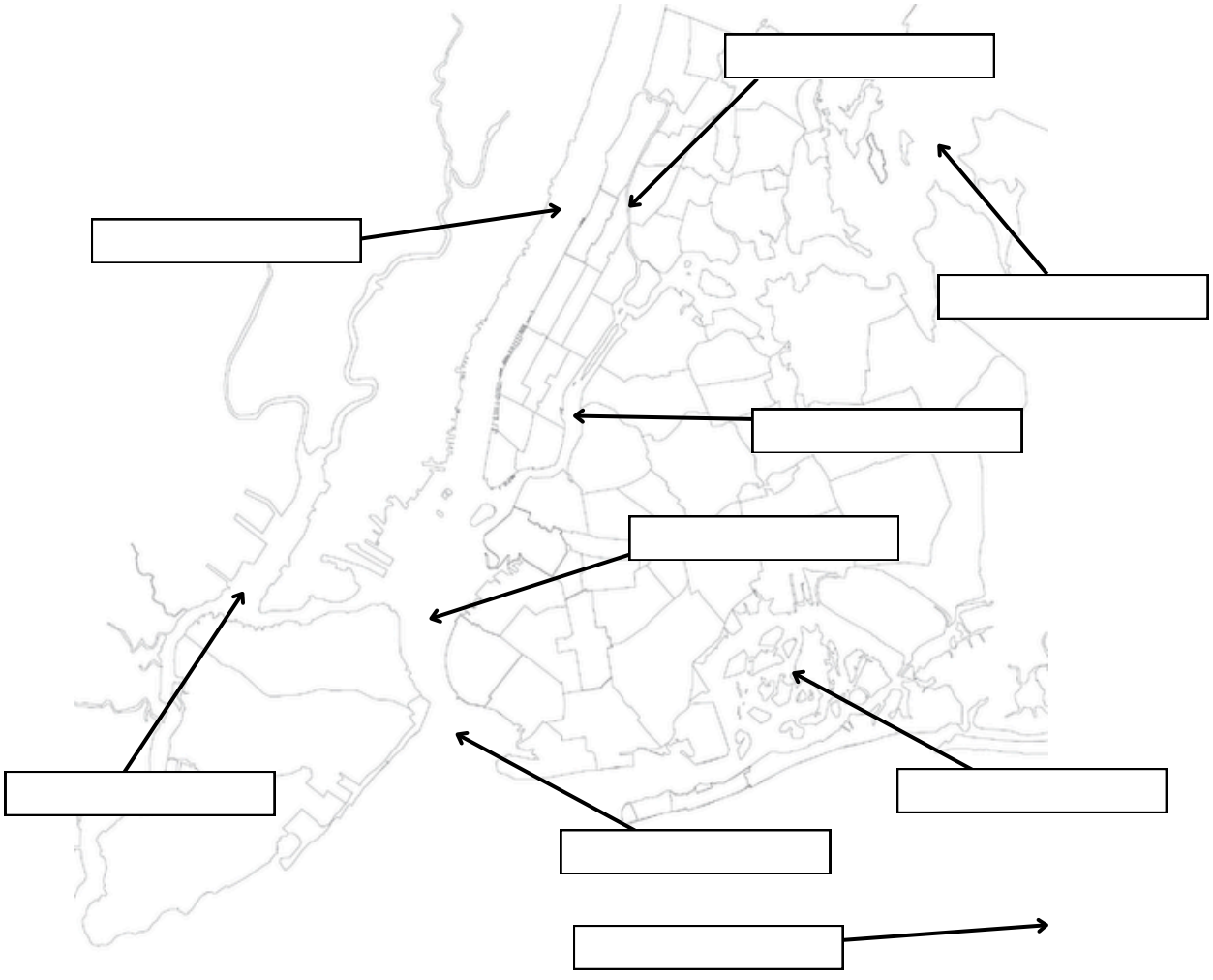
What is an Estuary?



An estuary is the area where a river meets the ocean! Estuaries are unique because they have a mixture of fresh water from a river and saltwater from the ocean. This mixed water is called brackish water. Estuaries are unique because they are the only type of environment that contain a diverse ecosystem of both freshwater and saltwater fish.

We live in one of the largest naturally occurring harbor estuaries in the world, the New York-New Jersey Harbor Estuary. This area has many rivers, streams, bays, inlets, coves, and tidal straights.

Do you know the major bodies of water around you?
Fill in the blanks with the bodies of water below:
Hudson River, East River, Harlem River, Atlantic Ocean, Long Island Sound
Upper New York Bay, Lower New York Bay, Newark Bay, Jamaica Bay



SO FUN FACT

Did you know that the East River and the Harlem River are not actually rivers? They are tidal straits, which are narrower passageways that connect two larger bodies of water. On the other hand, the Hudson River (actually a river!) flows from a source (the Adirondack Mountains) all the way out into the Atlantic Ocean.

The History of the Harbor

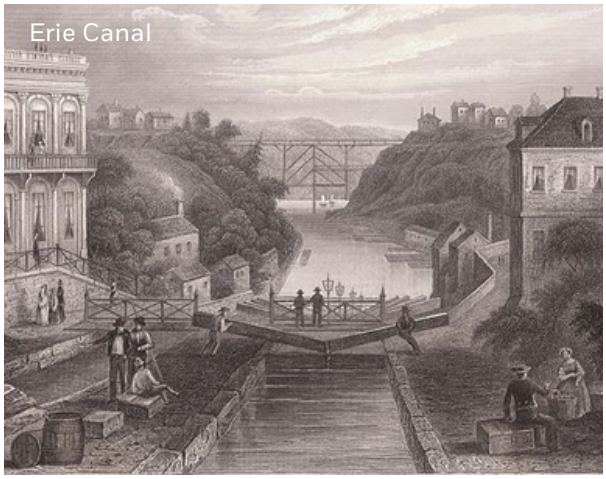


The Hudson River was originally known as the Shatemuc, or the “river that flows both ways,” by the Lenape. It is now called the Hudson River, after Henry Hudson, an Englishman who sailed his ship up the river in 1609.[2] In the 1620's, people from Europe such as the Dutch and the English began to colonize this area.



During the American Revolution, George Washington called the Hudson River the “Key of America,” because of its ability to connect people from the Atlantic Ocean all the way to the Great Lakes and Canada.[3]

The Fulton Fish Market opened in 1807, and until it moved to the Bronx in 2005, it served as an important center for selling and buying seafood.[4]



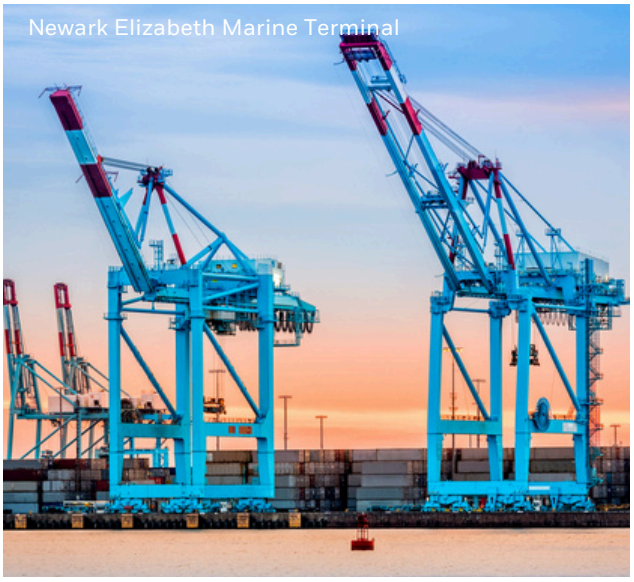
In 1825, the Erie Canal opened, making it easier to transport goods from the Hudson River to the West. The waterfront was dominated by commercial activities, but in 1897, the first recreational pier was created at Corlear’s Hook in Manhattan. It was a place where people could gather to eat food and enjoy music.[5] In the late 19th century, animals grazing on the coast of NJ would be loaded onto barges and sent to the Meatpacking District to be slaughtered and sold at meat markets. [6]

