BOP CCERS Curriculum

National Science Foundation

Index

A New York City Water Cycle

BOP Curriculum
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Apr 9, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	2	Classroom	Science

Summary

Students will go outdoors to observe and document the water cycle in motion where they live. Students will also discover how they and their community impact not only the movement of water through the cycle, but also the water quality.

Objectives

- Describe the movement of water through the water cycle.
- Understand that water changes states when it gains energy from the sun or loses energy to the environment.
- Understand that gravity causes water to move downhill and to precipitate from the clouds.
- Create a model of the water cycle using the original pictures of water in the act of precipitating, infiltrating, condensing, running off, evaporating and transpiring.

Materials and Resources

Supplies

- sticky notes (one pad per group)
- colored markers
- projector cameras
- buckets of water (if weather is uncooperative)
- water sprayers (if weather is uncooperative)
- printed student photographs and poster board/paper OR presentation software (e.g. Prezi, PowerPoint)

Before you get started

Tips for Teachers

Students will take their own photographs and then construct a water cycle diagram. If you plan on printing out the pictures and having the students arrange them on posterboard, you could consider having groups of 4-5. If the students will be using digital photographs arranged on something like Powerpoint or Prezi you should consider having students work in pairs. Consider whether you want a standard water cycle diagram available for students to look at any point in this lesson.

Background

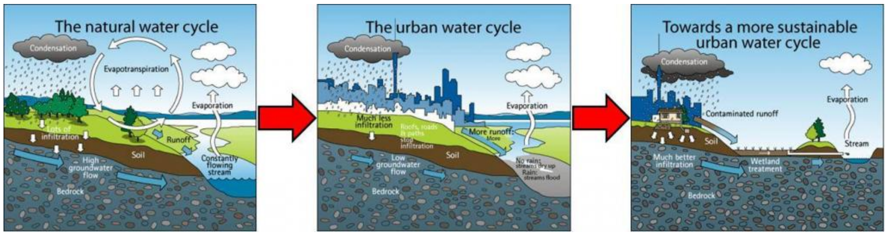
The water cycle has no starting point. But, we'll begin in the oceans, since that is where most of Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapor into the air. Ice and snow can sublimate directly into water vapor. Rising air currents take the vapor up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapor rises into the air where cooler temperatures cause it to condense into clouds.

Air currents move clouds around the globe, cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snowpacks in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt.

Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff and groundwater seepage accumulate and are stored as freshwater in lakes. Not all runoff flows into rivers [and lakes], though. Much of it soaks into the ground as infiltration. Some water infiltrates deep into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time.

Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge, and some groundwater finds openings in the land surface and emerges as freshwater springs. Over time, though, all of this water keeps moving, some to re-enter the ocean, where the water cycle "ends" ... oops - where it "begins."

Source: http://water.usgs.gov/edu/watercyclehi.html

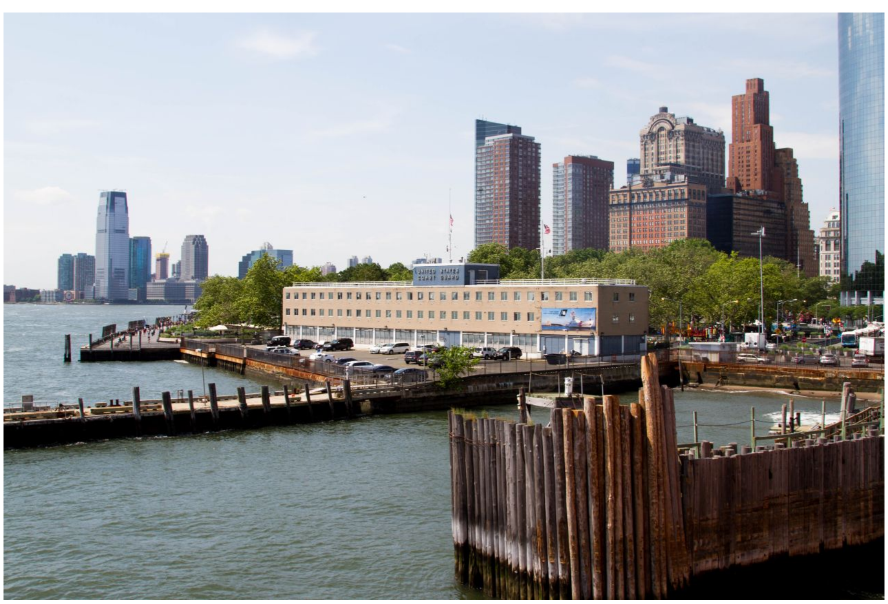


Source: http://www.sswm.info/category/implementation-tools/wastewater-collection/hardware/surface-runoff/stormwater-management

