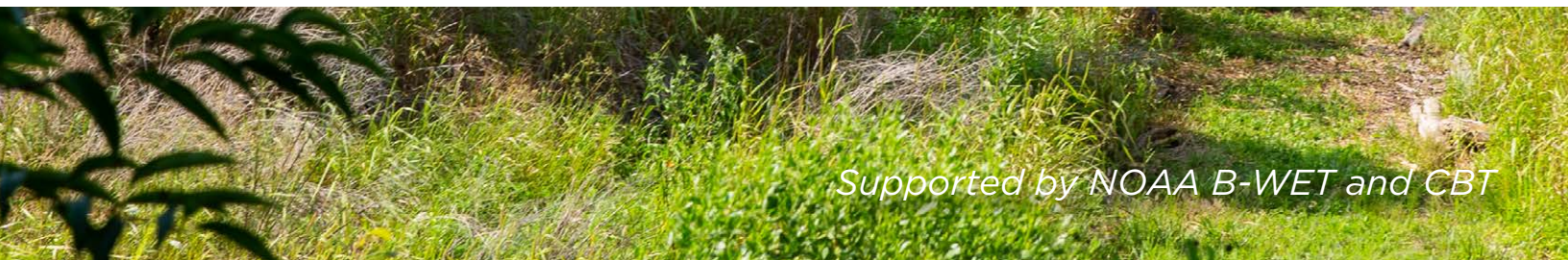
NATIONAL AQUARIUM®

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS



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THE CHESAPEAKE BAY

Name: _____ Period: _____Date: _____

FLIP

The Chesapeake Bay is an Estuary

An estuary is a somewhat closed body of water where fresh water mixes with salt water. An estuary opens into the ocean, which is the source of the salt water. The fresh water comes from rain or snow that falls onto the land and then drains away in streams, or comes from springs that bring groundwater to the surface. Both join to become rivers that flow into the estuary.

Because the Chesapeake Bay is partly enclosed by land, fresh water and salt water meet and mix there. Fresh water in the Bay come from rivers, so the water is less salty at the mouths of rivers. Salt water from the Atlantic Ocean flows into the Bay at its opening in southern Virginia so the Bay is saltier farther south.

The Chesapeake Bay Watershed

The Chesapeake Bay is enclosed by Delaware and the eastern parts of Maryland and Virginia. The fresh water in the Bay comes from many rivers, which drain about 64,000 square miles spread over New York, Pennsylvania, Maryland, Delaware, West Virginia, Virginia, and Washington D.C.

The land that drains into the Chesapeake is called its watershed. A watershed is an area of land from which water (rain or snow) drains into a stream, river, or other body of water. Everything that gets into the water anyplace in the watershed of the Chesapeake Bay eventually ends up in the Bay.

FLOP

Big Idea Question

What is the source of fresh water in an estuary?

Where is the water the saltiest in the Chesapeake Bay?

What is a watershed?

Does trash on the streets of Baltimore enter the Chesapeake Bay?

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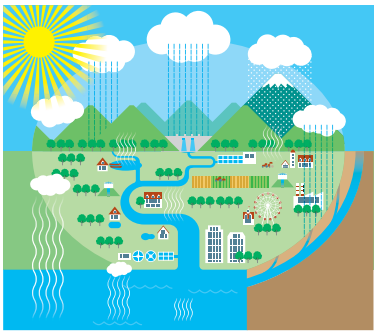
THE CHESAPEAKE BAY

FLIP	FLOP
Baltimore City The Chesapeake Bay watershed is divided into many smaller watersheds that flow into Chesapeake Bay. There are four of these smaller watersheds in Baltimore City: • The Gwynns Falls watershed • The Jones Falls watershed • The Herring Run watershed • The Baltimore harbor The Inner Harbor in Baltimore is on the Patapsco River.	*What river in Baltimore carries fresh water into the Bay?*
Function of an Estuary Estuaries have very high levels of plant nutrients because they are almost enclosed by land. Freshwater runoff carries these nutrients from the land. Any body of water with high levels of plant nutrients has high numbers of plants and algae. Since plants are the start of the food chain for all the animals that live in the water, where there are lots of plants, there are many animals. In part because of the large food supply, estuaries are particularly good places for many young animals to get their start. Estuaries are nurseries for many species of fish, shrimp and other animals that live in the ocean as adults. Fish like shad, herring and striped bass (rockfish) migrate from the ocean through the estuary and into rivers to spawn, or lay their eggs. The eggs develop into larval (baby) fish, which move down into the estuary to feed and grow before leaving to live in the open sea. 	*How do the nutrients from the land influence organisms that live in water?* *What does the estuary provide to animals that inhabit it?*

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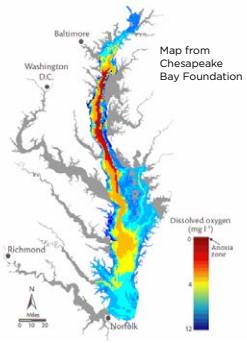
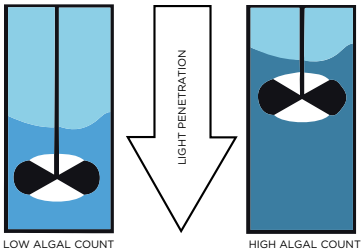
THE CHESAPEAKE BAY

FLIP	FLOP
Importance of Estuaries to Humans Blue crabs live in estuaries all along the Atlantic and Gulf coasts, but they are most often associated with Maryland where they are a popular delicacy, eaten steamed or as crabcakes. The Chesapeake Bay provides 50 percent of the total blue crab harvest in the United States. Striped bass (also called rockfish in the Chesapeake region) are the one of the most famous fish found in the Bay. They are important both as sportfish and for commercial catch. About half of the fish and other sea animals we eat depend on an estuary during some part of their life. When we damage an estuary, we not only hurt the plants and animals that live there, we also destroy part of our food supply.	*How can your actions in your neighborhood or school affect our food supply?*
Water Quality All animals need oxygen for survival. Aquatic animals use oxygen (02) that is dissolved in the water. This oxygen enters the water through photosynthesis of aquatic plants and dissolved from the air.  Salinity is the amount of dissolved salt in the water. Salinity is measured in parts per thousand (ppt). The salinity in an estuary ranges from freshwater (0 ppt) in the rivers to saltwater (30 ppt) near the ocean. Most of the Bay is brackish water, a mix of salt and fresh water. Temperature varies in the Chesapeake Bay based on season. pH is how acidic the water is. Turbidity is how cloudy the water is. Turbidity is influenced by the amount of phytoplankton in the water and the amount of dirt in the water. Turbidity often changes because of rainfall picking up dirt as it washes off the land. TAKING SECCHI DISC MEASUREMENTS 	*Do organisms get dissolved oxygen from the O2 in the water?* *What is the salinity of a river?* *Referring to the diagram, does water with high algae growth increase or decrease light penetration?*

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ANIMAL FACT SHEETS

American Eel

Anguilla rotrata

The American eel is a smooth, snake-like fish with a green-ish, yellowish-brown or blackish body and a whitish belly.

Habitat:

Ocean currents carry young eels thousands of miles from the Bahamas to the U.S. coast. Before entering the Bay, the young eels change to brown. Some of these brown eels stay in the shallow waters of the Bay, but most continue to swim many miles up the Bay's rivers to fresh water. After a few months, the young eels change into the adult "yellow eel" stage. Adults remain in rivers and streams for most their lives.

American eels prefer to live in water with a salinity of 1-30 ppt, low turbidity, and a pH of 6.8 to 8.6. Water temperature between 40 ÐF (4 ÐC) and 90 ÐF (32 ÐC) with medium to high dissolved oxygen is best for American eels.

Range:

American eels live throughout the Chesapeake Bay watershed.

Feeding:

The eel feeds at night on worms, small fish, clams and mollusks, and crustaceans like soft-shelled crabs.

Predators:

Predators of the American eel include larger fish and fish-eating birds such as gulls, eagles, and ospreys.

Other Facts:

- Males grow to be two feet long. Females grow to be between three and five feet long.
- American eels usually live for at least five years. Some can reach 15 to 20 years old.
- Once they can reproduce, they return to the Sargasso Sea to lay eggs and die.

Sources and Additional Information: Field Guide: American Eel by Chesapeake Bay Program, Fishes of Chesapeake Bay by Edward O. Murdy, Ray S. Birdsong, and John A. Musick; Life in the Chesapeake Bay by Alice Jane Lippson and Robert L. Lippson; Maryland Fish Facts: American Eel – Maryland Department of Natural Resources; Animal Diversity Web: Anguilla rostrata – University of Michigan Museum of Zoology

ANIMAL FACT SHEETS

Blue Crab
Callinectes sapidus

The blue crab is a swimming crustacean with bright blue claws and an olive green shell. It is one of the most recognizable species in the Chesapeake Bay.

Habitat:
Blue crabs are crustaceans with a hard outer skeleton and segmented arms and legs. They are usually found on the bottom of the Chesapeake Bay in shallow grasses during warm weather. They hibernate in the deep trenches of the Bay in winter. They like to live in water between 34 and 91 °F (1-33 ĐC). When air temperatures drop below 50 °F (10 ĐC), adult crabs leave shallow waters and travel to deeper areas where they bury themselves throughout the winter. Water temperature above 91 °F (33 ĐC) is deadly.

It is more common to find males in fresher water. Females like to stay in saltier waters. Blue crabs in general prefer water with a salinity of 3-15ppt, 9.2 mg/L of dissolved oxygen, low turbidity, and a pH between 6 and 8.

Range:
Blue crabs can live in the Atlantic Ocean from Nova Scotia in Canada to Argentina in South America. They can be found in the Chesapeake Bay and the rivers that feed the Bay year-round.

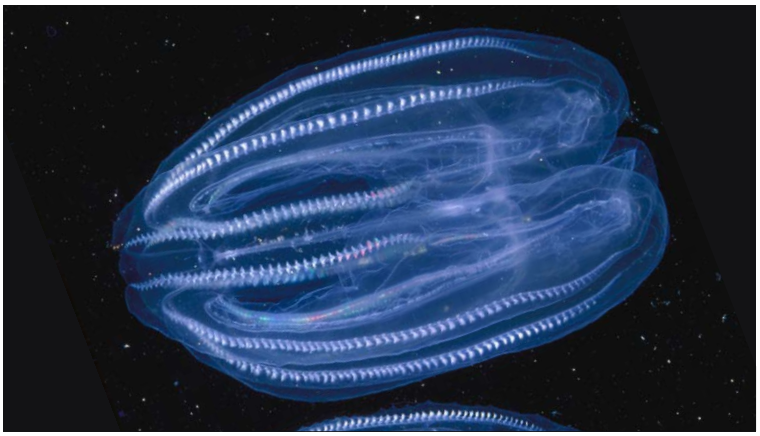
Feeding:
Blue crabs will feed on nearly anything they can find, including clams, oysters, mussels, smaller crustaceans, freshly dead fish, and plant and animal remains that have broken down. They will even eat smaller and soft-shelled blue crabs.

Predators:
Predators include large fish like croakers and red drum, fish-eating birds like great blue herons, and sea turtles.

Fun Fact:
- The blue crab's scientific name comes from the Greek words for "beautiful" and "swimmer."
- Blue crabs are one of the most important commercial and recreational catches in the Chesapeake Bay.

Sources and Additional Information: Learn the Issues: Blue Crabs by Chesapeake Bay Program, Life in the Chesapeake Bay by Alice Jane Lippson and Robert L. Lippson, Chesapeake Bay: Nature of the Estuary, A Field Guide by Christopher P. White, Maryland Fish Facts: Blue Crab – Maryland Department of Natural Resources, Animal Diversity Web: Callinectes sapidus – University of Michigan Museum of Zoology, Callinectes sapidus – Smithsonian Marine Station at Fort Pierce, http://www.chesapeakebay.net/fieldguide/critter/blue_crab

ANIMAL FACT SHEETS



Comb Jellies

Mnemiopsis leidyi, Beroe ovata

Comb jellies are clear, jelly-like invertebrates (animals without backbones) with bright, reflective color bands. Pink comb jellies have a sac- or egg-shaped body that is often tinted pinkish to reddish-brown. Sea walnuts have a colorless, walnut-shaped body, with two of their body lobes longer than the rest.

Habitat:
Comb jellies live near the surface of both shallow and deep waters and swim by beating tiny hairs on their bodies to push themselves forward. Sea walnuts often swim together in large swarms.
Comb jellies, in general, prefer water with a salinity of 32-35ppt, 8-10 mg/L of dissolved oxygen, and a pH between 8 and 8.4. They like to live in water between 50 and 68 °F (10-20 ÐC).

Range:
Sea walnuts have a larger range. They occur as far north as the Baltimore area. They are present year-round but are most common in spring and summer. Pink comb jellies can be found in late summer to autumn in the middle and lower Chesapeake Bay, south of Kent Island, Maryland.

Feeding:
Comb jellies love to eat plankton. These tiny creatures flow with the current alongside the comb jellies, making them an easy meal. Comb jellies also sometimes feed on fish larvae.

Predators:
Even though they are both comb jellies, the pink comb jelly is a major predator of the sea walnut.

Other Facts:
- Unlike jellyfish, comb jellies do not have stinging tentacles.
- Comb jellies break apart when taken out of the water.
- Although sea nettles and other stinging jellyfish are more well-known, comb jellies can be found more often in the Bay.

ANIMAL FACT SHEETS

Common Grass Shrimp
Palaemonetes pugio

A common grass shrimp's body is divided into small segments and is nearly clear. It has a pointed, jagged "horn" that reaches over its eyes. Its first two pairs of walking legs have claws. The shrimp grows to 1.5 inches in length.

Habitat:
Common grass shrimp are found throughout the Bay, except at the mouth near the ocean because it is too salty. Common grass shrimp usually prefer water with a salinity of 2-36 ppt and a pH between 6 and 8. They are found in shallow waters, often among the bay grasses. Common grass shrimp prefer water with medium to high turbidity. They usually live in water between 55-84 ÐF (13-29 ÐC), but the common grass shrimp may move to warmer, deeper waters in the winter. The prefer dissolved oxygen levels are between 6-11 mg/L..

Range:
Common grass shrimp are found throughout most of the Chesapeake Bay and its tributaries.

Feeding:
Grass shrimp feed on worms, algae and other tiny crustaceans, such as crabs and shrimp.

Predators:
Small fish such as sunfish and killifish feed on grass shrimp.

Other Facts:
- The common grass shrimp is the most common of the four species of grass shrimp known to live in the Bay.
- They often carry a parasitic isopod, Probopyrus pandalicola, which looks like a bulge near the shrimp's gill area.