1. https://www.riverkeeper.org/hudson-river/history/
2. https://ospi.k12.wa.us/sites/default/files/2023-10/manahatta_to_manhattan.pdf
3. https://www.amrevmuseum.org/virtualexhibits/among-his-troops/pages/continental-army-along-the-hudson#:~:text=During%20the%20Revolutionary%20War%2C%20Americans,miles%20from%20New%20York%20City.
4. https://www.marinersmuseum.org/2023/03/fulton-fish-market-a-new-york-city-maritime-landmark/
5. https://www.archives.nyc/blog/2020/7/24/new-yorks-working-waterfront
6. https://hudsonriverpark.org/the-park/waterfront-transformation/history-of-hudson-river-park/

The History of the Waterfront


East River Drive

In 1929, construction for the East River Drive began, and by the 1950s, four of the five Boroughs had multi-lane arterial highways.[1]


Newark Elizabeth Marine Terminal

In the 1960's, the commercial cargo industry moved over to the NJ side of the Hudson River which had more space to accommodate new technology that was needed to handle containerized shipments. [1] During this time, manufacturing began to decline in NYC and more office buildings were built.


Ellis Island

However, the history of the region can still be seen today. The harbor continues to be a major gateway for immigration and continues to play a big role in commerce and industry. Many of the things you own, eat, and use may have been shipped here on a cargo ship that passed through the harbor. The Port of NY and NJ supported over 560,000 jobs in 2022! [3]

As you will see on the next few pages, our waterfront has also changed and improved in many ways. We have more parks and green spaces so that more people can access the waterfronts to enjoy activities such as fishing, boating, and observing wildlife.


Lower Manhattan Coast

Ferries used to be the main way for people and goods to get around New York City! Over the past few years, we've seen new ferries and boats like the NYC Ferry start reconnecting people with these modes of transportation. How is it beneficial to the city that we use ferries for getting around?

1. NYC Department of Records and Information Services https://www.archives.nyc/blog/2020/7/24/new-yorks-working-waterfront
2. Statue of Liberty & Ellis Island https://www.statueofliberty.org/ellis-island/overview-history/
3. North Jersey Transportation Planning Authority https://www.njtpa.org/Newsroom/NJTPA-News/NJPTA-Update-Blog/2023/June-2023/Port-of-New-York-and-New-Jersey-Remains-the-Larges.aspx#:~:text=Tax%20Revenue%20Print-,Port%20of%20New%20York%20and%20New%20Jersey%20Supports%20Over%20563%2C000,%2415.7B%20in%20Tax%20Revenue

The Waterfront: Then and Now

wiki



South Street Seaport served as an important commercial hub after the Fulton Fish Market opened in the 19th century. Some of the historic buildings have been preserved and can still be seen today. The Seaport has rebuilt itself after the September 11th attacks in 2001 and Hurricane Sandy in 2012, and today people gather there to enjoy restaurants, shops, and views of the East River.



The Waterfront: Then and Now

NYPL



As mentioned on the previous page, South Street Seaport played an important role as a hub for various ships. Some of those ships can still be seen today at the Seaport. The 1908 Lightship Ambrose guided mariners to the Port of NY during the largest period of immigration in US history. The 1885 Tall Ship Wavertree was used to travel around the world to transport cargo.



https://theseaport.nyc/history/

Credit: Zane Elias

The Waterfront: Then and Now



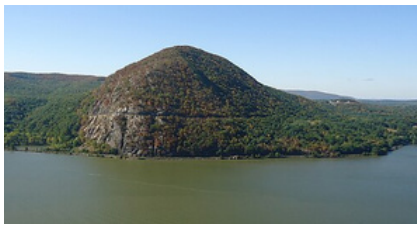
Since 1910 when it opened, Chelsea Piers served as the city's premier passenger ship terminal. It is where the Titanic was scheduled to arrive in 1912. It also served as the location where soldiers departed from during WWI and WWII, and later as a cargo terminal in the early 1960's. Since then it has been transformed into a world-class sports and entertainment complex where people can come together to enjoy a variety of activities and events.



http://dev-mura.chelseapiers.com/company/history/

The History of the Water: Pollution vs. Protection

1800's: After the Erie Canal was built, NYC continued to grow, and trade along the Hudson River increased. During this time, untreated sewage and industrial waste were dumped into the river.



1947-1977

General Electric (GE), a power company, released over 1 million pounds of PCBs (toxic chemicals used in many products before 1980) into the Hudson River.

1965

ConEd, a power company, planned to pump water into Storm King Mountain for power generation. People came together to protect the scenery and threatened fish species of the area. This case proved that citizens could take legal action to protect the environment.

1970

The National Environmental Policy Act (NEPA) was enacted. NEPA helps to protect the environment by requiring federal agencies to assess the potential environmental impacts of proposed projects.

1972

A law called the Clean Water Act (CWA) was passed, making it illegal to pollute waterways without permits. CWA also helps to protect wetlands.

1986

The North River sewage treatment plant began operating in Manhattan. Before then, 568 million liters (150 million gallons) of raw sewage was contaminating the river each day. Once the plant began operating, bacteria concentrations dropped significantly.

2002

The Environmental Protection Agency (EPA) settled on a cleanup plan with GE to remove PCBs (dumped in the 40's-70's) from the Hudson River

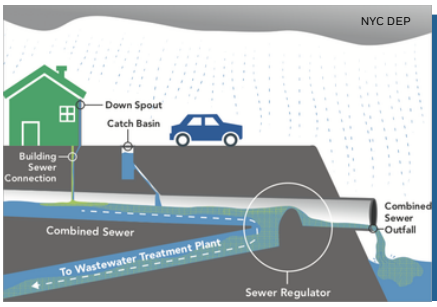
2009

The removal of PCBs began, and after six years, 150 tons of PCBs were removed from a 40-mile stretch of the Hudson River.

2012

NY State signed an agreement to develop long-term control plans to deal with CSOs, to reduce CSO discharges into NYC waters by 32 billion liters (8.4 billion gallons) a year.

After all of these efforts to protect the environment, water quality began to improve. And as conditions improved, many animal and plant species returned to the area. In recent years, 222 species of fish have been recorded in the Hudson and its watershed. Most industries and municipalities have stopped directly polluting our waterfront. People began to recognize the benefits of having healthy waterways, and now it is treated with more respect.