Instruction Plan

Engage

1. Ask students the following questions:
    - What is precipitation?
    - What types of precipitation are there?
    - What types of precipitation do we experience living here in NYC?
    - Which state is water in for each type of precipitation you named?
2. Divide students into small groups. Give each group a stack of sticky notes and colored markers (each group gets a different color to write with).
3. Groups brainstorm what happens to the precipitation that falls here. Where does the water go? How does it get there?
4. Students write each idea on a separate sticky note.
5. Bring the class back together.
6. Project the below image (or a similar image that shows a NYC scene with road, water, buildings and park) in front of the class.
7. Facilitate groups/students coming up to the image and posting their sticky note on the photo. (e.g. “rain” could go in the sky, “runoff” could go by the edge of the dock, “infiltration” could go by the trees, etc.)
8. Recap the students’ ideas. For example, “Rain falls onto the grass in the parks and infiltrates the soil. Rain falls onto the street and runsoff the edge of the dock into the harbor.” Help the students understand that their sticky notes are all part of the water cycle.
9. Have a set of water cycle sticky notes pre-written before class. Fill in any gaps that the students missed (e.g. transpiration) and explain where it fits into the water cycle.



Explore

1. Students will go outdoors and become water cycle sleuths. Students use a camera to capture water moving through the water cycle. For example, they are to catch water in the act of precipitating, running downhill, infiltrating, etc.
2. Students will also photograph any human impacts on the water cycle. For example, students could photograph (or possibly stage) litter that could get caught up in runoff.
3. Ideally, students will have the opportunity to work outside on a day when it is raining, has just rained, or when snow is melting. If the weather is uncooperative, students can bring out water sprayers and buckets of water to simulate rain falling over different surfaces.
4. Divide students into small groups. Give each group a camera and a Photograph Record Worksheet.
5. Go outdoors! Define the students' work area.
6. Students work as a team to get the pictures they need and they fill out the Photograph Record Worksheet as they take each photograph. See examples below.
7. Bring students back together. Ask the groups which part(s) of the water cycle they have been unable to photograph.
8. Brainstorm as a class how to obtain the images they need. For example, students may suggest drawing a picture or using photoshop to depict evaporation or transpiration. (See Teacher Resources for links to simple transpiration activities.)

http://justrightplumbingla.com/yard-and-parking-lot-drains/yard-and-parking-lot-drains/

http://www.wallpapermania.eu/wallpaper/lost-of-water-drops-on-a-green-leaf-macro-hd-wallpaper

Explain

1. This lesson is an opportunity to introduce or reinforce the concept of Combined Sewer Overflows (CSOs).
2. Water that doesn't evaporate or infiltrate becomes surface water runoff. Surface water may flow over the ground surface or enter storm drains. Water captured by storm drains flows downhill through sewer pipes (downhill direction determined by the pipe orientation) into a wastewater treatment plant. Stormwater shares these pipes with raw sewage (also called the sanitary sewer). The stormwater is treated and then discharged into the nearest body of water. However, when the sewer system becomes overwhelmed with storm water, both the raw sewage and storm water flow directly into the nearest body of water through combined sewer overflow (CSO) outfalls. This means that almost every time it rains we have raw sewage flowing into our harbor.

Elaborate

1. Students can take additional photos or create additional drawings in order to fill any gaps in their water cycle.
2. Discuss the following with the class:
   - Did we leave any parts of the water cycle out?
   - When water isn't in the process of evaporating, condensing, etc., where is it?
   - Identify the places water "rests"/is stored (harbor, rivers, puddles, clouds, plants, etc.) within the cycle.
   - Where do freezing (snow/glaciers) and melting fit in the water cycle?
   - Where do dew and fog fit in the water cycle?
   - Where does the water that the plants transpire come from?
   - Should we include capillary action as a force in the water cycle?

Evaluate

1. Students will create a New York City Water Cycle model utilizing their photographs. Students can use PowerPoint, Prezi, or printed photographs and poster board to create their models. Each group should have one complete set of photographs to work with.
2. To begin, students label each photograph with the part of the water cycle (or human impact) it represents. This activity can serve as an evaluation of students' comfort with water cycle vocabulary.