Sources and Additional Information: Field Guide: Common Grass Shrimp by Chesapeake Bay Program, Life in the Chesapeake Bay by Alice Jane Lippson and Robert L. Lippson; Chesapeake Bay: Nature of the Estuary, A Field Guide by Christopher P. White; Animal Diversity Web: Palaemonetes pugio – University of Michigan Museum of Zoology, Palaemonetes pugio – Smithsonian Marine Station at Fort Pierce

ANIMAL FACT SHEETS

Dark False Mussel
Mytilopsis leucophaeata

The dark false mussel is a dark brown bivalve (two-shelled) mollusk. They are native to the Chesapeake Bay. This species is a close relative of the invasive zebra mussel.

Habitat:
They can survive wide changes in salinity, but are most commonly found in freshwater and brackish water environments. However, dark false mussels may also be found in coastal waters with a higher salinity. They prefer to live in areas with salinities between 1 and 15 ppt.

Dark false mussels like to live in water between 62 and 72°F (17-22 ÐC). During cold winters, entire populations can die out. Dark false mussels prefer water with 4.2–13.3 mg/L of dissolved oxygen, and a pH between 7 and 9.

Range:
Dark false mussels can be found in many habitats within the Chesapeake Bay. However, they are typically found more often in the saltier mid-Bay, living among oyster reefs.

Feeding:
Dark false mussels are filter feeders that feed on phytoplankton (tiny, microscopic plants floating in the water).

Predators:
Dark false mussels are food for crayfish, sturgeons, yellow perch, blue crabs and diving ducks.

Other Facts:
- Dark false mussels are considered invasive pests in parts of Europe.
- Using its “foot,” the dark false mussel can attach to hard surfaces, and it is able to attach to both natural and man-made surfaces including stones, wood, oysters, bottles, and walls.

ANIMAL FACT SHEETS

Mummichog
Fundulus heteroclitus

The mummichog is a plump fish with a flattened head and a rounded or squared tail. They have pointed teeth and a lower lip that juts out beyond the upper one. They grow to be five to six inches long, with females larger than males. Males and females are different colors, and both males and females can alter their coloring slightly based on their surroundings.

Habitat:
Mummichog live in muddy marshes, tidal creeks, grass flats, and along sheltered shores. In colder months, they often retreat to deeper waters or burrow six to eight inches deep in bottom mud or silt.

Mummichog are a tolerant species. They can withstand changes in temperature and salinity, low oxygen, and polluted water. Mummichogs can withstand temperature fluctuations from 43Ð to 95 ÐF (6-35ÐC). In the Chesapeake Bay, they prefer to be in fresh water with salinity ranging from 5 to 30 ppt, but it is recorded that they can survive in water with up to 120 ppt. Mummichog can survive in water with pH levels as low as 3.75 and as high as 8. These fish can tolerate low dissolved oxygen and high turbidity.

Range:
They are permanent residents of the entire Chesapeake Bay but are also found on the Atlantic coast of North America from Canada to Mexico.

Feeding:
Mummichog eat a variety of items including algae, plants, insects (adult and larvae), worms, small crustaceans and mollusks, the eggs of their own species, and other fish.

Predators:
Larger fish, wading birds, and seabirds eat mummichog.

Other Facts:
- They can eat up to 2,000 mosquito larvae in a single day. They are sometimes used as a natural method of mosquito control.
- “Mummichog” is a Native American word meaning “going in crowds;” mummichogs often form schools of hundreds of individuals.

Sources and Additional Information: Field Guide: Mummichog by Chesapeake Bay Program; Fishes of Chesapeake Bay by Edward O. Murdy, Ray S. Birdsong, and John A. Musick; Life in the Chesapeake Bay by Alice Jane Lippson and Robert L. Lippson; Mummichog: Fundulus

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ANIMAL FACT SHEETS

Northern Pipefish

Syngnathus fuscus

Northern pipefish are small, skinny fish growing between 6 and 8 inches long. Their bodies are pale tan to brown. They have long snouts and brownish, fan-shaped tail fins.

Habitat:

Northern pipefish live in bay grass beds in shallow waters in the summer time. Then move to deeper water during the winter. They can be found in waters with low turbidity and a temperature of 39-62 ÐF (4-17 ÐC). They usually live in water with a salinity of 32-36 ppt, dissolved oxygen of 5-9 mg/L, and a pH between 6 and 8.

Range:

Northern pipefish are found throughout the Chesapeake Bay and freshwater rivers year-round.

Feeding:

Tiny crustaceans (crabs, shrimp, etc.), fish eggs, small juvenile fish, and other small, aquatic animals are prey for northern pipefish.

Predators:

Pipefish have few predators because of their ability to camouflage themselves within grass beds. They imitate blades of grass by aligning themselves vertically within the grass beds. Bass, gars, perch, drums, and weakfish are possible predators to pipefish.

Other Facts:

- The male carries eggs in a pouch.
- Pipefish are closely related to seahorses.

Sources and Additional Information: Field Guide: Pipefish by Chesapeake Bay Program; Fishes of Chesapeake Bay by Edward O. Murdy, Ray S. Birdsong, and John A. Musick; Life in the Chesapeake Bay by Alice Jane Lippson and Robert L. Lippson; Common Pipefish – Friends of Merrymeeting Bay; Fishbase - Syngnathus fuscus by Rainer Froese; Syngnathus fuscus – Encyclopedia of Life

ANIMAL FACT SHEETS

Striped Bass
Morone saxatilis

Striped bass are also known as rockfish. They have seven or eight long stripes along their metallic sides. Their body changes in color from light or olive green to blue, brown or black. Their belly is white. They have a dark, forked tail fin and three spines on their anal fin.

Habitat:
The striped bass lives in various habitats with low turbidity throughout the Chesapeake Bay and local rivers. They move upstream in spring to reproduce in fresh water. They spend summer and winter in deep channels. Striped bass survive in temperatures between 43-70 ÐF (6-21 ÐC). They prefer a salinity between 20-30 ppt and dissolved oxygen between 5 and 8 mg/L.

Range:
Striped bass are found throughout the Chesapeake Bay watershed year-round. Most spend the summer along the New England coast and the fall and winter off North Carolina. On the Atlantic coast, striped bass range from Canada to Florida. They are most common from Maine to North Carolina.

Feeding:
Striped bass feed on a variety of small fish such as menhaden and anchovies, squid, invertebrates including worms, and crustaceans such as crabs and shrimp.

Predators:
Sharks, larger fish, and fish-eating birds such as ospreys eat striped bass. are possible predators to pipefish.

Other Facts:

- The striped bass is Maryland's state fish. They are one of the most popular commercial and recreational catches in the Chesapeake Bay.
- The Bay is the largest striped bass nursery area (area where babies grow) on the Atlantic coast. Seventy to 90 percent of the Atlantic striped bass population uses the Bay to reproduce.
- The oldest recorded striped bass was 31 years old. The largest recorded striped bass was 125 pounds, caught on the North Carolina coast in 1891.

Sources and Additional Information: Field Guide: Striped Bass by Chesapeake Bay Program; Fishes of Chesapeake Bay by Edward O. Murdy, Ray S. Birdsong, and John A. Musick; Life in the Chesapeake Bay by Alice Jane Lippson and Robert L. Lippson; Maryland Fish facts: Striped Bass –

ANIMAL FACT SHEETS

Striped Killifish
Fundulus majalis

The striped killifish is a silvery, minnow-like fish that lives in the tidal creeks and sand flats of the Chesapeake Bay region. Striped killifish grow to be about eight inches long, with females growing slightly larger than males. They are the largest killifish found in the Chesapeake Bay. Male striped killifish have vertical black bars along their sides, while females have three horizontal bars.

Habitat:
Striped killifish live in tidal creeks, grass beds, and sand flats. They are more often found in sand than other killifish. They often swim in large schools in shallow waters. When the tide goes out, they are can get stranded in tide pools. In colder months, they burrow in the mud or live in tidal creeks where the salinity is lower than in the marshes.

They can withstand low dissolved oxygen levels and temperatures ranging from 55-84 ĐF (13-29 ĐC). Striped killifish prefer brackish water (higher salinities) and rarely enter fresh water. They generally live in water with a pH of 6-8 and low turbidity.

Range:
They are permanent residents of the entire Chesapeake Bay.

Feeding:
Striped killifish feed on a variety of items in salt marshes including phytoplankton (microscopic aquatic plants), mollusks (snails, clams, etc.), crustaceans (crabs, shrimp, etc.), mosquito larvae, and dead fish.

Predators:
Larger fish, wading birds, and seabirds are predators of striped killifish.

Other Facts:
- They are used as bait in recreational fishing.
- During the breeding season, males become brightly colored.

Sources and Additional Information: Field Guide: Striped Bass by Chesapeake Bay Program; Fishes of Chesapeake Bay by Edward O. Murdy, Ray S. Birdsong, and John A. Musick; Life in the Chesapeake Bay by Alice Jane Lippson and Robert L. Lippson; Maryland Fish facts: Striped Bass –

ANIMAL FACT SHEETS

White Barnacles
Balanus subalbidus

Barnacles are small, grayish-white animals. They have a flat base and an opening at the top. The opening has two shells that open and close like trap doors. Barnacles live on rocks, pilings, boat hulls and other hard surfaces throughout the Chesapeake Bay.

Habitat:
Barnacles are more common in the northern half of the Bay. They are sensitive to very cold or dry weather. They can tolerate a large temperature range, but prefer to live in water between 48Ð and 60 °F (9-16 ÐC).

White barnacles prefer water with a salinity of 5-30 ppt, 9-12 mg/L of dissolved oxygen, medium to high turbidity, and a pH between 4 and 6.5.

Range:
White barnacles are found throughout the Chesapeake Bay, from salty waters to nearly fresh water.

Feeding:
Barnacles feed while underwater. The barnacle's shells open and close repeatedly. Feathery appendages emerge to collect and sweep in tiny food particles such as plankton.

Predators:
Barnacle larvae are an important food source for young fish in the spring. Flatworms are major predators of adult barnacles.

Other Facts:
- Barnacles grow by adding calcium carbonate to the edges of their shell plates. The interior of the barnacle grows by shedding its outer skeleton, just like blue crabs and other crustaceans that molt.
- Although they may look like mollusks (snails, slugs, etc.) with their shells, barnacles are actually crustaceans and are related to lobsters, crabs and shrimp.

Sources and Additional Information: Life in the Chesapeake Bay by Alice Jane Lippson and Robert L. Lippson, Chesapeake Bay: Nature of the Estuary, A Field Guide by Christopher P. White, Balanus eburneus – Smithsonian Marine Station at Fort Pierce

ANIMAL FACT SHEETS

White-Fingered Mud Crab
Rhithropanopeus harrisii

The white-fingered mud crab is greenish-brown or olive colored. Their claws have white tips. One claw is always larger than the other. The white-fingered mud crab is one of the most common animals in the Chesapeake Bay.

Habitat:
White-fingered mud crabs prefer brackish waters. They often hide in oyster reefs and underwater plants. These crabs commonly live on shallow shores with muddy or sandy soils.

These mud crabs can tolerate to a wide range of salinity but prefer salinity ranges between 1 and 40 ppt. White-fingered mud crabs prefer water with a temperature between 37-86 °F (3-30 ĐC), a pH between 6 and 8, 0.554-9 mg/L of dissolved oxygen, and medium to high turbidity.

Range:
White-fingered mud crabs can be found throughout the East Coast of the United States. They are found from the southwestern Gulf of St. Lawrence, Canada, through the Gulf of Mexico, to Vera Cruz, Mexico.

Feeding:
These mud crabs mainly feed on decaying or dead organisms such as leaves, clams, oysters, mussels, and fish.

Predators:
Predators include birds, fish and larger crabs.

Fun Fact:
- White-fingered mud crabs are considered invasive on the West Coast of the United States and in Europe.

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SPECIES CARD

COMMON NAME:

SCIENTIFIC NAME:

PICTURE

TEMPERATURE :

DISSOLVED OXYGEN:

TURBIDITY :

SALINITY:

pH :

ANIMAL CHECKLIST

What Lives in the Harbor?

Plot your data on the parameter scales below. Is the water healthy?

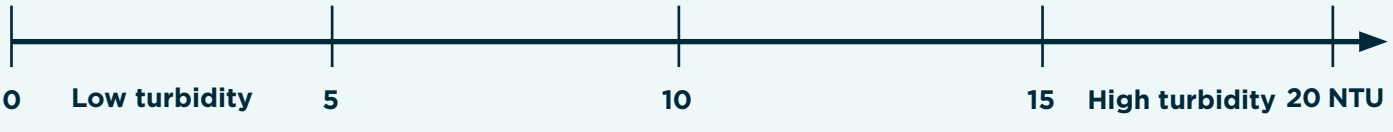
1. Dissolved oxygen (DO) is needed for aquatic animals to breathe. Levels below 5 mg/L can be stressful. Fish kills can happen when levels are under 1 mg/L.

2. Salinity is the level of dissolved salt in the water. Rain, drought, and the seasons affect the salinity.

3. Organisms need a specific **temperature** to survive. Temperature can affect the amount of dissolved oxygen in the water, and hot water can be a pollutant.

4. pH measures if something is an acid or a base. Water is neutral and has a pH of 7. An ideal pH level for most organisms is between 6 and 8.

5. Turbidity is the clarity of the water. Over 15 NTUs are considered to be harmful to bay grass growth. High turbidity can make it hard for fish to breathe due to sediment being caught in their gills.



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ANIMAL CHECKLIST

Which species would you expect to find in the Inner Harbor based on the water quality data you viewed?

Under each parameter, write your data with units. For each species, place a ✔ or **x** under each parameter showing if your data matches the species' requirements.

	Dissolved Oxygen _____	**Salinity** _____	**Temperature** _____	**pH** _____	**Turbidity** _____
SPECIES	✔ or **x**	✔ or **x**	✔ or **x**	✔ or **x**	✔ or **x**
American Eel					
Blue Crab					
Comb Jelly					
Common Grass Shrimp					
Dark False Mussel					
Mummichog					
Northern Pipefish					
Striped Bass					
Striped Killifish					
White Barnacle					
White-Fingered Mud Crab					

1. Based on the data, list the animals that you think you would see in the harbor.

2. Did you see any of the animals you predicted above in the videos you watched? Which ones?

3. What do you think is the biggest water quality issue (pH, temperature, dissolved oxygen, salinity, turbidity) facing animals in the harbor?