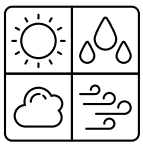


FUN FACT

60% of NYC relies on a combined sewer system; a single pipe that carries both stormwater runoff and sewage from buildings. During heavy storms, treatment plants are unable to handle the increased flow, so a mixture of stormwater and untreated sewage is discharged directly into waterways. These events are called combined sewer overflows (CSOs).

Hudson River Valley Institute https://www.hudsonrivervalley.org/corridor-of-commerce#:~:text=Business%20such%20as%20ice%20harvesting,and%20brewing%20dominated%20the%201800s.
Scenic Hudson https://www.scenichudson.org/viewfinder/celebrating-the-scenic-hudson-decision/
DEP https://www.nyc.gov/site/dep/water/combined-sewer-overflows.page

Climate Change



Weather is what is happening outside today. Is it sunny, rainy, cold, etc.? Climate is the weather of a region, over a long period (30 years+) of time.

Climate change is the long-term change in the average weather patterns that we can see on a local, regional, and global scale caused by the rapid emission of greenhouse gases due to human activities. We can see the effects of climate change through land and ocean temperature increases, sea level rise, and an increase in frequency and severity of extreme weather events such as hurricanes, heatwaves, wildfires, droughts, and floods.



Compared to the countryside, the urban area where we live has less greenery, and much more concrete and buildings. This contributes to more intense heat waves and floods in cities.

Heat waves are more intense in cities, often referred to as the Heat Island Effect. This happens because dark colors (streets and rooftops of buildings) absorb heat, and there are less plants, which have the natural ability to cool the temperature around them through a process called transpiration. If you've been to a park with lots of plants on a hot day, you can probably recall how it felt much cooler than it does outside of the park.

Here is some data that shows how climate change impacts temperature:

- Since 1900, the average annual temperature in Central Park has increased at a rate of 0.17°C (32.3°F) per decade, or a total of 1.9°C (35.4°F).
- Scientists predict that:
  - average annual temperatures will increase 2.3~3.2°C (4.1~5.7°F) by the 2050s
  - heat waves will triple by the 2080s from two to six per year
  - hot days above 32.2°C (90°F) will triple by the 2050s from 18 to 57 days

NY NJ

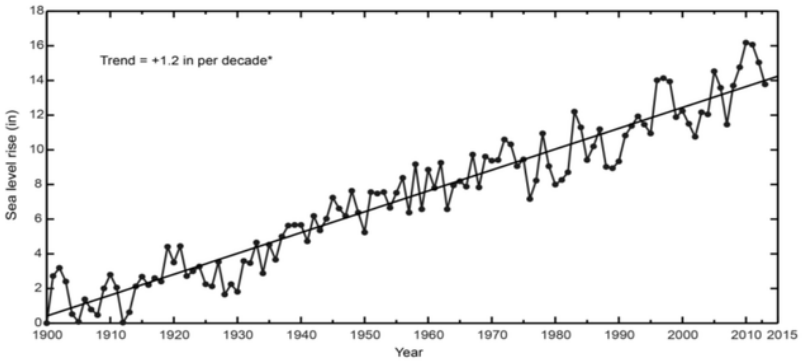
Cooling centers are indoor spaces that have air-conditioning, which can offer relief during heat waves. Use the QR Code on the left to check where cooling centers near you are.

The cooling center closest to where I live is: _____

https://climatekids.nasa.gov/menu/weather-and-climate/
https://www.nyc.gov/assets/dep/downloads/pdf/environment/education/climate-change-introduction-presentation.pdf

Climate Change

NPCC, 2019



Sea level rise in New York City has averaged 3 cm (1.2 in) per decade, or a total of 33.5 cm (1.1 ft) since 1900, almost twice the observed global rate. Sea level is expected to rise 27.9~53.3 cm (11-21 in) by the 2050s. [1]

Coastal New Jersey has experienced 45.7 cm (18 in) of sea level rise since the early 1900s, more than twice the global mean of about 20.3 cm (8 in). [2]

The Hudson River is at sea level, which means it is also being affected by sea level rise. In Manhattan, the river has risen 48.8 cm (1.6 ft) since 1850.

Average annual precipitation has increased by up to 2 cm (0.8 in) per decade since 1900, or a total of 20.3 cm (8 in). As climate change progresses, heavy rainfall events, or cloudbursts, will become more common, which will flood public transportation networks, overwhelm sewer systems, and affect harbor water quality. [1]



Flooding [3][4]



A 100-year flood, or a 1 is a flood that is so severe that it only has a 1% chance of occurring in any given year (100-year flood plains can occur more than once every 100 years however!). It is also called a 1% annual chance flood.

Similarly, a 500-year flood is a flood that has a 0.2% chance of occurring in any given year, and is also called a 0.2% annual chance flood. An area that has a 1% (or 0.2%) chance of flooding in any given year is called a 1% (or 0.2%) annual chance floodplain.

It is estimated that in New York City, a 1% annual chance flood could affect up to 400,000 people and 72,000 buildings. Major storms will also occur more frequently, meaning that the type of storm that has a 1% annual chance of occurring will have nearly a 3% annual chance of occurring in the 2050s.

1. https://www.nyc.gov/assets/dep/downloads/pdf/environment/education/climate-change-introduction-presentation.pdf
2. https://njclimateresourcecenter.rutgers.edu/climate_change_101/sea-level-rise-in-new-jersey-projections-and-impacts/
3. https://www.usgs.gov/special-topics/water-science-school/science/100-year-flood
4. https://www.nyc.gov/assets/planning/download/pdf/plans-studies/climate-resiliency/flood-risk-nyc-info-brief.pdf