3. Ask students to think about what makes water move through the water cycle. Why doesn't the water just stay in the same state and in the same place forever? Give groups time to discuss amongst themselves.
4. If students have a difficult time figuring out gravity and sunlight are responsible for water's movement, show them a standard water cycle diagram and have them to look for clues.
5. Students' water cycle models should include all parts of the water cycle (processes and "resting" places); show the multiple paths water takes through the water cycle in New York City; and convey the idea that gravity and energy from the sun drives water's movement through the cycle.

Standards

CCLS - ELA Science & Technical Subjects

-
    - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
    - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
    - Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.
    - Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
    - Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
    - Weather and Atmosphere

NYS Science Standards - Major Understandings

-
    - During a phase change, heat energy is absorbed or released. Energy is absorbed when a solid changes to a liquid and when a liquid changes to a gas. Energy is released when a gas changes to a liquid and when a liquid changes to a solid.

Photograph Record

Date: _______________ **Time:** __________ **Weather:** ______________________________

Photograph #	**Describe what's going on in the photograph**

Add Pollution to Your Steward-Shed Model

BOP Curriculum
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Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	1	Classroom	Science

Summary

Students take their research and observations from the field and synthesize them in order to experiment with how pollution moves through their steward-shed model.

Objectives

- Translate students' research and observations into representation on a model.
- Consider some of the benefits and shortcomings of using a model as a representation.

Materials and Resources

Supplies

- Materials that can represent pollution
  - Variety of colored powders or dyes (cocoa, fruit drinks, food coloring, etc.)
  - Glitter, sprinkles, cous-cous, rice krispies
  - Small pieces of plastic
  - Soil
  - Liquid soap
  - Oil
- Any other reasonable materials mentioned by the students in the previous lesson (Steward-shed Investigation Part 4 - Pollution Based on Field Observations)
- Spray bottle
- water

Before you get started

Tips for Teachers

- Consider having students bring in materials and supplies to represent the pollution instead of you doing it all.

Instruction Plan

Engage

1. Students get into small groups.
2. Each group gets their steward-shed model, all version of their Class Steward-shed Maps, and "Our Steward-shed" Library of Resources.
3. Students review what types of pollution they are going to add to their model and how to represent it.

4. Students discuss exactly how to put the materials on their model.
    - Place them on top of the modeling clay?
    - Push them into the clay?
    - Put them inside or on top of the built structures?

Explore

1. Each group gets the “pollution” materials they need and spray bottle with water.
2. Students carefully place materials on their model.
3. Students predict: What will happen when we spray water on our model?
4. Students should start slow with spraying the water on their model and should observe the model closely after each couple of sprays.
5. Students record their observations on one of their Class Steward-shed Maps.
6. Students write: based on these results, if we were to make another draft of this model, we would like to revise ______________________________ because ____________________________________.
7. Consider whether you want students to clean off the pollution and do a second trial with different materials or different placement.
8. Students share their results with the class.

Elaborate

1. Ask your students the following series of questions:
    - Ask your students, What worked well about your model? What worked well about using these materials?
    - What’s wrong with this model? What doesn’t work so well about it?
    - What would you do differently if you were to do it again?
2. If it hasn’t come up in discussion, point out that the model is an imperfect representation of what happens in the steward-shed.
3. Ask your students:
    - How else (besides a 3D model) could we represent or record the pollution in our steward-shed?
    - What kinds of representations would be most useful for explaining or showing the state of the steward-shed to people who have not studied it as extensively as we have? (This could be the beginning of the discussion that leads into the stakeholders considered in Steward-shed Part 10 - Steward-shed Challenge)

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
    - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
    - Cause and effect relationships may be used to predict phenomena in natural systems.
- Influence of Engineering, Technology, and Science on Society and the Natural World
    - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
    - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
- Scale, Proportion, and Quantity
    - Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

- Science Addresses Questions About the Natural and Material World
    - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes
- Structure and Function
    - Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
    - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
    - Structures can be designed to serve particular functions.
- Systems and System Models
    - Models can be used to represent systems and their interactions.
    - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
    - Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