4. How can you improve the water quality parameter you identified in the previous question?

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What Lives in the Harbor

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STEWARDSHIP ACTION PROJECTS

What issues in your neighborhood or school community could impact water quality and aquatic species in the harbor? Choose one issue you wish to address. Choose an action from the list or think of your own that could be done to make a positive change. Funds are available to help with the completion of action projects.

EVERYDAY CHOICES

- Reducing/reusing/recycling/upcycling
- Composting
- Saving energy
- Conserving water

COMMUNITY ENGAGEMENT

- Making presentations
- Creating social media campaigns
- Organizing an event
- Sharing messaging at community events, fairs and festivals
- Mentoring
- Creating PSAs, flyers and posters

CIVIC ACTION

- Attending town or community meetings
- Writing to elected officials/decision makers
- Advocating for policy change

The following actions require some support and the National Aquarium can assist with completing these projects.

WATERSHED RESTORATION AND PROTECTION

- Reducing/reusing/recycling/upcycling
- Creating a wildlife habitat at your school
- Planting trees or grasses
- Removing invasive plant species
- Organizing a community cleanup event
- Creating solutions to manage storm water runoff

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

ACTION PROJECT WORKSHEET

Research Guide

Name: _____

Partner(s): _____

Class: _____

Which water quality factor are you focusing on? (turbidity, pH, dissolved oxygen, or salinity)

_____

Approved websites for research: (NO Wikipedia, Google answers, Yahoo answers, etc.)

The National Aquarium – **aqua.org**

The Chesapeake Bay Foundation – **cbf.org**

Blue Water Baltimore – **bluewaterbaltimore.org**

National Oceanic and Atmospheric Administration – **noaa.gov**

United States Geological Survey – **usgs.gov**

1. Explain what your chosen factor tells you about the quality of the water, or what it measures.

_____

_____

_____

_____

_____

_____

_____

Sources Used:

2. How does _____ affect the aquatic organisms living in the Chesapeake Bay?

_____

_____

_____

_____

_____

_____

_____

_____

_____

Sources Used:

3. What is causing the problem with your chosen factor?

_____

_____

_____

_____

_____

_____

_____

Sources Used:

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What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

ACTION PROJECT WORKSHEET

Research Guide

4. What **SPECIFICALLY** are people doing to cause the problem surrounding your chosen water quality factor?

_____

_____

_____

_____

_____

_____

Sources Used:

5. What are possible solutions to this problem? What actions can the government, communities, businesses, and/or individual people take to help fix the problem?

_____

_____

_____

_____

_____

_____

Sources Used:

Action Project

The action that I am going to take to fix this problem is (see Stewardship handout for ideas):

_____

_____

_____

_____

• My targeted audience (my school, neighborhood, city, etc.):

_____

• Resources I will need: _____

_____

_____

_____

_____

_____

_____

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_____

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_____

ACTION PROJECT WORKSHEET
Strategy Selection Grid

Use this grid to decide which strategy you would like to focus on to complete your action project. Each **strategy** is an idea that improves the water quality parameter your class chose. For example, with an action project that focuses on improving turbidity in Baltimore's Inner Harbor your class should come up with 5 strategies that improve turbidity. The **criteria** are the specific guidelines your class will use to chose a strategy. Example criteria include: fits within $500 budget, or a specific timeline. The strategy that best fits all the criteria is the strategy your class will choose. Fill in the top row with the ideas you will be considering. Use the column on the far left hand side to list the criteria you have developed to make your selection. Rate each strategy against each criterion use a 1-5 scale (1 meaning it does not meet the criteria and 5 meaning it completely meets the criteria). Total the scores at the bottom.

		STRATEGIES				
		STRATEGY 1:	**STRATEGY2:**	**STRATEGY 3:**	**STRATEGY4:**	**STRATEGY 5:**
CRITERIA	**CRITERION 1:**					
	CRITERION 2:					
	CRITERION 3:					
	CRITERION 4:					
	CRITERION 5:					
	total score for each issue					

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What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

ACTION PROJECT WORKSHEET

Student Proposal

My Project:

How does this project improve water quality in Baltimore Harbor:

I will need the following supplies to complete my project:

Item	3 Places Researched for Pricing	Best Price From (include link)	Cost Per Item	How Many Do I Need?	Total Price
EXAMPLE: 14X22" POSTER BOARD	**OFFICE MAX: $3.99 FOR 8** **STAPLES: $4.24 FOR 8** **MICHAEL'S: $3.69 FOR 8**	**MICHAEL'S** https://www.michaels.com/14x22-white-poster-board-8ct/10176773.html	**$3.69**	**1**	**$3.69**

*Reminder: Each **school** gets $500. Teachers will need to determine what individual supplies may be able to be shared amongst the class.

TOTAL COST:

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What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

ACTION PROJECT WORKSHEET

What Needs to Happen to Get it Done!

You will need to talk to others to get permission and ask for help. To prepare for these conversations, think through each of the below questions. Think of it as your "elevator speech" - quickly get them interested, connected to the issue, and excited. **Show them how your project is meaningful!**

What data can you share? How will you share it? Ex. graphs, charts

_____

_____

Why should they care about your project? Why should they want to help?

_____

_____

How will this project help others?

_____

_____

What else can you share to get them interested and motivated to help?
Think about pictures, videos, news stories....

_____

_____

Who do you need to talk to? Who must give permission? Who can help this project succeed?

If the project would happen off school grounds, who owns the land or building? If the project would happen on school grounds, should you talk with the principal, school manager, head of maintenance, teachers...?

_____

_____

Who would need to help you? Examples: classmates, teachers, a local business, the town....

_____

_____

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What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

ACTION PROJECT WORKSHEET

Making Your Action Project Happen!

List out the major tasks, in order, that need to happen to complete your action project. Start with the planning and go through completion. Assign 1 or 2 people to each Task - the Task Manager(s) are in charge of making sure their assigned task is completed by the completion date and for sharing updates with the group.

TASK:

_____

_____

Task Manager(s) _____ Completion Date: _____

TASK:

_____

_____

Task Manager(s) _____ Completion Date: _____

TASK:

_____

_____

Task Manager(s) _____ Completion Date: _____

TASK:

_____

_____

Task Manager(s) _____ Completion Date: _____

TASK:

_____

_____

Task Manager(s) _____ Completion Date: _____

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What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

ACTION PROJECT WORKSHEET

Celebrate!

Be proud of what you have accomplished! Sharing your project with your school community and the larger community will educate others on the issues and inspire them to take action.

How can you spread the word? Examples include...

- Write articles for your school paper, local newspaper or a website
- Deliver a morning announcement
- Make posters or flyers and post around the school or in the community (like community centers and local businesses)
- Host a presentation, ribbon cutting or kick-off party
- If you host an event, invite newspapers, school officials, parents, donors, etc.
- Design and install a permanent sign to educate people about your project

What will you do to educate others about your project?

_____

_____

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**Adapted from ShoreRiver's Student Action Project Worksheet*

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

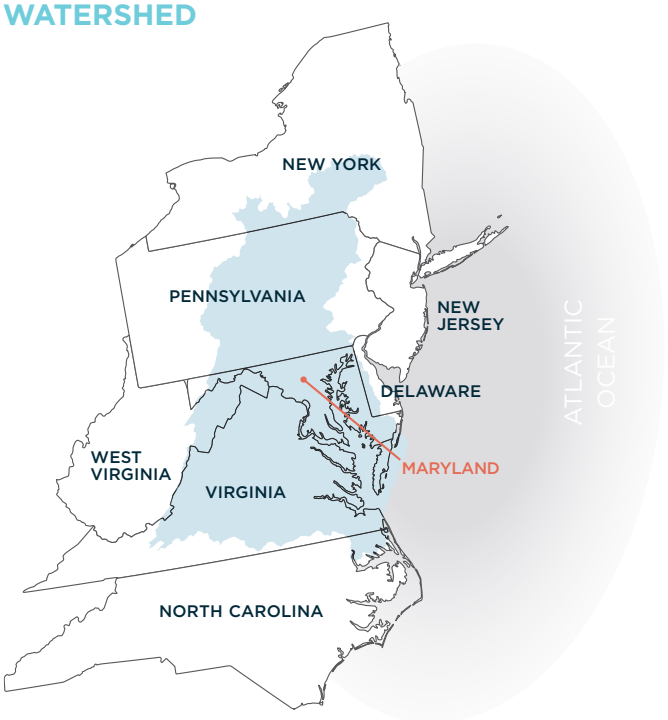
KNOW YOUR WATERSHED

KNOW YOUR WATERSHED

Most of the 18 million people that live in the Chesapeake Bay Watershed, don't live directly next to a waterway, so why should they care about water quality? Because wherever you are in the Chesapeake Bay Watershed, you are only 15 minutes away from a tributary that ends up in the Chesapeake Bay. You are more connected to the Chesapeake Bay than you think!

A **WATERSHED** is any land that drains water from precipitation or snow melt into a certain body of water. The Chesapeake Bay Watershed is made up of parts of Maryland, Virginia, West Virginia, Pennsylvania, Delaware, New York, and all of Washington, DC. The whole watershed is 64,000 square miles.

THE CHESAPEAKE BAY WATERSHED



There are also sub-watersheds, smaller areas of land that drain into smaller bodies of water, that then drain into the larger watershed. In Baltimore, part of the Chesapeake Bay Watershed, the sub-watersheds are Herring Run, Jones Falls, Gwynns Falls, and the Baltimore Harbor itself. These sub-watersheds then flow into the Patapsco River, then into the Chesapeake Bay and eventually into the Atlantic Ocean.

All neighborhoods throughout the watershed are connected to the waterways, whether they are close to the water or not. How is this possible? Storm drains! Storm drains connect neighborhoods to waterways. But what are storm drains and how do they work? Storm drains were designed to quickly carry rainwater away from paved surfaces like roads and sidewalks to prevent flooding. Neighborhoods need roads and sidewalks, but rainwater cannot soak into them, so storm drains were put into place. Storm drains carry rainwater run-off and snowmelt away, but where does that water go? Storm water pipes lead directly into a body of water without being treated or cleaned at all.

KNOW YOUR WATERSHED

STORM DRAINS were designed with the intent that pollutants would not get into them because they were just meant to carry rainwater, but sadly this is not the case (pollution or pollutant can refer to trash, organic matter like leaves and grass clippings, excess nutrients like phosphorus and nitrogen, pet waste, toxic chemicals, or any other substance or material that can end up in the watershed or waterways, but does not belong there and harms the environment). Urban and suburban areas have a lot of impervious surfaces. Impervious surfaces are areas that water cannot soak into. These include sidewalks, roads, sport courts, roofs of houses and buildings, and even heavily compacted soil often found in highly foot-trafficked areas. All these impervious surfaces collect pollutants and all these pollutants get washed and blown into storm drains that flow out into our waterways. This is how your neighborhood is connected to our waterways. Pollutants from neighborhoods end up in tributaries to the Chesapeake Bay through storm drains almost as easily if they were simply dumped there. It is important to minimize pollutants that could get into storm drains, in order to make our waters healthier. Storm drains link your neighborhood directly to our waterways!

KNOW YOUR WATERSHED

Directions: As you watch each video in this lesson, take notes so you are prepared for your class discussion. Watch this video and answer the questions on this page.

Watch:

- Stormy the Raindrop Visits the Chesapeake Bay (10:02)

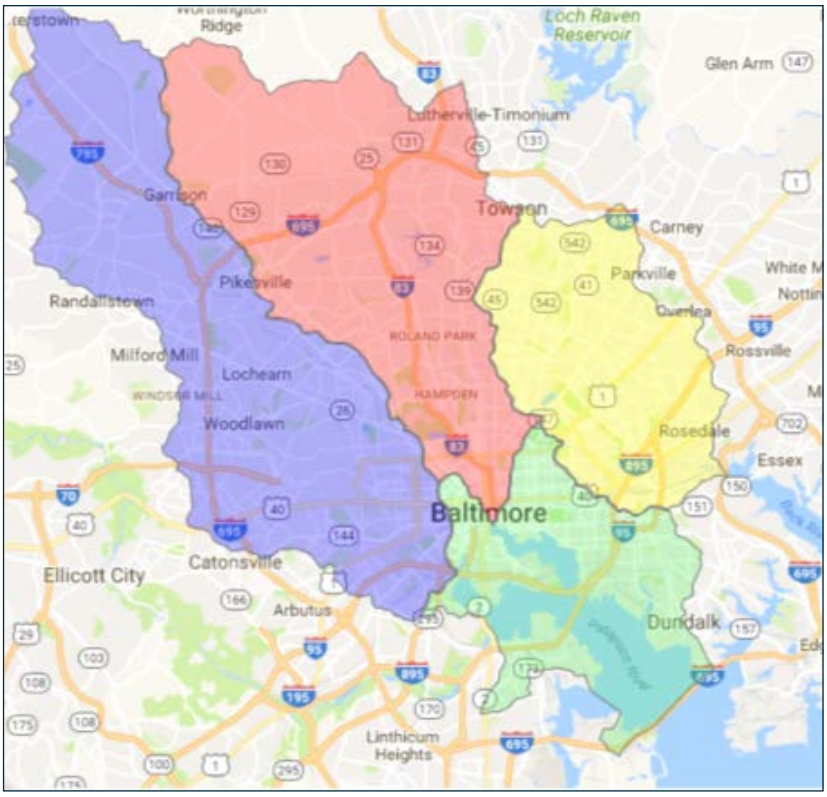
Questions:

What is a watershed?

What watershed do you live in?

What six states are part of your watershed?

Find your home on a map of Baltimore, compare it to the following map of Baltimore. What sub-watershed do you live in?



SUB-WATERSHEDS OF BALTIMORE

Purple = Gwynns Falls

Red = Jones Falls

Yellow = Herring Run

Green = Baltimore Harbor

ACTIVITY: WHO POLLUTED THE PATAPSCO?

Directions: Watch "Who Polluted the Patapsco?". Answer the questions about the activity. Watch the remaining videos, take notes about the videos, and answer the questions.

Procedure:

1. Watch and read along with "Who Polluted the Patapsco?".
2. When you hear the name of a character mentioned in the story, the contents of its container will be dumped into the large container representing the river.

WHO POLLUTED THE PATAPSCO?

*(Character names are written in **BOLD**. Listen for the name of the character labeled on each container. When you hear each character named, its contents will be dumped into the river.)*

There was a time hundreds of years ago when this land was very wild. This was a time before roads and cars. Only a small number of native people lived here then. These people depended on nature for many of the things they needed, but they lived simply and didn't change the land too much. Those people hunted in the forests, found food in the swamps and wetlands, and caught fish in the river. This beautiful, sparkling river was home to many fish and other wildlife.