Activity: Thinking about Heat Waves and Floods

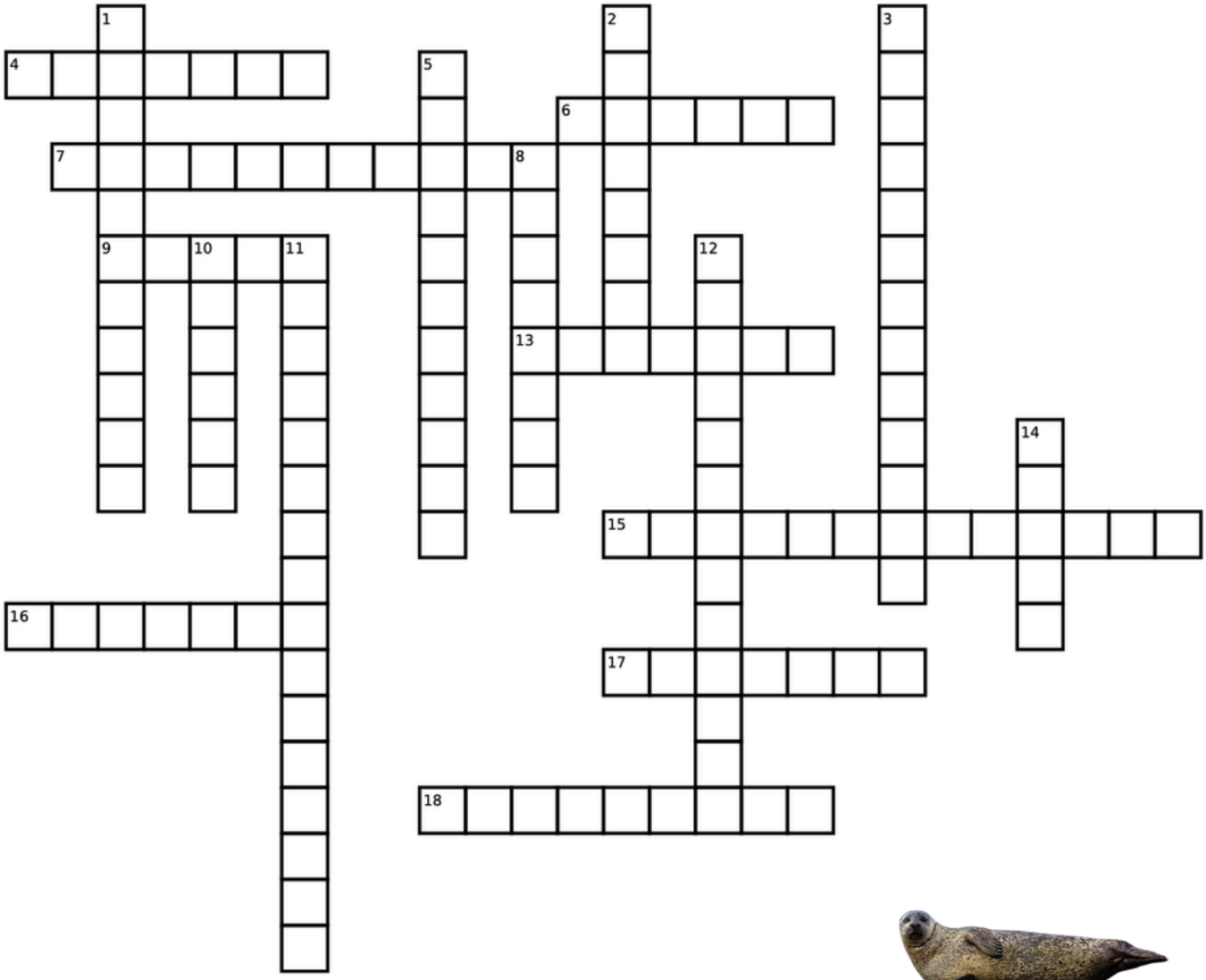
What was the most memorable or surprising thing that you learned so far? What are some things that you would like to learn more about?

How will climate change, especially heat waves and floods, affect the area where you live, or go to school? Think about how it will affect your community as well as the overall ecosystem.

What can you do to prepare for an extreme weather event such as a flood or a heat wave? Talk to your friends and family about how you can keep each other safe.

Activity: Crossword Puzzle

Let's review some of the words and concepts you've learned so far. Feel free to flip back through the pages to jog your memory!



Down:

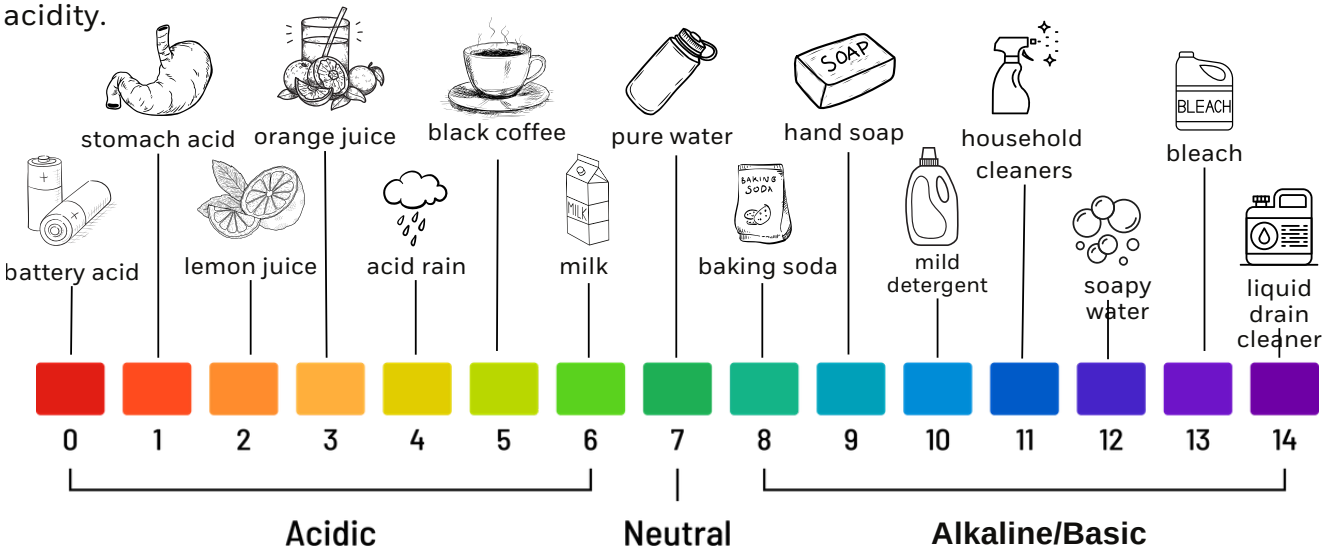
1. Not actually a river!
2. Laying one on the sand can improve accessibility to the water
3. Where you can go to avoid a heat wave
5. Burning these is a leading cause of climate change
8. This means "river that flows both ways"
10. A layer of stones that prevents erosion
11. This causes heat to be more intense in urban areas
12. This allows plants to cool the temperature around them
14. A wetland with lots of woody plants

Across:

4. A solid structure used to make land more stable
6. A cage filled with rocks or concrete to create a seawall
7. Heavy rainfall events
9. A wetland that is constantly flooded
13. The area where a river meets the ocean
15. A long-term change in weather patterns
16. When land wears away over time
17. It provides direct access to the water
18. When this was built, it made the transportation of goods to the West easier

Water Quality: the pH Scale

The pH scale measures how acidic or basic/alkaline something is. pH stands for potential of hydrogen. The more hydrogen ions a substance has, the lower its pH and the greater its acidity.





Water continuously circulates from the ocean to the atmosphere, to the land, and back to the ocean. This is called the water cycle. Air pollution and runoff add carbon dioxide and other harmful chemicals into this cycle, which leads to ocean acidification. When the ocean becomes more acidic, it affects the plants and animals that live there. For example, more acidic water makes it difficult for shell-building animals such as mussels, clams, urchins and starfish to grow. [1]

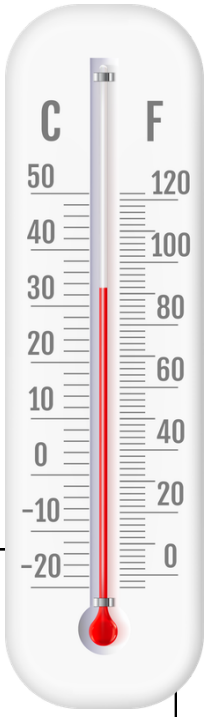
If the NY-NJ harbor estuary becomes more acidic, how will that affect each of the animals on page 5?

How is wastewater treated? [2]

There are 14 facilities that help to treat, or clean, wastewater so it can be released safely into the waterways around New York City. This is done through a number of steps. First big objects like twigs, leaves, and litter are removed. Next, lighter solid material floating at the top, and the heavy sludge at the bottom are removed. Air is then added into the water, to create a healthy environment for microorganisms that help consume organic materials in the water. After that, the water is disinfected, to remove any microorganisms that might cause diseases. And finally, the water is released into one of our waterways.