NGSS - Disciplinary Core Ideas

- ESS2.C: The Roles of Water in Earth's Surface Processes
    - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
    - Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- ESS3.C: Human Impacts on Earth Systems
    - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- ETS1.A: Defining and Delimiting Engineering Problems
    - The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
- ETS1.B: Developing Possible Solutions
    - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- ETS1.C: Optimizing the Design Solution
    - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)
    - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- LS2.A: Interdependent Relationships in Ecosystems
    - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

NGSS - Science and Engineering Practices

- Asking Questions and Defining Problems
    - Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
    - Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- Constructing Explanations and Designing Solutions
    - Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Developing and Using Models
    - Develop a model to describe unobservable mechanisms
    - Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
    - Develop a model to predict and/or describe phenomena
- Obtaining, Evaluating, and Communicating Information

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NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
  - Weather and Atmosphere
- Grade 6, Unit 4
  - Interdependence
- Grade 7, Unit 1
  - Geology
- Grade 8, Unit 4
  - Humans and the Environment: Needs and Tradeoffs

Build a Model of your Steward-shed

BOP Curriculum
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Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	2	Classroom	Science

Summary

Students build an impermeable model of their steward-shed in order to explore how water moves through that area's topography.

Objectives

- Translate a 2D map to a 3D model.
- Identify important features of their steward-shed based on prior knowledge and research.
- Make predictions and observations about their steward-shed model.

Materials and Resources

Supplies

- Aluminum/foil pan
- Modeling clay or similar material (ideally non-drying clay in different colors)
- Household materials to represent the built environment on the model (e.g. paper towel roll, take-out containers, bottle caps, aluminum foil, etc.)
- Scissors
- Tape
- Spray Bottle
- Water

Before you get started

Tips for Teachers

- Consider having the students bring in clean recycling items to use for their model (e.g. paper towel roll, take-out containers, bottle caps, aluminum foil, etc.)
- This watershed model is supposed to be impermeable. Do not supply students with permeable materials such as sponges or cloth for their watershed model. That step will come in Part 8 of this investigation.

Preparation

- Prepare a zoomed-in satellite image of your class' steward-shed, with the boundaries drawn on it, from the lesson Steward-shed Investigation Part 1 - Paper watersheds.

Instruction Plan

Engage

1. Students get into small groups.
2. Each group gets a copy of the paper class steward-shed map from the previous lesson Steward-shed Investigation Part 1 - Paper Watersheds.
3. Each group gets an aluminum tray.

485472.jpg

1. Students review the shape and dimensions of their class steward-shed map and decide how they will recreate it in their aluminum tray.
2. Students review the elevation change on their class steward-shed map and decide how to represent this elevation change in a 3D model (e.g. 10 ft of elevation on the map = 1 inch of relief on the model). Write the conversion on the class steward-shed map.
3. Note: this is a good opportunity for cross-over with math class as the students need to consider both proportions and conversions as they translate their 2D paper map into a 3D model.
4. Each group gets modeling clay.
5. Students build their steward-shed in relief. If available, they may use different colors of clay to represent different types of land.

Explore

1. Each group gets “Our Steward-shed” Library of Resources.
2. Using this information and their own knowledge of the area, students choose a few notable land features to represent on their model. (e.g. park, pier, box store, school, apartment building).
3. On the class steward-shed map, students write down which land features they chose and why they chose them.
4. Each group gets tape, scissors and a variety of materials with which to make these land features.
5. Using the same scale as above, students do their best to make the land features to scale.
6. Students discuss: How do the buildings and other land features work into and become part of the topography? (i.e. buildings are often the tallest things around.) What happens to precipitation that falls on top of a building?

Explain

1. Each group gets a spray bottle.
2. Students discuss: Does it matter how the water is sprayed on the model? If so, from what angle should it be sprayed: the side, the top, different positions?
3. Students predict: What will happen when we spray water on our model? Where will it go?
4. Students should start slow with spraying the water on their model and should observe the model closely after each couple of sprays.
5. Students record their observations in words and/or diagrams.
6. Students discuss:

- Which direction did the water flow? What factors influence the direction of the water flow?
- Where did the water collect? Explain why it collected there.
- Name some different types of pollutants you might find in your steward-shed?
- What do you predict will happen when you spray water over the pollutants on your steward-shed model?

Elaborate

1. Based on their results, students revisit the class steward-shed map.

2. Students consider:
    - Does the model seem to be a good representation of the map?
    - Do we need to make any changes to our model at this point?