Imagine that the container of clear water in front of you was taken from the Patapsco River a long, long time ago. Eventually, more people traveled to this land from across the ocean. They found rich soil for farming, forests full of wildlife, and a river that provided plenty of food and water. It was the perfect place to live.

But the river has changed a lot since then. This is the story of those changes.

Years went by, and occasional storms drenched the area. High winds whipped through the **TREES** and blew leaves into the water.

More and more people moved to the area. Gradually, the city of Baltimore grew up along the banks of the Patapsco River. Upstream, **FARMERS** planted crops to feed the city's growing population. Some of those crops grew right up to the banks of the river, and fertilizers washed off the land and into the water. Other farmers kept pigs, cows, and other animals in their **BARNYARDS**. As rainwater drained out of the barnyard, it carried some of the manure into a little creek behind the farm. The creek flows into the Patapsco.

At first, the city was small, but builders and developers started to drain swamps and cut down trees to build houses, schools, churches, stores, roads, hospitals and many other buildings as more people moved into the area. Rains washed loose soil from these **CONSTRUCTION SITES** into the river.

As the city grew, more and more people began to move to the nearby countryside. These rural houses are not connected to the city sewer system. Wastewater from these houses flows into septic tanks under the ground. One **HOMEOWNER** has not maintained their septic tank, and poorly treated sewage seeped into the river.

To meet the electricity needs of Baltimore, area officials decided that they would need to generate more power. Far upstream, a **COAL MINE** was dug. Rainwater drained down into the mine shaft and soaked the piles of waste and scraps from mining. This made the rainwater become acidic, sort of like a strong vinegar. Then the acid water trickled into the river. To burn the coal and produce power, an **ELECTRIC POWER PLANT** was built along the river, too. Gasses coming out of the smokestacks combine with moisture in the air to form acids. The pollution falls back to earth as acid rain or smog.

Baltimore is now a large metropolitan area. Traffic congestion can also be a problem for **COMMUTERS** and truck drivers who drive to and from work. Exhaust fumes, just like power plants emissions, can cause acid rain. If a vehicle is not kept in good repair, it might also leak oil or other fluids, which will wash off the pavement and into the river with the next rain.

KNOW YOUR WATERSHED

And how do the residents of Baltimore and the surrounding areas spend their time? In one neighborhood, a lot of **GARDENERS** are out working in their yards. Some of them are using weed killers and insect sprays to keep the lawns pretty. The next rain will wash some of these into a storm drain nearby and into Herring Run that drains to the Patapsco.

One father is teaching his daughter how to change the **ANTIFREEZE** in the family truck. They pour out the used antifreeze into the driveway. Antifreeze is sweet tasting and can poison animals if they drink it. It can also get into the storm drain and travel to nearby Jones Falls and poison aquatic animals.

In another neighborhood, a boy is **WASHING THE CAR**. The soapy water rushes down into the driveway into the storm drain; the storm drain empties into Gwynns Falls, which also travels to the Patapsco. The grease and grime on a car contain asphalt from the roads, asbestos from the brakes, rubber particles from the tires, toxic metals, and rust. If the boy had gone to the local car wash, the water would have been treated before it returned to the river.

Next door, a family is cleaning out their garage. They find an old rusty can with a tattered skull and crossbones label still stuck on it. What could it be? It looks dangerous, and they want to get rid of it before someone gets hurt. But how? Junior gets an idea: "Let's pour it down the drain by the curb!" So, the **MYSTERIOUS LIQUID** goes down the storm drain. The poison is out of site, but it is headed for the river.

On nice days, many people head down to the Inner Harbor. Some zoom all around in **MOTORBOATS** and don't notice that a little oil leaks into the water. A group of friends have spread blankets along the shore for a **BEACH PARTY**. Lots of families are **PICNICKING** in the parks too. Some of these people have left their trash behind, and some trash blew away. With the next storm, that trash will wash into the river. On the shore, a **PERSON FISHING** snags a hook on a log and breaks off the nylon fishing line.

So, who polluted the river?

Questions:

Do you think the water quality in this river is good or bad? Would you drink this water? Would you swim in it? Would you eat fish from it? Why?

Is this water safe for wildlife? How can we determine if it is safe for wildlife?

Who polluted the river? Name 4 different pollutants in the river.

Why does water pollution happen?

What effect did the increasing population have on the water quality?

In what ways can population increases help the river?

Think about the pollutant in each container. How can we prevent these pollutants from entering the river in the first place?

Do pollutants that enter the river stay in one place? Where do they go?

Who is responsible for preventing pollution? Who is responsible for cleaning up pollution?

Is it easier to prevent pollution from entering the river or to clean it up later? Why?

What can you do from home to help improve the water quality and health of the rivers around Baltimore?

KNOW YOUR WATERSHED

Challenge:

Once different pollutants have entered the river; how can we get them out? Create a new product, invention, or system to minimize the impact of pollution on the river and clean the water. For example, the Trashwheel Family has been put in place to remove trash from the waterways. The solution can be realistic or far-fetched, but the invention should help remove at least one of the pollutants from the river and improve the health of the water.

Watch:

- Freddy the Fish Teaches About Stormwater (4:28)
- Freddy the Frog and Stormwater Run-off (6:20)
- Managing Stormwater Run-off (2:04)
- How Pollutants Affect Streams series (3:00)
- Stormwater Run-off Model (0:31)
- DC Water: Life of a Raindrop (4:30)
- DC water: Life of a Raindrop Sequel (3:54)

Questions:

What is stormwater? What is stormwater run-off? What is in stormwater run-off?

Why do we have storm drains? Where does stormwater go?

What should go down storm drains? Why?

What is a bioindicator? What animal do scientist often use as a bioindicator? Why?

What is Washington D.C. doing to prevent polluted stormwater from entering the waterways? How can you convince people in Baltimore to do the same thing?

What can cities and urban areas do to reduce stormwater run-off?

AT-HOME PROJECTS

Storm Drain Watch

It is important to keep storm drains clean and clear because everything that is in or immediately around a storm drain ends up in the waterways which affects the health of waterways around Baltimore and the Chesapeake Bay, plant and animal life in the watershed, and ultimately humans. Students will monitor the storm drains in their neighborhood for trash and debris. With an adult to supervise, students will remove any trash or debris accumulated on or immediately near storm drains frequently. Students will NOT stick their hands or arms in the drain to remove trash or debris. Trash should be removed wearing protective gloves or with a trash grabber. Remove all debris away from the opening with brushes and brooms and throw away any trash. Adults will be responsible for removing anything sharp like shards of glass or needles. Dispose of those items in a separate "sharps" container. Participants will not empty any liquids out of containers, even if it looks like water, throw the closed container with the liquid into a trash bag. Organic debris (leaves, sticks, dirt) can be swept or raked into a nearby green space, deposited in a compost area, or bagged for curbside pick-up per normal neighborhood waste disposal procedures, but it must be removed from paved surfaces completely to prevent it from entering the waterways.

Each time you clean a storm drain, use the Marine Debris Tracker application, and the NOAA List within the app, to geotag and log the amount and types of trash collected. This gives NOAA citizen science data that they use to research how and what type of trash enters our waterways. Alternatively, students can use the tally sheet on page 23 of this document, Marine Debris Tracker Tally Sheet to keep track of what kinds of trash they are removing from the drain. Using the data from the Marine Debris Tracker application or your tally sheet, look at what kind of trash is removed from the storm drains (chip or snack bags, food wrappers, Styrofoam cups or containers, plastic bags, cigarette butts, etc.). Transform your data into a graph and post this information on your school's website and social media. Include ways to reduce each kind of trash to educate others.

Students will also research and make signs or fliers to post near storm drains with information about storm drains and storm water including the environmental harm of what is in stormwater, where stormwater run-off travels to once it leaves the street, and what we can all do as a community to keep neighborhoods and waterways clean and healthy. *This activity addresses turbidity, pH, and dissolved oxygen issues.*

Water Quality Bingo

There are many actions that go unnoticed when it comes to improving water quality. Small actions can be done every day, right in your own neighborhood that improve water quality in Baltimore Harbor. Once you notice things in your neighborhood that help with water quality, it's easy to make everyday choices that maintain the health of our waterways. Students will walk around their neighborhood looking for actions that improve water quality to complete their bingo card. Some actions must be done by the students, and others are simply observations to be made. To get credit for each sighting, students will need to have a video taken while doing an action or take a picture with the found item if there is no action to perform. Students need to get any 5 in a row to get bingo. Students need to be present in each video or picture to get credit for the item. The topic or title of each item should be made obvious as well to track their progress to get bingo. *This activity addresses turbidity, pH, and dissolved oxygen issues.*

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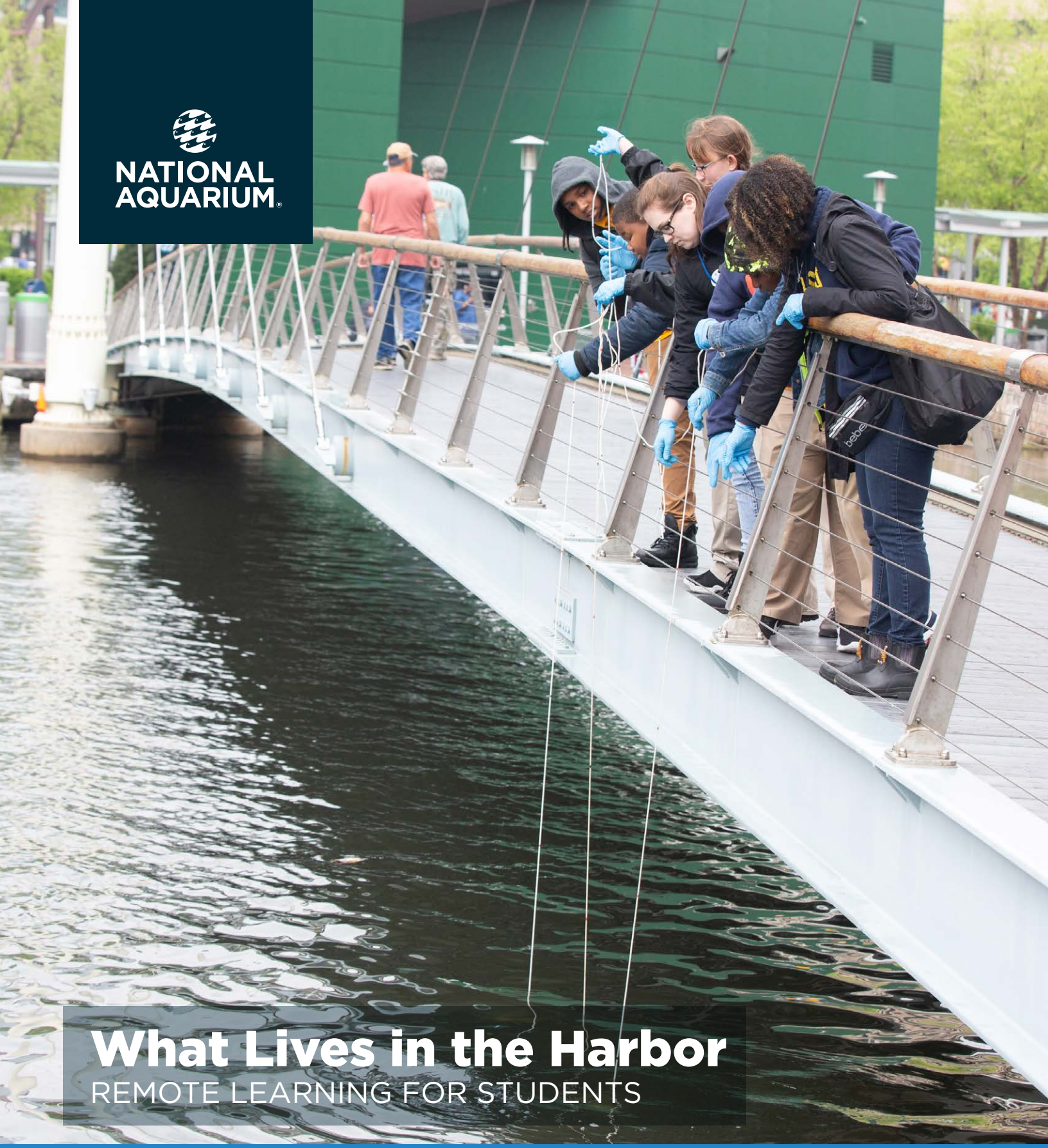

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

EROSION AND TURBIDITY

EROSION AND TURBIDITY

TURBIDITY is how clear or cloudy the water is, measured by how many meters you can see down in the water column due to the number of suspended particles. Turbidity is measured with a Secchi disk. Erosion of soil on land is a major cause of turbidity in the water. When soil is eroded, it washes into storm drains or directly into the waterways, adding to the amount of sediment in the water. Stream and riverbanks and other areas without a lot of vegetation are susceptible to erosion. Natural areas like forested stream banks, wetlands, and marsh areas prevent erosion while also trapping sediment and preventing it from entering the waterways. Water becomes more turbid after storms because of the amount of sediment and debris that gets washed or blown into the waterways. Boat traffic, stirs up sediment that is already in the water, also increasing turbidity. Urban areas that have a lot of impervious surfaces easily carry sediment and debris to storm drains, which do not trap sediment. Algae blooms, caused by excess nitrogen and phosphorus nutrients from fertilizers, pet waste and even human waste getting into the water, also contribute to higher turbidity because of the increased amount of particles in the water. Highly turbid water makes it difficult for fish to breathe as sediment gets caught in their gills. It also makes it difficult for fish who depend heavily on sight to find their food. When sediments settle on the bottom, it can smother fish eggs and other bottom dwelling organisms like oysters. When there is a lot of sediment in the water it can block sunlight from reaching submerged aquatic vegetation (SAV) growing on the bottom of a body of water, which then slows the production of dissolved oxygen.

Directions: As you watch each video in this lesson, take notes so you are prepared for your class discussion. Watch these 2 videos and answer the questions on this page.

Watch:

- Billy Blue Hair: What is Erosion? (2:43)
- Make Your Own Erosion (3:49)

Questions:

What is erosion?

How is erosion on land related to turbidity in the water?

EROSION AND TURBIDITY

EXPERIMENT: EROSION MODEL

Directions: Watch the Erosion Model video. After the experiment, watch the other videos listed, take notes, and answer the questions.