1. https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification
2. https://www.nyc.gov/site/dep/water/wastewater-treatment-process.page

Water Quality: Temperature



Temperature is measured using a thermometer.
Celsius (C) and Fahrenheit (F) are two different temperature measurement units. Celsius is the most common unit for measuring temperature in the world, where the freezing point of water is 0°C, and the boiling point is 100°C. In the US, we use Fahrenheit to measure temperature. The freezing point of water is 32°F and the boiling point is 212°F.

According to the thermometer on the right, the temperature is

_____°C, or _____°F.

Imagine you have two buckets of water. You keep one bucket under a shady tree, and the other one in a sunny area. Do you think the temperature of the water in both buckets will stay the same? Why?

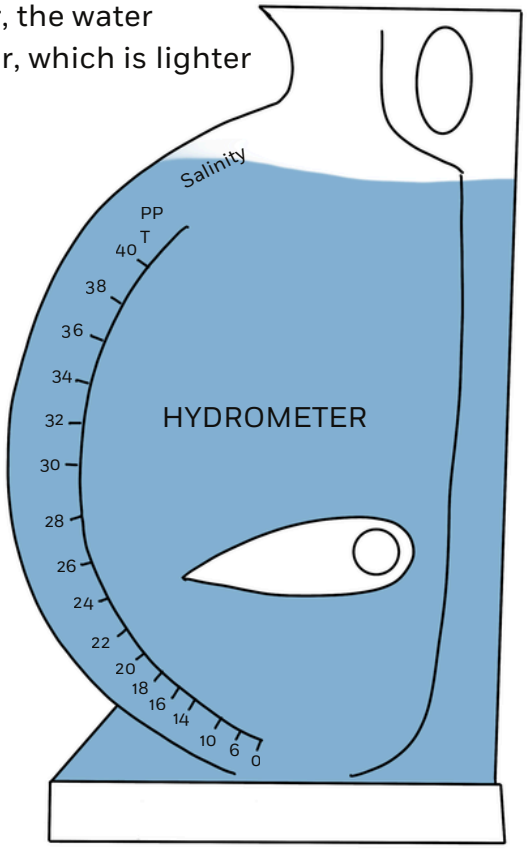
We are mammals, which means we are warm-blooded animals. Regardless of the temperature outside, the temperature of warm-blooded animals stays at around 36°C~38°C (97°F~102°F). Warm-blooded animals have the ability to regulate their body temperature through different ways such as shivering when cold, or panting or sweating when hot.

Insects, worms, fish, amphibians, and reptiles are cold-blooded animals. They do not have the ability to generate their own body heat. This means that their body temperature is usually the temperature of their environment. Even though they cannot generate their own body heat, they can adjust their body temperature by laying out in the sun when cold or hiding under a rock when hot.

How do you think warmer temperatures as a result of climate change will affect animals that live in the NY-NJ harbor estuary? (Take a look at the animals on page 5!)

Water Quality: Salinity

Salinity is used to tell us how much salt is in the water. A hydrometer is used to measure salinity. If there is more salt in the water, the water becomes more dense, lifting the needle of the hydrometer, which is lighter than the salt water it is in.



Salinity of different water types

fresh water	less than 0.5 ppt
brackish water	0.5~35 ppt
salt water	more than 35 ppt

If there is 1 gram (g) of salt in 1 liter (l) of water, the salinity of that water is 1 part per thousand (ppt).

The salinity of the water on the right is _____ ppt.
That means that there are _____g of salt per every 1 l of water, or ____g/l.
This water would be categorized as _____ water.

ppt and gm/l are two different units of measurement that are equal to one another.
Can you convert gm/l into milligrams per liter?
Hint: There are 1,000 milligrams in 1 gram
____g/l = _____mg/l

Climate change is affecting the water cycle. Higher temperatures means that more water evaporates in subtropical zones, and this moisture is carried through the atmosphere towards the poles, and by trade winds across Central America to the Pacific Ocean, where it causes more rain. This leaves behind a lot of salt in the North Atlantic, causing the salinity to increase. [1]

How do you think an increase in salinity will affect the animals on page 5?

Other Water Quality Tests

Scientists conduct many other tests to determine the health of a body of water. For example, the amount of enterococci (a type of bacteria in the genus of Enterococcus) in the water tells us of the presence of untreated sewage in the waterways. The amount of dissolved oxygen (DO) tells us how much oxygen is available for living aquatic organisms. The turbidity, or how clear the water is, tells us if the water has a lot of particles such as silt, algae, or sewage in it.

1. NASA https://climate.nasa.gov/news/58/with-a-pinch-of-salt/
2. DEP https://www.nyc.gov/site/dep/environment/resources-for-educators.page
3. NOAA https://oceanservice.noaa.gov/education/tutorial_estuaries/est01_whatis.html

Date:

Estuary Explorers Waterfront Lab Data Sheet

For this activity you will need a bucket, a hydrometer, pH paper, a test tube, and a thermometer.

Salinity

Fill a hydrometer with sample water and place it on a flat surface. After 30 seconds, read the numbers on the outer edge for salinity (ppt). Record your findings below.

The salinity of the water sample is _____ ppt

pH

Fill the test tube to the top with sample water. Tear off a piece of pH paper about 2 inches long, and put it in the test tube, and keep it there for one minute. Compare the color of the pH paper to the colors on the pH chart. The number next to the matching color will tell you what the pH of your sample is.

The color of the pH tape is _____

The pH of the water sample is _____

This means that the water is (acidic / basic / neutral)

Temperature

Before you measure the temperature of the water, begin by making some observations. What are today's climate conditions? Is it hot, humid, snowing, windy, etc.?
Use your thermometer to measure the temperature outside. Based on this temperature, what do you think the temperature of the water is?

Today's climate conditions: _____

Today's temperature: _____ °C _____ °F

Water temperature prediction: _____ °C _____ °F

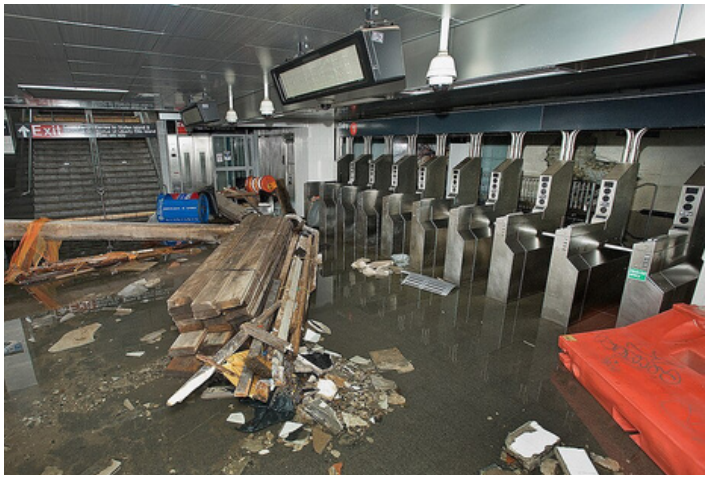
Put the thermometer all the way into the bucket of water, and wait two minutes for the thermometer to adjust to the water's temperature. Pull the thermometer partly out of the water so that it can be read. Be careful to keep your fingers off the bulb (the part that reads the temperature).