Standards

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    - Weather and Atmosphere
- Grade 6, Unit 4
    - Interdependence
- Grade 7, Unit 1
    - Geology
- Grade 8, Unit 4
    - Humans and the Environment: Needs and Tradeoffs

Can you Out-Filter an Oyster?

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Apr 8, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	2	Classroom	Science Math

Summary

Students will work in small groups to build a “filter” out of household materials and compete against other groups to see who can do the best job filtering the special mixture of “harbor estuary water” that the teacher creates for them.

Objectives

1. Identify some of the common pollutants found in the New York Harbor estuary.
2. Plan, diagram and design a filter that removes certain “pollutants” from the water
3. Compare the functioning of their filter to the functioning of an oyster

Materials and Resources

Supplies

- filter Kit Supplies aluminum trays (approx 13”x9”) - 2 per group
- colander - 1 per group
- measuring cup - 1 per group
- 250 mL plastic beaker - 1 per group
- household materials for building filter
  - napkins
  - paper towels
  - sponges
  - coffee filters
  - gauze
  - cotton balls
  - cotton swabs
  - straws
  - masking tape
- household materials for the “New York Harbor Estuary Solution”
  - salt
  - potting soil (with styrofoam pieces)
  - cooking oil
  - dish soap
  - Chocolate Rice Krispy Treats
  - food coloring

Before you get started

Tips for Teachers

- “New York Harbor Estuary Solution” recipe (amounts are an approximate guide)
  - 1 ½ cups water
  - ¼ tsp salt
  - 1 Tbs potting soil
  - 1 tsp cooking oil
  - 1 tsp dish soap
  - 1 tsp Cocoa Krispies
  - 1-2 drops food coloring
- Prepare all the “New York Harbor Estuary Solutions” in advance except one to do as a demo in front of the class.
- Prepare all Filter Kits in advance.
- This activity is designed to have the students design, build and test the filter only once. If you have the time, consider allowing the students to revise their design and build a second filter based on what they learned from the first test.

Background

According to NOAA and the Chesapeake Bay Foundation, a single Eastern Oyster (*crassostrea virginica*) can filter up to 50 gallons of water a day. Oysters are filter feeders, which means they eat by pumping large volumes of water through their body. In order to eat, oysters open their shells slightly, exposing the little hairlike structures on their gills, called cilia. The oyster moves these cilia in a wavelike motion creating a localized water current, thereby drawing the water inward and over the gills. This process both ventilates the oysters gills for respiration and captures particles that the oyster will eat. The exact mechanism of particle capture is a complex one, and is accomplished in two different ways: the hydrodynamic mechanism draws in particles through the movement of water; and the mucociliary mechanism uses cilia structures and mucous to capture particles. Particles removed from suspension by these two mechanisms are transported along the gills to the labial palps.

The mechanism by which oysters and other bivalves differentiate between different types of particles is not well understood. The labial palps are able to sort and select individual particles, moving the algae, food and nutrients towards the esophagus, while all other non-nutritious particles become pseudofeces and expelled before going into the digestive system.

Most of the particles filtered by oysters are about 1-10 microns in diameter, approximately the same size as the single-celled phytoplankton (algae) that make up most of their diet. Some of the food particles are also ejected as pseudofeces without passing through the gut, because oysters need to ventilate their gills for more time than they need to feed.

Instruction Plan

Engage

1. Show the students one of the Oyster Filtration Youtube videos listed under Teacher Resources. Discuss as fits the needs of your class.
2. Separate students into small groups.
3. Hand out a “Can You Out-Filter an Oyster?” worksheet to each student.
4. Review activity directions/rules (you may want to add more of these rules to the “Directions” section of the worksheet:
5. Use as few or as many materials as you choose.
6. Materials may be altered (e.g. rip the sponge in half).
7. The teacher will pour the estuary solution through each filter so the pouring is consistent and fair from group to group.
8. Each filter is allowed to process the estuary solution for exactly one minute.
9. You may not touch your filter in any way during the filtering (e.g. You may not press on the sponge to squeeze out the water).
10. Use the colander as the foundation of your filter. Do not alter the colander in any way.
11. The colander will sit in one aluminum tray, which will catch the water coming out of the filter. You will transfer the colander to the second aluminum tray at the end of one minute. The liquid in the first aluminum tray will be poured into the 250mL beaker. Do not alter the trays in any way.
12. Create a “New York Harbor Estuary Solution” in front of the class. Add ingredients one by one, soliciting from the class what happens to the ingredient in the water (dissolve, sink, suspend, float, etc.) and what the ingredient represents in real life.