Watch:

- Raindrop Impact, the Battle in the Field (2:14)
- Soil Conservation (2:29)
- Water Erosion (4:10)
- Water Turbidity (2:27)
- Turbidity in the Chesapeake Bay (7:04)
- Turbidity in Streams (5:19)
- Turbidity (5:05) This video is about water in Minnesota, but we have the same issues in Maryland.
- Baltimore County Stream Restoration (4:28)

Questions:

After the experiment, what did the water look like in each of the cups? Which catch cup had the most soil in it? Which had the least? Why? Compare the clarity (turbidity) in each cup. Be prepared to share observations from the experiment during your class discussion.

Why is soil conservation important on land?

Why is soil conservation important for the waterways? What conserves the most soil on land and prevents the most run-off? How?

What are some different types of water erosion?

Have you seen any evidence of soil erosion around your home, in your neighborhood, at school, or in other places around your city? During or after a rainstorm, find evidence of water erosion and take a picture.

What is water turbidity? Where does the dirt in the water come from?

How does high turbidity affect the Chesapeake Bay?

What is stream restoration? Why is it important?

Watch:

- Measuring Turbidity Without a Secchi Disk (1:40)
- Stream Table Demonstration (1:33)

AT-HOME ACTION PROJECTS

(Please note: not all projects deal exclusively with turbidity.)

Maintain the Green

For this experience, students will help maintain a garden or green space that is already in place. Instructors should assist students in finding a garden that they are able to walk to from their homes. Instructors should find out who maintains the garden and contact them to ask if and how students can help during this time. Activities may include pulling weeds, daily watering, clearing space for new plants, or planting new seedlings for spring. Students should be encouraged to set their maintenance schedule with the garden owner/manager and anyone else who maintains the garden in order to best practice social distancing. *This activity addresses turbidity, temperature, pH, and dissolved oxygen issues.*

Political Campaign

Students will "run for office" with a campaign to improve water quality in Baltimore Harbor. Students will research a chosen water quality parameter and how to improve it. Each student's political campaign should include a self-written slogan, a brochure that outlines their platform including what they will do to improve water quality if elected, and a 30 second to one-minute video ad demonstrating their desire to improve the parameter. In their campaign, students should include information about the water quality parameter, how it effects the health of the harbor, actions they, the candidate, promise to take to improve the parameter, and what the community can do to get involved and improve the parameter, too. In the ad video, students should be demonstrating the actions they promise to do in their campaign. *This activity address turbidity, temperature, pH, dissolved oxygen, and salinity issues.*

Put on a Show

Students will write songs, raps, poems, or skits based on the water quality parameter they want to see improved in Baltimore Harbor. Students will research their chosen parameter, looking for information about it, what actions affect it, and what people can do to improve it. Students will plan and script their performances with information based on their research. Performances will include information about the parameter and its definition, why the parameter is important for the health of the harbor and how it effects water quality, what actions people can take to improve the parameter, and how storm drains connect actions in neighborhoods to our waterways. Songs, raps, and poems should be at least 2 minutes long, and skits should be at least 5 minutes. Teachers can upload performances to your school's website or social media or share them with the wider community via news outlets and local TV stations. *This activity addresses turbidity, dissolved oxygen, temperature, pH, and salinity issues.*

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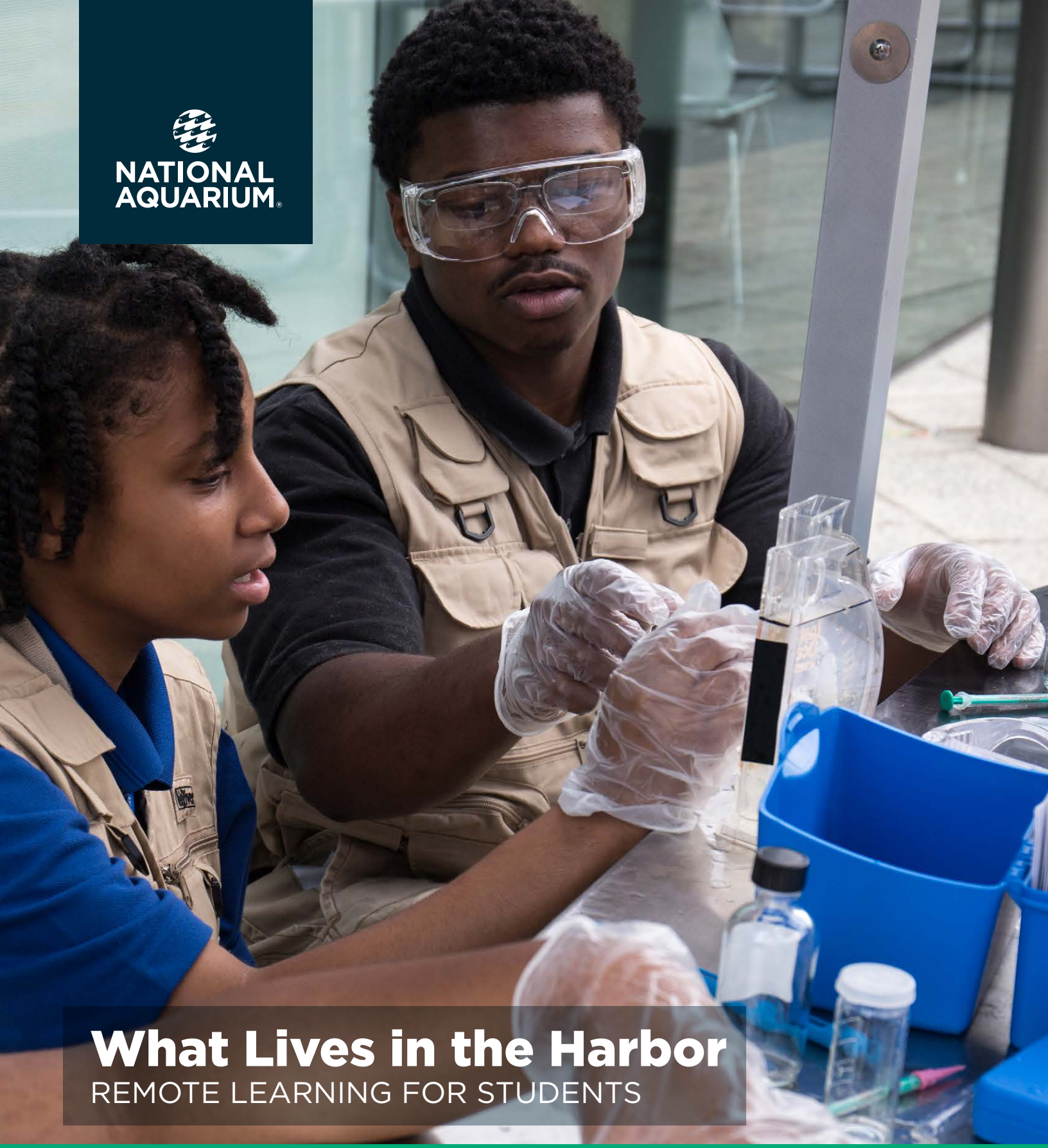


What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

DISSOLVED OXYGEN

DISSOLVED OXYGEN

DISSOLVED OXYGEN is the amount of oxygen available under the surface, which fish and other marine organisms need to survive. Dissolved oxygen (DO) can be measured with a digital probe and is measured in milligrams per liter (mg/L). Healthy dissolved oxygen levels in an estuary range from 5-12 mg/L. A waterway with a reading below 5 mg/L is considered stressed, a reading of 1-3 mg/L is considered poor or hypoxic, and 0 mg/L is anoxic, with no dissolved oxygen available for organisms. Waterways with low levels of dissolved oxygen suffocate organisms, which depend on oxygen to breathe. Most of the dissolved oxygen available in a body of water comes from phytoplankton and other aquatic plants, growing under the water's surface, during photosynthesis. Wind and wave action also increase dissolved oxygen levels by trapping oxygen from the air. Excess nitrogen and phosphorus nutrients from fertilizer, pet waste, and even human waste, lower dissolved oxygen levels. These excess nutrients cause large algae blooms that cover the water's surface and block sunlight from reaching the submerged aquatic vegetation (SAV) at the bottom. When there is a large algae bloom, bacteria start to eat the algae and use up all the oxygen that other organisms need to breathe when doing so, which causes fish kills. Large amounts of sediment from erosion and run-off also prevent sunlight from reaching plants under the water's surface. If sunlight cannot reach plants underwater, they will stop photosynthesizing and stop producing oxygen. When dissolved oxygen levels drop in a body of water, it becomes a hypoxic environment, causing many organisms to die. Dissolved oxygen levels will also decrease if water temperatures increase.

Directions: As you watch each video in this lesson, take notes so you are prepared for your class discussion. Watch these 3 videos and answer the questions on this page.

Watch:

- Bay 101: Dissolved Oxygen (1:31)
- Introduction to Dissolved Oxygen (5:22)
- Dissolved Oxygen in Lakes and Rivers (3:48)

Questions:

What is dissolved oxygen?

Why is dissolved oxygen important?

DISSOLVED OXYGEN

EXPERIMENT: WHERE DOES THE OXYGEN IN WATER COME FROM?

Directions: Watch the video Where Does the Oxygen in Water Come From?. After the experiment, watch the other videos listed, take notes, and answer the questions.

Watch:

- DO and Photosynthesis Experiment (3:59)
- Aquatic Plants with Oxygen Bubbles (1:24)
- Dissolved Oxygen and Water Quality Testing (8:23)
- Eutrophication (3:47)
- Bay 101: Algae Blooms (1:43)
- Bay 101: Fish Kills (0:58)
- Factors that Increase DO (0:46)
- Factors that Decrease DO (1:19)

Questions:

- What were the leaves in the experiment doing?
- What happens during photosynthesis?
- Do aquatic plants photosynthesize? Why is light important for aquatic plants?
- What is eutrophication? What does it do to a body of water?
- What kind of water has more dissolved oxygen?
- How can we protect and promote SAV to increase DO levels?
- Are there any other water quality parameters that affect DO production levels?
- What increases DO in water?
- What decreases DO in water?

Watch:

- The Winkler Method for Testing Dissolved Oxygen (6:48)
- Boiling Water to show DO (0:54)

AT-HOME ACTION PROJECTS

Get Growing

For this activity, you will start seedlings at home. Choose between native plants that attract pollinators (such as milkweed or black-eyed Susans) or edible plants (such as tomatoes or zucchini). Some edible plants, including onions, celery, lettuce or potatoes, can even be started from food scraps you may already have on hand. Other plants can simply be started from the seeds of fruits and vegetables. Plant, water and keep your plants at home, using pots or other large containers. However, your indoor plants will not help improve the water quality in Baltimore Harbor. Ask permission to start a garden space on the property where you live. If that is not possible, you may donate the seedlings you've grown to an established garden in your neighborhood. *This activity addresses turbidity and dissolved oxygen issues.*

Game Designer

For this activity, you will invent a board game or card game with a water quality theme, complete with rules, directions and a board with cards or pieces for playing the game. Your game may be based on popular existing games, but the topic must be centered around water quality. You should be able to explain: What is the object of the game? How do you win? What are different scenarios, problems and solutions? *This activity may address turbidity, temperature, pH, dissolved oxygen and salinity issues.*

It's Our Doody!

Pet waste isn't just unpleasant to step in; it can be harmful to humans and our waterways. Students will create an education campaign with signs, posters, and/or fliers, or brochures on the harms of leaving pet waste on the ground. Students will research about the harms of leaving pet waste on the ground regarding the health of people and the watershed, and the laws and regulations for pet waste in Baltimore to inform neighbors why they should pick up pet waste. Students are encouraged to create clever slogans for their education campaign like, "If they poop, you scoop" to get people's attention. Look for signs of high dog traffic, where there is a lot of dog waste, or at any pet waste stations, around your neighborhood to post your information. Teachers will post students' education campaigns on the school's website or social media pages. Students will also monitor pet waste stations around their neighborhood and supply them with used plastic grocery bags. Educating the public about why leaving pet waste on the ground is unhealthy and giving easy access to bags to clean up pet waste from lawns and streets, will help improve the health of Baltimore Harbor. *This project addresses dissolved oxygen and turbidity issues.*

NATIONAL AQUARIUM®

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

pH AND OCEAN ACIDIFICATION

pH AND OCEAN ACIDIFICATION

pH is how acidic or basic the water is. pH is measured with litmus paper and compared on a scale of 0-14 with a color indicator. The pH of freshwater ranges from 6-8. Saltwater can be 8 or higher. pH levels that are below 6 or higher than 8.5 are considered dangerous for aquatic organisms. Organisms can only survive within a small pH range. Even small changes in pH have a large effect on organisms because the pH scale is logarithmic, meaning a one integer difference changes the concentration of a solution 10 times. For example, a pH of 6 is 10 times more acidic than a pH of 7, but a pH of 5 is 100 times more acidic than a pH of 7. Plants, soil, different organisms, acid rain, decomposing matter, freshwater inflow from precipitation and freshwater tributaries, and human activity all affect pH levels. Rapid changes in pH in a body of water indicate a serious pollution problem that could be from oil or other toxic chemicals entering the waterway. When the pH of a body of water changes too much, organisms will have to leave, or they will die. Movement of entire populations of aquatic organisms causes disruptions in ecosystems and food webs. These populations may even become a nuisance in their new environment, outcompeting other organisms for survival. Human activities, like burning fossil fuels to use for our transportation and energy needs, increases carbon dioxide (CO2) in the atmosphere. The world's oceans are considered a carbon sink, they absorb large amounts of CO2 from the atmosphere into the water, which improves air quality. But CO2 does not just disappear when it enters the water, it turns the water more acidic. Organisms with hard calcium carbonate shells like oysters, mussels, and other shellfish are very susceptible to pH changes. Baby oysters in their larval form, along with other shellfish, are not born with hard shells - they form them during the early stages of their life cycle. If the pH decreases and the water becomes more acidic, shellfish populations will decrease because they will not be able to form their protective shells and are unlikely to survive to be able to reproduce, because the calcium carbonate in their shells will dissolve in the more acidic water. Without a protective shell, oysters and other shellfish can easily become prey to other animals. Decreased shellfish populations disrupt food webs and impact humans who depend on shellfish harvesting for their income.

Directions: As you watch each video in this lesson, take notes so you are prepared for your class discussion. Watch these two videos and answer the questions on this page.

Watch:

- Acids, Bases, and the pH Scale (4:43)
- Brain Pop UK: pH Scale (3:58)

Questions:

What does pH have to do with aquatic environments?

List all marine animals you can think of that have a shell.

pH AND OCEAN ACIDIFICATION

EXPERIMENT: HOW DOES pH AFFECT AQUATIC ANIMALS WITH SHELLS?

Directions: Watch the video of the experiment How Does pH Affect Aquatic Animals with Shells?. After the experiment, watch the other videos listed, take notes, and answer the questions.