Water temperature: _____ °C _____ °F

Resilience

Resilience is the capacity to anticipate, prepare for, respond to, and recover from significant threats with minimum damage to social well-being, the economy, and the environment.

On page 19, we learned about 1% annual chance and 0.2% annual chance floods. As devastating floods like this become more likely due to climate change, our waterfronts must become more resilient and prepared for the future

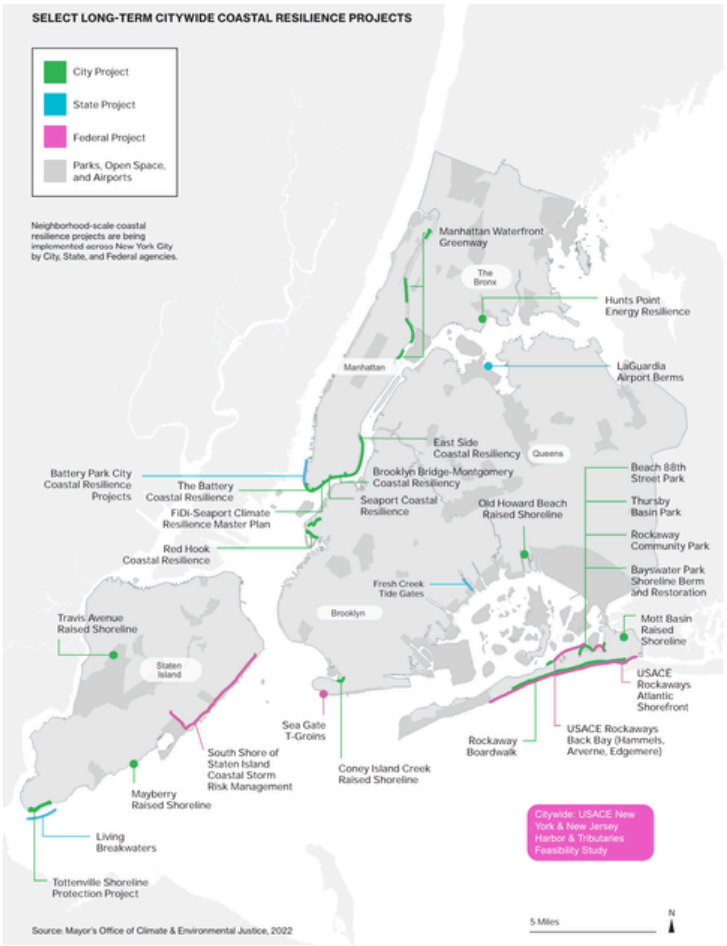


Hurricane Sandy

In October of 2012, a massive storm began in the Caribbean, making its way north through the Atlantic Ocean towards the NY-NJ region. It made landfall near Atlantic City, NJ on October 29 with maximum winds of 129 kilometers (80 miles) per hour.

As a result of its power and scale, Hurricane Sandy had devastating impacts on NY and NJ. Over 140 people lost their lives as a direct result of the storm, at least 650,000 houses were damaged or destroyed, and 8.5 million people experienced power outages.

As a result of the devastating impacts of Hurricane Sandy, and to prepare for future events, there are many projects underway to strengthen the resiliency of the region, as can be seen on the map to the right, and on page 28.



https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf

Activity: Rising Water

Flooding will become more frequent and severe as climate change progresses. During Hurricane Sandy, many coastal areas were flooded, some experiencing over 3 m (10 ft) of water! The QR code below will take you to a map that shows you how much of the NY-NJ region will be flooded by various amounts of sea level rise.

Set the “water level” to 10 ft to see how much of the region would be flooded if another storm like Sandy were to happen. Color in the areas on the map below that would be flooded if the water level were to reach 10 ft.



Coastal Resilience Projects

Source: NYC HCR



Living Breakwaters Project
This project will incorporate breakwaters (concrete rock structures) which will serve as barriers that will help to reduce damage caused by storm waves. What makes this project unique is that these breakwaters are what we call green infrastructure, because they will also serve as a habitat for oysters and other living things, improving the ecosystem of southern Staten Island. It will also be a place where people can learn and become involved in their waterfront. It is scheduled to be completed by fall of 2024. [1]

South Battery Park City Resiliency Project
This project will help to strengthen the resilience of the lower Manhattan waterfront by incorporating flood walls, barriers, improved drainage systems, and green roofs. It will also serve as an accessible and open recreational space for all people to enjoy. [2]



Source: Battery Park City Authority

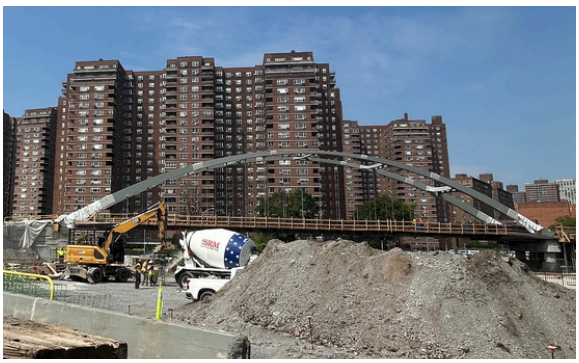


Source: NYC DDC



East Side Coastal Resiliency Project
This project which is scheduled to be completed by the end of 2026, will enhance 3.9 km (2.4 miles) of Manhattan's Lower East Side shoreline by using flood walls, flood gates and raised parklands. It will improve flood protection in the area, and create more accessible open spaces while preserving the view of the East River. Since having access to the waterfront is so important to local communities, construction is being done one section at a time, so that a percentage of the park always remains open. [3]

When finished, this park will have multiple pedestrian bridges connecting it to the neighborhood, so that all people can access this park easily. These bridges are created in Venice, and shipped all the way to NYC where they are reassembled!



1. https://hcr.ny.gov/living-breakwaters-project-home
2. https://bpca.ny.gov/sbpcrp/
3. https://www.nyc.gov/site/ddc/about/press-releases/2022/pr-111022-waterfront-alliance-verification.page

Resilience - Green Infrastructure

Rain gardens are one example of green infrastructure (systems built into our communities to mitigate the impacts of stormwater from heavy rain.) Rain gardens can be found on sidewalks throughout the city. They have layers of gravel, soil, and plants that help absorb water that would normally have nowhere else to go. They help to prevent flooding, and reduce the amount of water that flows into our sewers, preventing CSOs (see page 17).





Infiltration basins store rainwater below ground, and are made to look like their surroundings (grass or concrete), so they might be a little hard to spot. Water flows in from an opening on the curb and fills the chamber, where it flows through a pipe into the ground underneath. This process is called “infiltration.”

Permeable paving refers to different kinds of materials and techniques that allow water to seep in between the paving materials and be absorbed into the ground. It can be used instead of traditional concrete or asphalt, which is impermeable (water cannot pass through it).





Green roofs are made up of plants, soil, and a drainage layer. They can help to absorb rainwater, mitigate the heat island effect (see page 18), and provide an aesthetically pleasing green space for people to enjoy and destress. Since they help keep the building itself from heating up, green roofs are also known to reduce the amount of energy needed to cool the building.