Explore

1. Hand out one Filter Kit to each group and review the included materials.
2. Give students about 15 minutes to design and build their filter. Consider requiring groups to draw a preliminary sketch of their filter for approval before they are permitted to build it.
3. When a group finishes their filter make sure it is placed in one of the aluminum trays.
4. Pour the Estuary Solution through the filter slowly and evenly making a spiral motion around the bottom of the colander. Let the water drain through for exactly one minute.
5. When one minute is up transfer the colander to the second aluminum tray (as it will continue to drip) and pour the contents of the first tray into the 250mL beaker.
6. Put a piece of masking tape on the side of the beaker and write the filter name.
7. Students begin to work on “Part IV: Analyzing Your Filter” of the worksheet.

Explain

Once all filters have been tested bring all the beakers up to the font of the classroom and facilitate a discussion comparing and contrasting the results. Solicit from students which materials they chose to use and how they used them. Solicit from students what worked well and what they would do differently next time.

Elaborate

Students calculate how their filter compares to an oyster (#7 and #8 on worksheet).

Evaluate

Students work either individually or in their groups complete the “Machine vs Nature” section of the worksheet.

Standards

CCLS - ELA Science & Technical Subjects

- - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

CCLS - Mathematics

- - Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

NGSS - Cross-Cutting Concepts

- Energy and Matter
  - Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

NGSS - Disciplinary Core Ideas

- ETS1.B: Developing Possible Solutions
  - A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary)
- LS1.C: Organization for Matter and Energy Flow in Organisms
  - Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

NGSS - Science and Engineering Practices

- Constructing Explanations and Designing Solutions
  - Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 3
  - Diversity of Life
- Grade 6, Unit 4
  - Interdependence
- Grade 8, Unit 4
  - Humans and the Environment: Needs and Tradeoffs

NYS Science Standards - Key Ideas

- LE Key Idea 1
  - Living things are both similar to and different from each other and from nonliving things.
- LE Key Idea 5
  - Organisms maintain a dynamic equilibrium that sustains life.
- LE Key Idea 6
  - Plants and animals depend on each other and their physical environment.
- LE Key Idea 7
  - Human decisions and activities have had a profound impact on the physical and living environment
- PS Key Idea 2
  - Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.
- PS Key Idea 4
  - Energy exists in many forms, and when these forms change energy is conserved.

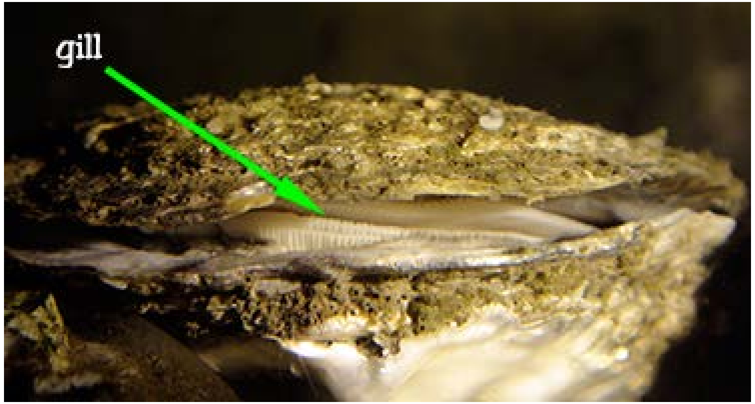
NYS Science Standards - Major Understandings

- - Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.
  - The environment may contain dangerous levels of substances (pollutants) that are harmful to organisms. Therefore, the good health of environments and individuals requires the monitoring of soil, air, and water, and taking steps to keep them safe.