Discussion Questions:

What happened to the eggshell in the saltwater solution?

What happened to the eggshell in the saltwater and vinegar solution?

What does the eggshell represent in aquatic environments?

Watch:

- What is Ocean Acidification? A Crash Course (2:05)
- Ocean Acidification Explained in Two Minutes (2:19)
- What is Ocean Acidification? (3:17)
- ACE Science Short: Ocean Acidification (2:51)
- Demystifying Ocean Acidification and Biodiversity Impacts (12:12)

Questions:

What is ocean acidification (OA)?

What causes OA?

What is OA doing to marine life?

How can we stop or slow OA?

Watch:

- Science Today: Ocean Acidification (4:04)
- Oyster Farmers and Ocean Acidification (4:11)
- Acidifying Waters Corrode Northwest Shellfish (6:07)
- Aquatic Grass Could Help Shellfish Threatened by Ocean Acidification (5:28)

AT-HOME PROJECTS

Harbor 101

Check out the "Bay 101" video series and get inspired to create a short video about an issue impacting Baltimore's Inner Harbor. Topics might include a plant or animal species that lives in the harbor, animals that don't live in harbor water but depend upon it (such as birds of prey), watermen and other Bay jobs, Baltimore's Trashwheel Family or other trash removal measures, storm drains, waterways that feed into the harbor, or how pollutants make their way into our local waterways. Other issues can be found on this page, "Chesapeake Bay Issues." *This activity addresses turbidity, temperature, pH, dissolved oxygen and salinity issues.*

Vote with a Butt

During trash clean-ups, cigarette butts almost always account for the number one type of trash collected. Cigarette filters, the butts, are made of a plastic called cellulose acetate, and are not biodegradable. Students will start a "voting" campaign that will double as a cigarette butt collection site to help adults stop littering them. Students will pose a question with two answer choices. Questions should be about the environment or the watershed. Students will also research a fun fact or more information about each question. For example, if the question is "Do you prefer crab or rockfish?", students can research about the populations of each to post with the question. Students will create and oversee the voting stations, changing the questions and facts frequently, and emptying the butts into a sealable trash bag. Voting stations should be in a highly visible place where there are many butts on the ground already. Students will also research and post signs near the collection bins informing neighbors what happens to the watershed when cigarettes are tossed on the ground.

To create the butt collection bins, students will use two of something that are the same size, 5-gallon buckets, coffee cans, glass jars, 2-Liter soda bottles or gallon containers, PVC piping, etc. to collect the butts. Any sort of collection bin will need to have a secure lid with a small opening for the butts, must be secured to something, so it doesn't blow away and become litter itself, and include a small piece of metal or wood, or small container of sand, to stub out cigarettes, so they don't burn in the receptacle. *This project addresses pH issues.*

Public Service Announcement

Look for an issue that affects water quality in your neighborhood. Focus on the biggest problem you see, whether that is clogged storm drains, pet waste, bare soil or another issue you have learned about. Then, create and post a flier addressing the issue near the problem, and record a two-minute public service announcement (PSA) to drive home your message. Information to share in the PSA might include how making these changes benefits the community, why people should care, what a healthy harbor could mean for them and their family—and the consequences of doing nothing at all! Share your PSA with your class. Your teacher can post it to the school's website or social media accounts. *This activity addresses turbidity, temperature, pH, dissolved oxygen and salinity issues.*

NATIONAL AQUARIUM®

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

TEMPERATURE

TEMPERATURE

TEMPERATURE is how hot or cold the water is. Temperature is measured with a thermometer in degrees Celsius. Most fish have a specific temperature range they can survive within. If water temperature in an area changes suddenly because of an unseasonably hot or cold day, or from super-heated water from industrial locations, fish will be shocked by the quick change and likely die because they cannot adjust their body temperature as quickly. Water temperature increases drastically when a waterway is close to power plants or factories that use water to cool their machinery, making that water hot after it touches the hot equipment. This super-heated water is then pumped out into the closest waterway. Water temperature is also increasing more gradually due to rising air temperatures from climate change and global warming because of increased levels of carbon dioxide (CO2) in the atmosphere. Human activity, like burning fossil fuels to use for our transportation and energy needs, increases CO2 in the atmosphere. When a gradual temperature change happens, fish populations may move to water that is closer to their normal temperature range, but organisms like oysters or mussels, cannot move and may die if the water temperature gets too far outside of their range. Movement of entire populations of aquatic organisms causes disruptions in ecosystems and food webs. These populations may even become a nuisance in their new environment, outcompeting other organisms for survival. Warmer ocean water from rising global temperatures also produces more intense and more frequent hurricanes as the Earth tries to cool the oceans. Changes in temperature may also affect when different species hibernate and may cause disruptions in food chains if an animal is out of hibernation, but their food source has traveled somewhere else, is not out of hibernation, or has died. Temperature effects life cycle process like when fish start spawning or migrating, as well. Temperature can also affect the number of males or females that hatch in a clutch of eggs, with more females being hatched in warmer temperatures.

Directions: As you watch each video in this lesson, take notes so you are prepared for your class discussion. Watch these 3 videos and answer the questions on this page.

Watch:

- Taking the Ocean's Temperature (2:31)
- Measuring Ocean Temperatures (1:10)
- Scientists Discover Sea Temperatures Rising Faster than Previously Thought (2:34)

Questions:

How do scientists measure ocean temperature?

Why do they measure ocean temperature?

TEMPERATURE

EXPERIMENT: OCEAN TEMPERATURE AND CURRENTS

Directions: First, watch Temperature's Effect on Water Density and take notes so you are prepared for your class discussion. Then, watch the remaining four videos and then answer the questions on this page.

Watch:

- How do Ocean Currents Work? (4:33)
- How Changes in Temperature Create Ocean Climates (3:10)
- Thermal Expansion: The Dance of Rising Oceans (2:50)
- The Secret to Rising Sea Levels: Thermal Expansion (1:15)

Questions:

What is density? How does water temperature affect its density?

In the experiment, which type of water was on the surface? Why?

Which type of water was on the bottom? Why?

What causes ocean currents?

How does warmer water make sea levels rise?

Watch:

- Temperature Affects Dissolved Oxygen (1:09)
- Changing Chesapeake: Fish Facing Warmer Waters (3:11)
- From the Field: Could Blue Crabs Weather a Changing Climate? (3:41)
- Warming Oceans and Marine Species Migration (4:25)
- Role of Sea Ice Pt. 1 (2:09)
- Role of Sea Ice Pt. 2 (2:26)
- Role of Sea Ice Pt. 3 (2:26)
- Fuel for the Storm (2:19)
- Forecasting Sea Level Rise for Maryland (9:36)

AT-HOME PROJECTS

Wanted Poster, Missing Poster

People don't always realize that many actions they do, or don't do, in their own neighborhoods can have a big influence on water quality. Students will create wanted or missing posters for at least five different causes of poor water quality providing the community with information about what actions cause poor water quality and what they can do to improve it. Students may use the templates on the following pages or create their own.

Students will place their posters throughout the neighborhood. Teachers can also post them on the school's website or social media pages. If people are made aware of these actions, and if everyone makes small changes to their behaviors, it will have a positive impact on water quality in Baltimore. *This activity addresses turbidity, temperature, pH, dissolved oxygen, and salinity issues in Baltimore Harbor.*

Wanted Posters:

The "Description" will include why an action is bad or how it affects water quality, its impact on water quality, and where it was last seen. "Wanted for" will include why it is wanted and what water quality parameters it affects. "How can you help" will include all solutions and actions people can do to improve the problem. The "Reward" will not monetary but a reward for water quality. Rewards should be specific, not simply "better water quality"; rewards must list how the action will improve water quality and what specific parameters will improve.

Alternatively, for actions that are completely missing from their neighborhood that positively affect water quality, like rain barrels, students will create "Missing" posters.

Missing Posters:

"Important information and details" will include information about how the action positively affects water quality. "How can you help" tells people what they can do so the action or item is not missing anymore. The "reward" is how it improves water quality. For example, if large oyster populations are missing, the reward, if populations increase, is clearer water since they are filter feeders that help with turbidity. For "More information" students will provide information on companies or organizations who are helping with the action or can provide the item.

Students will have to research each of their chosen topics to find this information.

Students will also be responsible for "catching" any culprits of poor water quality when applicable. For example, if any student in the class does a poster on pet waste, all students will be responsible fo picking up pet waste and throwing it in the trash. Students will document every time they do an action that prevents poor water quality issues with a picture or video.

Causes of Poor Water Quality

- Not picking up pet waste
- Storm drains with trash or debris around them
- Low oyster or sea grass populations
- Bare soil
- Little to no green spaces
- Changing and improperly disposing of car fluids in the street
- Pouring oil or other chemicals down a storm drain
- Destruction of wetlands, riparian zones, and natural shorelines

AT-HOME PROJECTS

Causes of Poor Water Quality, continued

- Cutting down trees
- Degraded sewage pipes
- Soil erosion
- Too many impervious surfaces
- Increased CO2 emissions
- Cigarette butts on the ground
- Poor car maintenance
- Poor boat maintenance
- Improper disposal of oil, household cleaners, or other chemicals
- Flushing “flushable” wipes or anything besides toilet paper
- Downspouts that outlet onto impervious surfaces
- Leaves and grass clippings on paved surfaces
- Eroded stream banks
- Higher than normal air temperature
- Non-native and invasive plants
- No native plants in the area
- Acid rain
- Washing cars on the street
- No rain barrels
- Increased boat traffic

TEMPERATURE

WANTED

DESCRIPTION

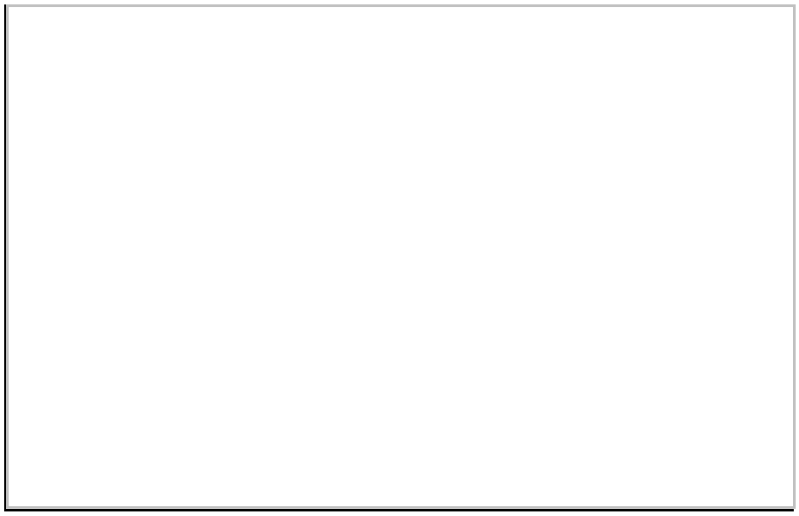
WANTED FOR

HOW YOU CAN HELP

REWARD

TEMPERATURE

MISSING



IMPORTANT INFORMATION AND DETAILS

HOW CAN YOU HELP?

REWARD

MORE INFORMATION

NATIONAL AQUARIUM®

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

SALINITY AND WATER DENSITY

NATIONAL AQUARIUM

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

SALINITY AND WATER DENSITY

SALINITY is the amount of dissolved salts in the water. It is measured with a salinity probe or a hydrometer and measured in parts per thousand (ppt). Freshwater is 0 ppt, estuaries range from 5-30 ppt, and saltwater is about 35 ppt. A reading of 40 ppt is considered lethal to most organisms. Precipitation affects salinity the most. If there is a period of drought, when there is no precipitation, the salinity level in a body of water will be higher, being less diluted from fresh water. Similarly, if there is above average precipitation, the water will become fresher. Human activities, like burning fossil fuels to use for our transportation and energy needs, can also affect salinity levels. Burning fossil fuels accelerates climate change, creating more intense weather events like more severe droughts in some areas, that can increase salinity, and more intense hurricanes in other areas, that can decrease salinity. Higher global air temperatures, also from climate change, causes more water to evaporate, leaving behind the salts and making water saltier. More acid rain, from more carbon dioxide (CO_2) in the atmosphere will cause more corrosion of rocks on land, making more salt minerals available in the watershed. In winter, the salinity level in some small freshwater creeks and streams can rise due to large amounts of de-icing salt used on roadways and washed into storm drains that empty out into those bodies of water. The Chesapeake Bay is an estuary, with a mix of salt and freshwater, getting saltwater from the Atlantic Ocean and freshwater from rivers, streams, and creeks. Most aquatic animals can only tolerate living in one kind of water, salty, fresh, or brackish, but some animals can travel to areas of different salinity depending on what stage of their life cycle they are in, like juveniles or spawning fish. The farther north you are in the Chesapeake Bay watershed, the fresher the water is because it is farther from the Atlantic Ocean. Oysters need saltier water to survive, which is why it is uncommon to have oysters growing in Baltimore Harbor, as the water is too fresh this far north and oysters need a saltier habitat to thrive. However, oyster populations further south can be affected by too much precipitation that turns the water too fresh for them to survive.

Directions: As you watch each video in this lesson, take notes so you are prepared for your class discussion. Watch these 3 videos and answer the questions on this page.

Watch:

- Billy Blue Hair: Why is the Ocean Salty? (5:15)
- Colossal Questions: Why is the Ocean Salty? (2:46)
- Why is the Sea Salty? (3:11)

Questions:

How does salt get into the ocean?

Where is the water too salty for animals or plants to live?

What is the average percentage of salt in ocean water?

What is easier to do in saltier water?

SALINITY AND WATER DENSITY

EXPERIMENT: SALINITY AND DENSITY

Directions: Watch the National Aquarium video Salinity and Density. After you watch the experiment, watch the other videos listed below while taking notes so you can answer the questions that follow.

Watch:

- Aquarius Ocean Circulation (1:58)
- One Year Observing the Salty Seas (3:17)
- Bill Nye the Science Guy on Ocean Currents (2:08)

Questions:

What is salinity? What is density? What does salinity have to do with density?

Is saltwater or freshwater more dense? Why?

What did the experiment show?

What happened when the instructor started with freshwater and poured in saltwater?

What happened when the instructor started with saltwater and poured in freshwater?

What are scientists using to detect ocean salinity across the entire globe?

Where is water saltier than in other places? Why? Where is it fresher? Why?