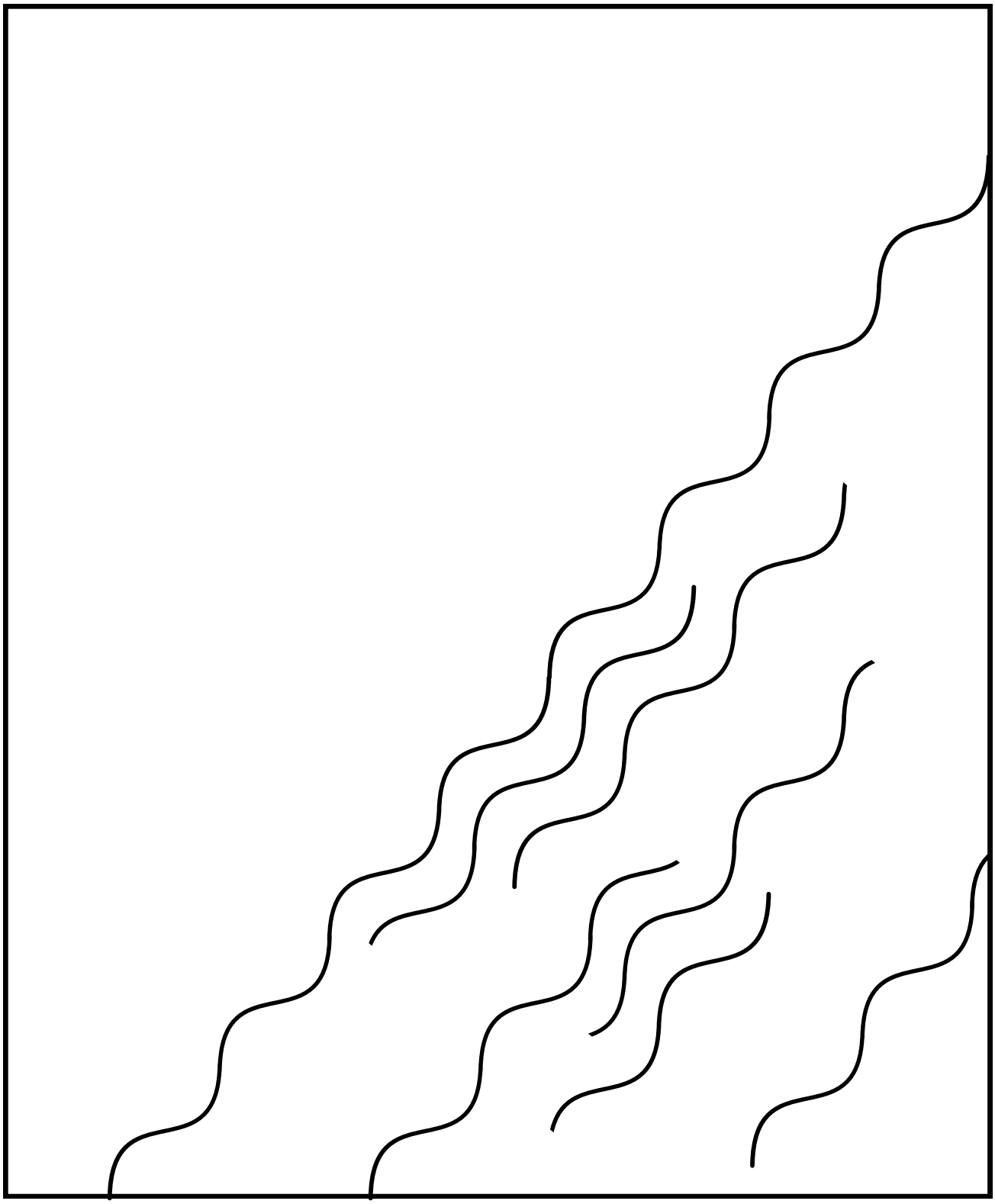
See if you can spot green infrastructure in your neighborhood!

https://www.nyc.gov/site/ddc/resources/features/2017/08/bioswales.page

Activity: Draw Your Ideal Waterfront

Here are some things you may want to include:

- Houses/Buildings
- Recreation Areas
- Wetlands
- Riprap
- Seawalls
- Get-downs
- High ground (area safe from floods)
- Beaches



Share your artwork with us!
Snap a photo of your ideal waterfront, and share it with us on Instagram by tagging @waterfrontalliance and using #OurWaterfront

Take Action!

What can you do to help protect our waterfront?

Find out what organizations are in your local community, and get involved!



Call or email your local representatives and tell them to support a clean and protected harbor.



Find out who your representatives are here:

NY

NJ

Become a Youth Ambassador for Climate Resilience!

Join the Waterfront Alliance to

- Learn more about what you can do to help your communities prepare for the climate crisis
- Find like minded individuals who are passionate about an equitable and just climate transition
- Get a certificate in Climate Hazards
- Access mentors to help with college and career planning

Go to waterfrontalliance.org to find out more.

*Reserved for students in Grades 8-12

Here's an example of what you can say/write:

Hello, my name is [NAME], I live in [DISTRICT/BOROUGH/NEIGHBORHOOD] and I am a student at [SCHOOL NAME].

I am writing to you to ask for your support in cleaning and protecting our harbor. I believe it is important to protect our harbor because [REASONS]. I look forward to hearing back from you and continuing this discussion. Thank you for your time.

Learn More!

Visit the links below for more resources and learning opportunities!

NYC STEM Education Network

Environmental Protection Agency Kids' Corner

Environmental Protection Agency Water Topics

NYC Department of Environmental Protection Resources for Educators

NJ Department of Environmental Protection State Environmental Education Directory