NYS Science Standards - MST

- - Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.
  - Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Oysters are Filter Feeders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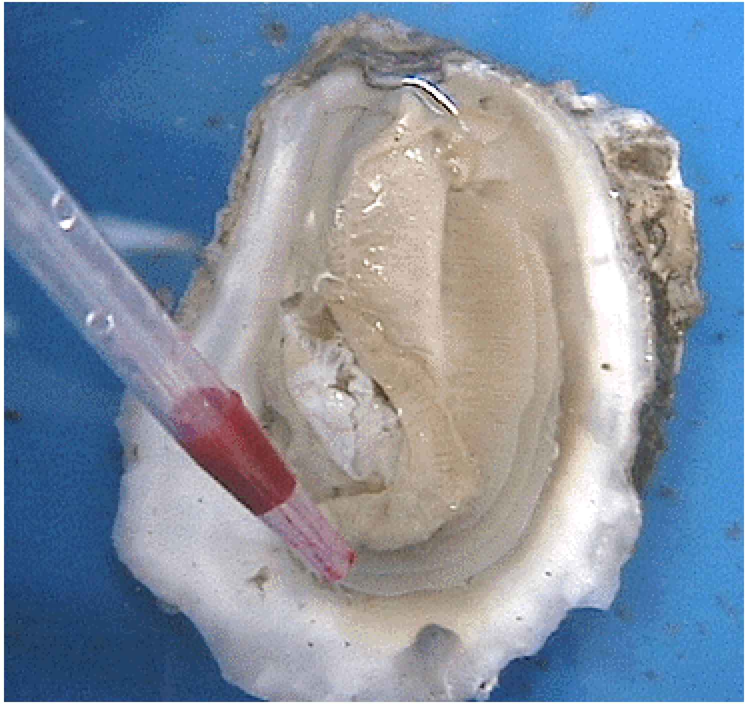
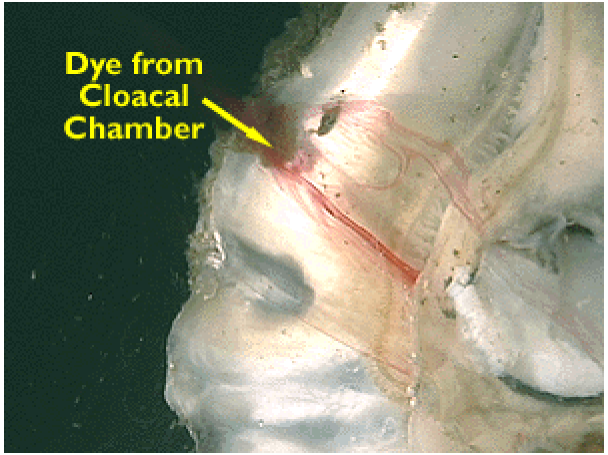
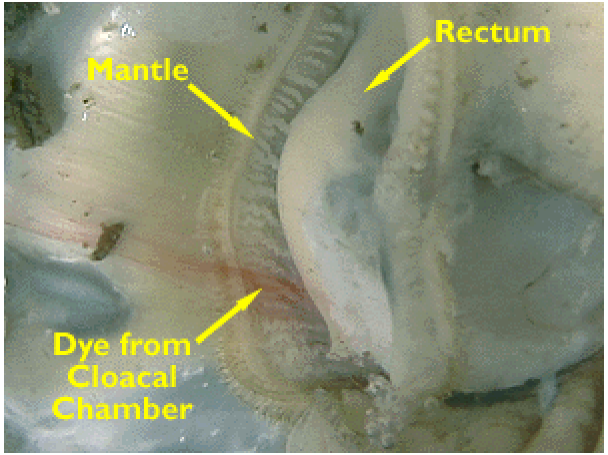