Watch:

- Impact on Oysters (2:49)
- Why Fish Can Drink Salt Water and We Can't (4:09)
- Salinity (6:21)
- Why Can't we Drink the Ocean? (3:32)
- The Basics of Freshwater (4:16)
- Aquatic Ecosystems (4:17)

Additional Salinity Experiments:

- Sea Water Experiment (2:59)
- Ocean Currents (2:33)

SALINITY AND WATER DENSITY

AT-HOME PROJECTS

Your Civic Duty

You are a citizen of your neighborhood, city, state, and country and can influence policy with persuasive arguments. Students will research proposed laws or actions that will affect the water quality of Baltimore Harbor. Students will research a topic, plan arguments, and present all evidence in favor of or against the action they choose, depending on its environmental impact. Students will communicate with community leaders or local government about these issues through letters or video messages. Research topics include planned construction near the harbor, trash or pollutant removal or containment measures, stream/living shoreline/wetland restoration, major pollution sources (like storm drain outlets or factories), product/substance bans or regulations, fishing regulations, etc. Your communication must include your position or argument on the action, all evidence that supports your argument to show the benefits or consequences of these plans in action, any solutions you have found, actions that are already happening, and how the action will affect your chosen water quality parameter. Students can choose different actions that they want to address individually, or you can decide on one action as a class. Teachers will determine which committee, representative, etc. is best to send the letters or videos to. Teachers can post student work and any return mail the class receives on the school's website or social media page. *This project addresses turbidity, temperature, pH, dissolved oxygen, or salinity issues.*

Watermen

Do some research on watermen from the Chesapeake Bay area. What is a waterman? Why are they important to Baltimore and the Chesapeake Bay? What challenges are they facing? What successes have they created? Then, think about how water quality affects watermen and their jobs. Are they fishing for different things in different areas? What are they fishing near Baltimore? If possible, see if you can interview a waterman (or woman!), or participate in a webinar with local watermen. Using what you've learned, create thoughtful interview questions.

Visit the Maryland Watermen's Association website for more ideas and resources. Discuss what you've learned with your class. You can choose to show your watermen knowledge with a essay, poster, video, or speaking presentation. Teachers can post presentations on the school's website to educate a wider audience. *This activity addresses turbidity, temperature, pH, dissolved oxygen, and salinity issues.*

SALINITY AND WATER DENSITY

AT-HOME PROJECTS

Oyster Expert

Oysters are a keystone species in the Chesapeake Bay. Do your research to become oyster experts! Find answers to questions like: What is a keystone species? What do oysters and oyster reefs provide? What can oyster shells be used for? What water quality parameters are affecting oysters? What parameters are the oysters affecting? What would happen if there weren't any more oysters in the Bay? How can we protect and increase oyster populations? How do sustainable fishing practices impact oysters? Are Marylanders acting sustainably in how they manage oysters as a food source? Are there any laws that protect oysters? Do we need new, different or better laws? Do you like to eat oysters? Do you have a favorite oyster recipe? Choose a suitable method to present your new expertise. Some options might include video clips, a digital poster or a persuasive written essay. Whatever you choose, include a visual representation of oyster anatomy, including what body part they use to improve turbidity, how their shells might change if the water pH changes, and how salinity effects where they can live. Share what you've learned with your class—and spread the word about the importance of oysters with your family or community! Teachers can post presentations on the school's website to educate a wider audience. *This activity addresses turbidity, pH, dissolved oxygen, and salinity issues.*

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

ASSESSMENT

It will be helpful to create a code to keep track of what you tell us without knowing your name. Please put the first letter of your first name, first letter of your last name, and the numbers for the month and day of your birthday in the boxes below, like the example:

	First letter of your first name	First letter of your last name	Month of your birthday	Day of your birthday
Example: Sophia Jackson, born on May 12th	S	J	5	12
Your first and last initials and birthday code				

1. What is a watershed?

a. ◯ All the bodies of water in one area
b. ◯ All the land that drains rainwater into a body of water at the lowest point
c. ◯ The water in storm drains
d. ◯ A garage where you store water

2. What watershed do you live in?

a. ◉ Potomac River Watershed
b. ◯ Susquehanna River Watershed
c. ◯ Chesapeake Bay Watershed
d. ◯ Delaware Bay Watershed

3. Name the 6 states and one district that are part of this watershed (Choose all that apply).

a. ☐ Maryland
b. ☐ Ohio
c. ☐ New York
d. ☐ New Jersey
e. ☐ Pennsylvania
f. ☐ Virginia
g. ☐ North Carolina
h. ☐ Washington DC
i. ☐ West Virginia
j. ☐ Delaware

4. How many square miles is the Chesapeake Bay Watershed?

a. ◯ 64,000 square miles
b. ◯ 1,000,000 square miles
c. ◯ 2 square miles
d. ◯ 50,000 square miles

5. What are the 4 smaller watersheds in Baltimore city? (Choose all that apply.)

a. ☐ Herring Run
b. ☐ Curtis Bay
c. ☐ Masonville Cove
d. ☐ Gwynns Falls
e. ☐ Jones Falls
f. ☐ Patapsco River
g. ☐ Baltimore Harbor
h. ☐ Stoney Creek

6. What is an estuary?

a. ◯ A saltwater lake
b. ◯ An area of land that drains into the water
c. ◯ A freshwater stream
d. ◯ A somewhat enclosed body of water that gets freshwater from streams and groundwater and saltwater from the ocean

ASSESSMENT

7. Why is an estuary a good habitat?

a. ◯ It has a lot of plant life because it receives a lot of nutrients from the land
b. ◯ It acts like a nursery for young animals, providing them with protection
c. ◯ There is lots of food available
d. ◯ All of the above

8. Brackish water is a mix of _____ and _____ water.

9. Name four animals that can live in the Baltimore Harbor.

a. ☐ Blue crab
b. ☐ Lionfish
c. ☐ Oyster
d. ☐ Horseshoe crab
e. ☐ Mummichog
f. ☐ Menhaden
g. ☐ Atlantic sea nettle
h. ☐ Atlantic sturgeon

10. What can cause high turbidity, making it harder for light to reach the bottom where plants grow?

a. ◯ Dirt washing into the Baltimore Harbor from land
b. ◯ Oysters filtering the water
c. ◯ Higher salinity causes higher turbidity
d. ◯ Too many fish in the water

11. Where does dissolved oxygen come from?

a. ◯ Wind and wave action that traps oxygen from the air
b. ◯ Fish breathing
c. ◯ Algae and plants under the water photosynthesizing
d. ◯ Both A and B
e. ◯ Both A and C
f. ◯ All of the above

12. Match the water quality parameter with its definition.

a. Temperature _____
b. pH _____
c. Turbidity _____
d. Dissolved Oxygen _____
e. Salinity _____

A. The amount of dissolved salts in water
B. How acidic or basic the water is
C. How hot or cold the water is
D. How clear or cloudy the water is
E. The amount of oxygen dissolved into the water available for aquatic animals

13. What actions can you do to keep the waters in Baltimore and the Chesapeake Bay healthy? (Choose all that apply.)

a. ☐ Keep storm drains clear of trash and debris
b. ☐ Pick up and throw away pet waste in a trash can
c. ☐ Plant grass, trees, or gardens to hold in soil
d. ☐ Walk, ride a bike or carpool to reduce carbon dioxide (CO_2) emissions
e. ☐ Paint storm drains with messages about where stormwater goes
f. ☐ Install rain barrels to downspouts on homes and buildings
g. ☐ Don't pour things like motor oil or soap down storm drains
h. ☐ Write to the government and community leaders to express your concern for the health of the Baltimore Harbor
i. ☐ Tell everyone you know how important the Chesapeake Bay is and what we can all do to help

NATIONAL AQUARIUM

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

ASSESSMENT

Tell us what you think about the following statements. Check the box that shows whether you think the statement is true or false, or you may check "I don't know."

	TRUE	FALSE	I DON'T KNOW
a. Blue crabs like to live in water with high turbidity			
b. Water quality impacts plants and animals living in the harbor			
c. All animals living in water need dissolved oxygen to survive			
d. Salinity is the level of salt dissolved in water			
e. A Secchi disk is used to measure dissolved oxygen			
f. Trash on the streets ends up in the storm drain and eventually in the harbor			
g. The quality of the water in rivers, lakes, and the ocean can affect the health of people living near them			
h. Actions done in your neighborhood can influence the water quality in Baltimore harbor			

NATIONAL AQUARIUM

What Lives in the Harbor

REMOTE LEARNING FOR STUDENTS

GLOSSARY*

ACID/ACIDIC A chemical substance that neutralizes alkalis, dissolves some metals and turns litmus red, typically, a corrosive or sour-tasting liquid; having a pH of less than 7

AGRICULTURE The science of farming, including cultivation of the soil for growing crops and rearing of animals for food and other animal-based products

ALGAE A simple, non-flowering, typically aquatic plant from a large group that includes seaweeds and many single-celled forms. Algae contain chlorophyll but lack stems, roots, leaves and vascular tissue

ALGAL BLOOM Rapid growth in the population of algae in a body of water, resulting in a discoloration of the water

ALKALINE See *Base*

ARGO A global array of free-drifting floats that measure the temperature and salinity of the upper 2,000 meters of the ocean

ARTHROPOD An invertebrate animal of the larger phylum Arthopoda such as an insect, spider, or crustacean

ATMOSPHERE The layer of gasses surrounding Earth composed mainly of nitrogen and oxygen

BACTERIA Single-celled microorganisms that have cell walls but no organelles or organized nucleus that are either free-living or grow on and derive nourishment from dead or decaying organic matter

BAY-SCAPING A landscaping practice using plants native to the Chesapeake Bay Watershed

BIODIVERSITY The variety of life on Earth or in a particular habitat or ecosystem

BODY OF WATER Any significant amount of water including oceans, bays, harbors, rivers, wetlands, streams and creeks

BRACKISH WATER A mix of salty and fresh water found in estuaries

CALCIUM CARBONATE A white insoluble solid occurring naturally as chalk, limestone, marble and calcite, which forms mollusk shells and stony corals.

CARBON DIOXIDE (CO2) A colorless, odorless gas produced by respiration and by burning carbon and other organic compounds; A naturally occurring gas present in the air and absorbed by plants during photosynthesis

CHESAPEAKE BAY WATERSHED Over 64,000 square miles of land that surrounds one of the world's largest estuaries (the Chesapeake Bay), including portions of six states (Maryland, Virginia, New York, Pennsylvania, Delaware, West Virginia) and Washington D.C.

CLIMATE The weather conditions prevailing in an area in general over a period of 20 to 30 years or more

CLIMATE CHANGE A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards attributed largely to the increased levels of atmospheric carbon dioxide produced by human use of fossil fuels

COMMUNITY SCIENCE Scientific data, observation, etc. that involves non-scientists sharing information with scientists for research purposes

COMMITTEE A group of people appointed for a specific function, usually consisting of members from a larger group

COMPACTED SOIL[1] Soil particles that are pressed together reducing pore space between them, containing few large pores and having a greater density, reducing the rate of water infiltration and drainage

CONSERVATION LANDSCAPING Gardening and landscaping practices that replace turf grass, non-native plants or impervious surfaces with native plants to improve water quality and provide habitat for native wildlife

CYANOBACTERIA A division of microorganisms that are related to bacteria but capable of photosynthesis

DAM A barrier constructed to hold back water and raise its level, forming a reservoir used to generate electricity or create a water supply

DATA COLLECTION SHEET Document used to collect and organize data from an experiment or observation

GLOSSARY CONTINUED

DEAD ZONE A place in which no life exists

DEBRIS Discarded trash or garbage, broken pieces of rock or pavement, or natural elements like sticks or leaves found in water

DECAY Rot or decompose through the action of bacteria or fungi

DECIMETER A metric unit of length, equal to one-tenth of a meter, or 10 centimeters

DECOMPOSITION The state or process of rotting, decay

DEPOSITION[2] Suspended particles settling down to the bottom of a body of water

DIFFUSION Movement of particles from an area of high concentration to an area of low concentration

DINOFLAGELLATE A single-celled organism, occurring in large numbers in marine plankton and also found in fresh water; some produce toxins

DISCHARGE To force or allow a liquid, gas or other substance out from where it was confined

DISSOLVED OXYGEN The amount of oxygen present in the water coming from the atmosphere, aquatic plants, and the flow of water

DISSOLVED SOLIDS/PARTICLES[3] Refers to any mineral, salt, metal, cation, or anion dissolved in water

DNR[4] The Department of Natural Resources is responsible for enforcing environmental and conservation laws and policies specific to each state

DOWNSPOUT A pipe used to carry rainwater from a roof to a drain or to ground level

DOWNSPOUT DISCONNECT Separating roof downspouts from the sewer system and redirecting the run-off water to pervious surfaces like a garden or lawn

DOWNSTREAM Situated or moving in the direction in which a stream or river flows

DPW[5] The Department of Public Works is responsible for a city's infrastructure services including sewer maintenance and operations, sanitation, street maintenance, storm water operations, emergency weather response and severe weather mitigation

ECOSYSTEM A biological community of interacting organisms and their physical environment

ENVIRONMENTAL STRESS[6] Physical, chemical and biological constraints on the productivity of a species or on the development of ecosystems

ENVIRONMENTALLY FRIENDLY Earth friendly; not harmful to the environment

EROSION Displacement of rock, soil or dissolved material from one area of earth's surface to another by wind, water or other natural agents

EROSION MODEL A model demonstrating the effects of rainwater on a biological surface

ESTUARY Partially enclosed body of brackish water with freshwater streams and/or rivers flowing into it and open to the sea at the mouth

EUTROPHICATION Excessive richness of nutrients in a body of water, frequently due to runoff from the land, which causes a dense growth of plant life on the water's surface and the death of animal life due to lack of oxygen

EVIDENCE Available facts and information indicating whether a belief or proposition is true

FERTILIZER A chemical or natural substance added to soil or land to increase its fertility

FISH KILL Localized death of fish populations usually associated with very low levels of dissolved oxygen in a body of water

FLOOD PLAIN An area of low-lying ground adjacent to a river or stream, formed mainly by river sediments and subject to flooding

FLOW OF WATER The amount of water flowing per a unit of time

FORESTATION Establishing tree growth

FOSSIL FUELS A fuel such as coal or gas, formed in the geological past from the remains of living organisms

FRESHWATER Water with less than 0.5 parts-per-thousand dissolved salts

GLOSSARY CONTINUED

GEOTAG Data embedded in a digital media file to indicate geographical information, like latitude and longitude, about a subject

GIS (GEOGRAPHIC INFORMATION SYSTEM) Presents layers of information into 3D images and maps

GLACIER A slow moving mass or river of ice formed by the accumulation and compaction of snow on mountains or near Earth's poles

GLOBAL CONVEYOR BELT A constantly moving system of deep-ocean circulation driven by temperature and salinity