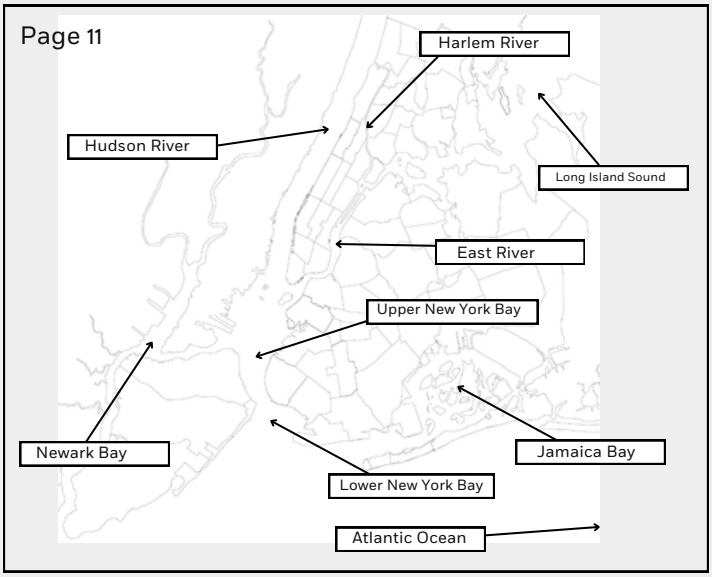
NYC Parks Learning Hub

Answers and Explanations

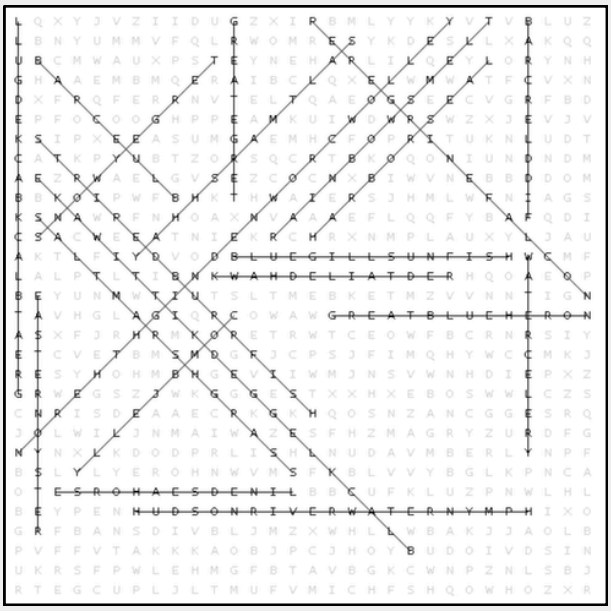
Page 3: Think about a waterfront (a pier, park along the river, beach, etc.) that you live near. How do you feel about it? Is it a place you can access easily? Do you feel a connection to it?
We hope that by the time you've finished this workbook, you will have a better understanding and see your local waterfront a little differently!

Page 9: Accessible waterfronts are important for any community that lives near water. What are some ways that you can act as a steward for your communities waterfront?
You can organize a shoreline cleanup event with your friends and family, learn about the ecology of the waterfront and lead tours, you can start an environmental monitoring program by contacting a local university or non-profit, etc.

Page 11



Page 7



Page 13: Ferries used to be the main way for people and goods to get around New York City! Over the past few years, we've seen new ferries and boats like the NYC Ferry start reconnecting people with these modes of transportation. How is it beneficial to the city that we use ferries for getting around?
Ferries help to reduce more environmentally damaging forms of transportation like driving, they also help to reconnect New Yorkers with the water.

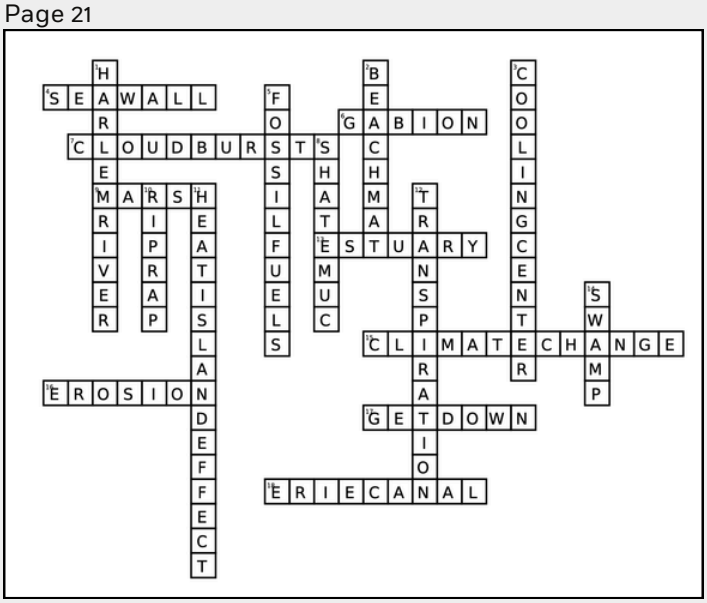
Page 20:
How will climate change, especially heat waves and floods, affect the area you live in, or go to school in? Think about how it will affect your community as well as the overall ecosystem.
Think back over the past year or two. How has it felt at home or at school when there was a heat wave? How was transportation (buses, trains, etc.) impacted during storms? If you have plants or animals (even rats or squirrels that live nearby!) in your neighborhood, think about how those living things could be impacted by extreme weather events.

Based on what you wrote on the left, what can you do to prepare for an extreme weather event such as a flood or a heat wave? Talk to your friends and family about how you can keep each other safe.
Think about specific things you can prepare (medication, chargers, packaged food, etc.) that might come in handy for extreme weather events. If phones aren't working, how will you find your family and friends? If there is a flood that affects your neighborhood, where will you go? Is there someone close to you that has a disability that might need accommodations during these events? If you have pets, how can you keep them safe too? It can be a little scary to imagine worst case scenarios, but thinking about them now and having a plan is important!

What was the most memorable or surprising thing that you learned so far? What are some things that you'd like to learn more about?
This workbook may not be able to answer all of the questions you have, but we hope it helps to get you thinking about these topics. We encourage you to stay curious, ask questions, keep searching for answers, and share what you've learned with others!

Answers and Explanations

Page 21



Page 22: If the NY-NJ harbor estuary becomes more acidic, how will that affect each of the animals on page 5?
If waters become more acidic, animals with a narrower pH range such as the striped burrfish, comb jelly, lined seahorse, and fiddler crabs will not be able to continue living in those habitats. As mentioned in the paragraph above this question, shellfish are especially vulnerable to higher acidity levels. If a certain organism disappears from an ecosystem, or has a smaller population, this will affect the entire ecosystem.

Page 23:
The temperature is on the thermometer is around 33°C, or 92°F.

Imagine you have two buckets of water. You keep one bucket under a shady tree, and the other one in a sunny area. Do you think the temperature of the water in both buckets will stay the same? Why?
Water has the ability to absorb heat without increasing the temperature of the water itself by a whole lot. That's why even on a very hot summer day, the ocean or pool water doesn't get as hot as it is outside. But if the two buckets are left out long enough, it's likely that the bucket under a shady tree will have a lower temperature than the one in the sun.

How do you think warmer temperatures as a result of climate change will affect animals that live in the NY-NJ harbor estuary? (Take a look at the animals on page 5!)
As we experience warmer temperatures and heat waves as a result of climate change, the temperature of bodies of water, such as the NY-NJ harbor estuary will also rise. Some animals can only live within a specific temperature range, and if the waters get warmer than that, they can no longer live in that habitat. One example of this is the rainbow smelt. It can only live in cooler waters of less than 20°C (68°F). The Hudson River records temperatures much higher than that, particularly during the summer months. For this reason, the rainbow smelt has been extirpated, or wiped out, from the Hudson River.

Page 24: The salinity of the water on the right is around 24 ppt. That means that there are 24 g of salt per every 1 l of water, or 24 g/l. This water would be categorized as brackish water. 24 g/l = 0.024 mg/l

How do you think an increase in salinity will affect the animals on page 5?
The salinity of a body of water directly affects an animal or plants ability to live in that habitat. If the salinity in the Hudson River increases, there may be some species that disappear from the lower parts of the river because they cannot tolerate higher levels of salinity. At the same time, there may be some animals that are able to live further upstream and expand their habitat because of this. For example, if the salinity of the lower Hudson River goes above 20 ppt, the Bluegill sunfish will no longer be able to live there. Bluegills eat many things including mosquito larvae, which means a decline in their population could mean an increase in mosquitos (oh no!), which could mean an increase in an infectious disease like West Nile Virus (which is spread by mosquitos). Bluegills are small fish, which means they have many predators including larger fish such as bass and perch, and these animals may also see a decline in population if they do not have enough prey.


WATERFRONT
ALLIANCE


ESTUARY
EXPLORERS