GLOBAL WARMING A gradual increase in the overall temperature of global oceans and land masses generally attributed to increased levels of carbon dioxide, chlorofluorocarbons and other pollutants trapped within the earth's atmosphere

GREENHOUSE EFFECT The trapping of the sun's warmth in Earth's lower atmosphere due to the greater transparency of the atmosphere to visible radiation from the sun than to infrared radiation emitted from the planet's surface

GREENHOUSE GASES A gas, such as carbon dioxide, that contributes to the greenhouse effect by absorbing infrared radiation (heat)

GROUND COVER Low growing, spreading plants, or a spread of organic material like mulch or crop residue left over after a harvest

GROUNDWATER Water held underground in rock crevices or in the soil

GULF STREAM A warm ocean current flowing north from the Gulf of Mexico along the east coast of the US

HABITAT A natural home or environment of a plant, animal or other organism

HEADWATERS A tributary stream close to or forming part of a river's source

HYDROGEN A colorless, odorless, highly flammable gas; chemical element of atomic number 1

ICE CAP A covering of ice over a large area, especially on the polar region of a planet

ICE SHEET A permanent layer of ice covering an extensive tract of land, especially a polar region

IMPAIRED WATERWAY[7] A lake, river or stream that fails to meet specific water quality standards, according to its classification and intended use

IMPERVIOUS SURFACE Mostly man-made structures such as asphalt, concrete, brick and rooftops that are waterproof and not soaking in water or cannot absorb water (in urban areas, this may include compacted soil)

INFORMED DECISION A decision made based on facts or information

INVASIVE SPECIES[8] An organism that causes ecological or economic harm, or harm to human, animal or plant health, within a new environment where it does not naturally occur

INVERTEBRATE An animal lacking a backbone, such as an arthropod or mollusk, comprising more than 90% of animal species

KEYSTONE SPECIES A species on which other species in an ecosystem largely depend, such that if it were removed the ecosystem would change drastically

LANDFORM A natural feature of the earth's surface

LANDSCAPE All the visible features of an area of land

LEAF COVER A type of naturally occurring ground cover consisting of fallen leaves in various states of decomposition

LIGHT PENETRATION How deeply light can penetrate into a medium

LITMUS PAPER Paper treated with litmus which is used to indicate the acidity or alkalinity of a substance (blue litmus paper turns red under acidic conditions; red litmus paper turns blue under alkaline conditions)

LIVING MULCH[9] Low-growing ground cover that adds nutrients to soil, enhances soil quality, decreases weeds and prevents soil erosion

LIVING SHORELINE A protected and stabilized coastal edge made of natural materials like plants, sand and rock that grows over time to protect marsh areas or against shoreline erosion

MACRO-INVERTEBRATE[10] An animal lacking a backbone that is big enough to see without the aid of a microscope

GLOSSARY CONTINUED

MANURE Animal dung used for fertilizing land

MOLLUSK An invertebrate of a large phylum which includes snails, slugs, mussels and octopuses that have a soft, unsegmented body and live in damp or aquatic habitats; most of these animals have an external calcareous (containing calcium carbonate) shell

MULCH Material such as decaying leaves, bark or compost spread around or over plants to enrich or insulate the soil

MURKY Dark and dirty, not clear

MWEE (Meaningful Watershed Educational Experience) An environmental literacy education practice that is student driven to facilitate learning with curriculum anchors and real-world application. Showing students how to become stewards for the environment and become more involved in their own education. Parts of a MWEE include issue definition, outdoor field experience, synthesis and conclusions, and stewardship and civic action.

NATIVE SPECIES A species that normally lives and thrives within a particular ecosystem

NEUTRAL pH A pH reading of 7 on a scale of 0-14

NITROGEN A chemical element (atomic number 7); a colorless, odorless, unreactive gas that forms about 78% of the Earth's atmosphere

NOAA[11] (National Oceanographic and Atmospheric Administration) NOAA is responsible for conserving and managing coastal and marine ecosystems and resources through the understanding of changes in climate, weather, oceans and coasts

NON-NATIVE SPECIES[12] A Species that occurs outside of its natural range or ecosystem

NONPOINT-SOURCE POLLUTION A pollution source that is difficult to identify because it comes from many sources all at once

NON-POTABLE Usually referred to water that is not suitable for drinking

NTU[13] Nephelometric Turbidity Unit is the unit used to measure the turbidity of a fluid or the presence of suspended particles in water

NUTRIENTS Substance essential for growth and sustainment of life

OCEAN ACIDIFICATION[14] A reduction in the pH of the ocean over an extended period of time caused primarily by uptake of carbon dioxide (CO2) from the atmosphere

OCEAN CURRENT A body of water moving in a definite direction, especially through a surrounding body of water in which there is less movement

- **DEEP OCEAN CURRENT** Movement within the bottom 90% of the ocean, mostly driven by changes in density caused by temperature and salinity changes (also known as Thermohaline Circulation)
- **SURFACE CURRENT** Movement within the top 10% of the ocean, mostly driven by wind

ORGANIC MATTER Any plant, animal, or soil matter

OSMOSIS The process by which molecules of a solvent pass through a semipermeable membrane from a more concentrated solution into a less concentrated one, thus equalizing the concentration on each side of the membrane

OXYGEN DEPLETION The reduction in concentration of dissolved oxygen in water, especially as a result of pollution

OYSTER Bivalve mollusks with rough, irregular shells that are frequently harvested as a food source or for their ability to grow pearls

PERMEABLE SURFACE (Porous or Pervious Surface) A surface that allows water to percolate into the soil in order to filter out pollutants

pH Stands for the "potential of Hydrogen" which refers to a substance's potential to make charged hydrogen atoms called ions

pH INDICATOR A compound that changes color at a specific pH value or in the presence of a particular substance and can be used to monitor acidity, alkalinity or the progress of a reaction

GLOSSARY CONTINUED

PH SCALE The scale that measures how acidic or basic a solution is on a scale of 1 to 14; solutions measuring 0-1 are extremely acidic, a pH reading of 7 indicates neutral pH, a reading of 13-14 indicates extremely basic pH; household examples include vinegar (pH 2), tomato juice (pH 4), milk (pH 6), baking soda (pH 9), and bleach (pH of 13)[15]

PHOSPHORUS A chemical element (atomic number 15); a poisonous, combustible nonmetal which exists in two common forms

PHOTOSYNTHESIS The process by which green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water

PHYTOPLANKTON Plankton consisting of microscopic plants

POINT-SOURCE POLLUTION[16] Easily identifiable source of pollution coming from a single source such as a pipe connected to a factory

POLICY A course of action proposed by a government, party, business or individual

POLICY MAKER Anyone who creates ideas and plans carried out by a government or business

POLLUTANTS A substance that enters the water, land or atmosphere and has undesirable effects on the resource

PONDING Water collecting in a large puddle

POOL A deep place in a river

PRECIPITATION Atmospheric water vapor that falls from clouds in the form of rain, snow, sleet or hail

PROBE To physically explore or examine something with an instrument

PTEROPOD A small mollusk with wing-like extensions of its body which it uses for swimming

RAIN BARREL Vessel used to collect and store rainwater run-off

RAPIDS A fast-flowing and turbulent section of the course of a river

RELEASE VALVE A valve used to control or limit the pressure of water coming from a pipe or hose

RESPIRATION A process in living organisms involving the production of energy, typically with the intake of oxygen and the release of carbon dioxide from the oxidation of complex organic substances

RIFFLE A rocky or shallow part of a stream with rough water

RIPARIAN BUFFER[17] Natural vegetation on the edge of a stream or riverbank serving as a buffer to pollutants entering a body of water from runoff; controls erosion, and provides habitat and nutrient input into the stream

RIPARIAN ZONE[18] Areas bordering rivers and other bodies of surface water, inclusive of a floodplain and riparian buffers

RIVER MOUTH The place where a river enters the sea

RUN-OFF Draining away of water from a surface

SALINITY Amount of salt dissolved in a body of water

SECCHI DISK A tool used to measure the water transparency, or turbidity, of a body of water

SEDIMENT/SEDIMENT PARTICLES Natural material broken down by erosion or weathering and transported by wind, water or ice

SEDIMENTATION The process of settling or being deposited as sediment (see *Deposition*)

SEINING Catching organisms with a net called a seine

SERC[19] The Smithsonian Environmental Research Center is a multidisciplinary, collaborative, and academic campus committed primarily to coastal research including water quality

SEWAGE Wastewater and excrement conveyed in sewers

SEWAGE PIPE Pipes that are connected to households and buildings that carry wastewater to a sewage/wastewater treatment plant. This is a separate system from storm drain pipes

SOIL CONSERVATION Prevention or reduction of soil erosion and depletion by protective measures against water and wind damage

SOIL EROSION Wearing away of topsoil by wind or water

GLOSSARY CONTINUED

SOIL QUALITY[20] The capacity of soil to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation

SOLUTION A liquid mixture in which the minor component (the *solute*) is uniformly distributed within the major component (the *solvent*)

STAGNANT WATER/STANDING WATER A body of water that is not flowing or running

STORM DRAIN Piping infrastructure designed to quickly move excess ground or rainwater away from impervious surfaces

STORM FLOW Rainwater runoff

STORM SURGE A rising of the sea as a result of atmospheric pressure changes and wind associated with a storm

STORMWATER (Rainwater) Water that originates from precipitation including rain, snow and ice melt

STORMWATER MANAGEMENT An effort to reduce stormwater run-off to improve water quality

STREAM ECOLOGY[21] The study of aquatic species, the way they interrelate, and their interactions with all aspects of flowing water systems

STREAM RESTORATION[22] Use of bioengineering practices, native material, channel stability structures and/or the restoration or management of riparian corridors to restore the natural function of the stream corridor and improve water quality by reducing sedimentation from the streambank

STREAM TABLE A sloped table-like structure containing sand or soil, with a water flow source at the top and drainage at the bottom, simulating stream flow with different variables

SUBMERGED AQUATIC VEGETATION (SAV) Rooted plants that grow completely underwater

SUBSOIL Soil layer under topsoil

SUSPENDED SOLIDS/PARTICLES[23] Small solid particles that remain suspended in water, used as an indicator of water quality

TEMPERATURE How hot or cold something is

TESTIMONY A formal written or spoken statement, especially in a court of law

THERMOHALINE CIRCULATION A deep ocean current driven by differences in water density controlled by temperature and salinity (*Thermo* refers to temperature and *haline* refers to salt)

THERMOMETER An instrument for measuring and indicating temperature

TIDE The alternate rising and falling of the sea, usually twice in each lunar day at any particular place, due to the gravitational attraction of the moon and sun

TOPOGRAPHY The arrangement of both natural and artificial physical features of a particular area

TOPSOIL The top layer of soil where most nutrients are found

TOTAL MAXIMUM DAILY LOAD (TMDL)[24] The calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant

TURBIDITY Cloudiness or haziness of a liquid influenced by the number of particles suspended in the water

- **HIGH TURBIDITY** Water with more suspended solids and less light penetration
- **LOW TURBIDITY** Water with fewer suspended solids and more light penetration

TURBIDITY TEST A test using a Secchi Disk, turbidity tube or turbidimeter to determine the clarity or cloudiness of water, measured in NTUs

TURBIDITY TUBE A measured tube with a Secchi Disk at one end to measure turbidity in a stream

TURBULENT Unsteadily or violently moving

UPSTREAM Opposite direction in which a stream or river flows, nearer to the source

WASTEWATER/SEWAGE TREATMENT PLANT A facility that removes impurities and contaminants from sewage or wastewater before returning it to a natural body of water

WATER CLARITY See *Turbidity*

WATER COLUMN A vertical expanse of water between the surface and the floor of a body of water

GLOSSARY CONTINUED

WATER EROSION Removal of soil and sediment by water

EPHEMERAL EROSION Erosion that ccurs on the same area of a slope, usually in well-defined depressions

GULLY EROSION Erosion which creates channels too deep for normal tilling that require special operations to fill

RILL EROSION[25] Erosion that occurs on different areas of a slope and can be remediated with tilling

SHEET EROSION[26] Uniform removal of soil in thin layers by rain and overland flow

STREAMBANK EROSION[27] A natural process that occurs when the forces exerted by flowing water exceed the resisting forces of bank materials and vegetation

WATER QUALITY The condition of water relating to chemical, biological and physical characteristics as they relate to its suitability for drinking or swimming

WATERSHED An area of land where precipitation collects and drains into a common body of water

WATERSHED RESTORATION Human intervention to return a marine ecosystem to its pre-damaged state

WATERWAY See *Body of Water*

WAVE ACTION Open water curling into an arched form and breaking on the shore

YARD WASTE Any dead plant matter like leaves, sticks, grass clippings, plant stalks, etc.

ZOOPLANKTON Plankton consisting of small animals and the immature stages of larger animals

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* All definitions from www.dictionary.com unless otherwise noted
[1] https://extension.umn.edu/soil-management-and-health/soil-compaction
[2] https://www.fondriest.com/environmental-measurements/parameters/hydrology/sediment-transport-deposition/
[3] https://water-research.net/index.php/water-treatment/tools/total-dissolved-solids
[4] https://learn.org/articles/What_Does_a_Conservation_Officer_Do.html
[5] https://www.govtjobs.com/government-job-descriptions-samples/public-works-director-job-description/
[6] https://science.jrank.org/pages/6549/Stress-Ecological.html
[7] http://www.lake.wateratlas.usf.edu/shared/learnmore.asp?toolsection=lm_impairment
[8] https://www.nps.gov/subjects/invasive/learn.htm
[9] https://www.gardeningknowhow.com/edible/grains/cover-crops/living-mulch-ground-cover.htm
[10] https://www.britannica.com/animal/macroinvertebrate
[11] https://www.noaa.gov/about-our-agency
[12] https://www.nps.gov/subjects/invasive/learn.htm
[13] https://www.tecnoconverting.com/technical-articles/what-is-ntu/
[14] https://oceanservice.noaa.gov/facts/acidification.html
[15] https://www.sciencebuddies.org/science-fair-projects/references/acids-bases-the-ph-scale
[16] https://www.nationalgeographic.org/encyclopedia/point-source-and-nonpoint-sources-pollution/
[17] https://dep.wv.gov/WWE/getinvolved/sos/Pages/RiparianMagic.aspx
[18] https://allaboutwatersheds.org/library/kyw-poster-files-and-links/riparian-zone
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[25] https://efotg.sc.egov.usda.gov/references/public/WI/Gully_Erosion_Prediction.pdf
[26] https://milford.nserl.purdue.edu/weppdocs/overview/sheet.html
[27] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ks/newsroom/features/?cid=nrcs142p2_033508