Dye from
Cloacal
Chamber


Mantle
Rectum
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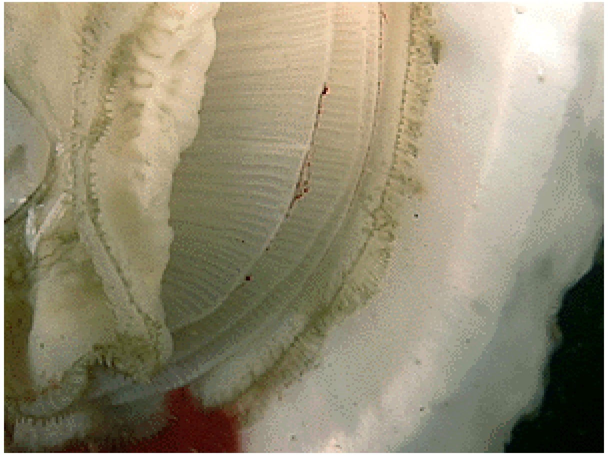
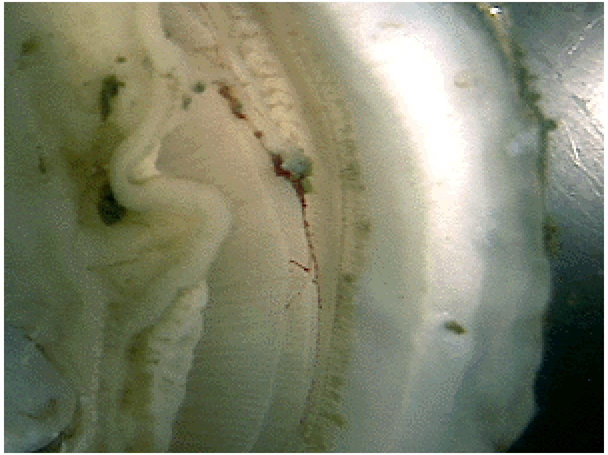
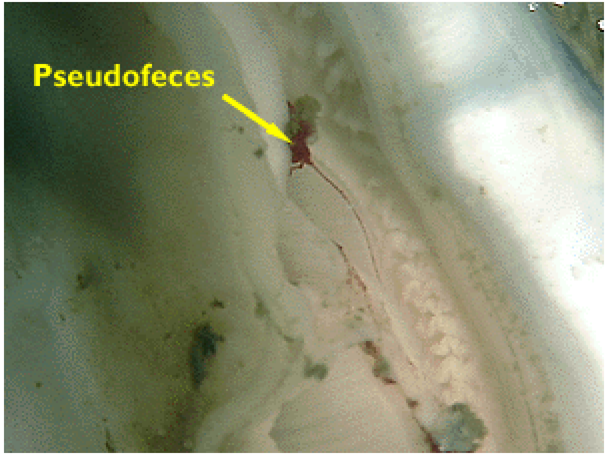
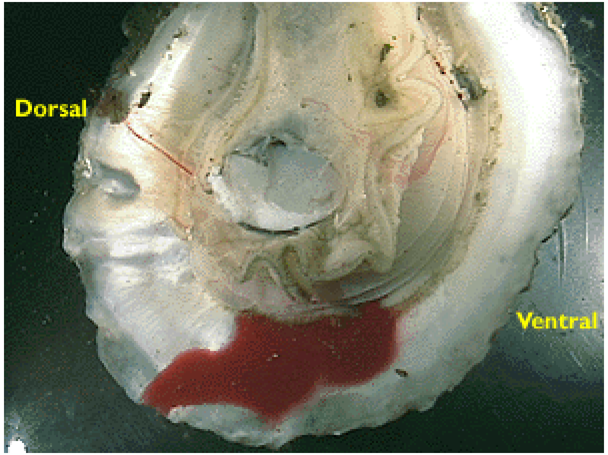





Pseudofeces


Dorsal
Ventral

Celsius to Fahrenheit

BOP Curriculum
bop-curriculum@nyharbor.org
Aug 27, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Water Quality Lessons	6-8th	2	Classroom	Math

Summary

This is an inquiry-based lesson that asks students to play with a table of Celsius and Fahrenheit values and see what conclusions they can draw about the relationship between the two sets of numbers. They also have the opportunity to discuss their ideas of "hot" and "cold" and examine what values correspond to those concepts.

Objectives

- To determine the formula for converting from Celsius to Fahrenheit.

Materials and Resources

Supplies

- 4 beakers
- Thermometers
- Graph paper
- Rulers
- Hint cards
- Data table for Celsius and Fahrenheit (0-10 degrees Celsius)
- Hot plate and ice for prep

Before you get started

Tips for Teachers

- Allow students to experiment with the numbers. Do your best to not lead them to the formula and allow them to spend time playing with the numbers and their relationship. It will be tempting to tell them the answer. Don't do it! They will learn much more from engaging with the math.

Preparation

- Fill at least three (and possibly four) large beakers of water at the following approximate temperatures: "hot," "warm," "cool," and "cold." The warm beaker should be around 70 degrees. Place them in a location in the room where students can touch the beakers in small groups. (Note: it's important to use large beakers because small samples will quickly change temperature and students will be unable to do the experiment.)

- Create hint cards to distribute if students need help figuring out how to convert Fahrenheit to Celsius. For example: "Try doubling the Celsius!" or "Why is the number 32 important? What operation do you think is used on 32?"

Background

- Too often, unit conversions are rote formulas that students use with little understanding. This lesson allows students to consider how the numbers are changing and experiment on their own with the math of the conversion formula.

Instruction Plan

Engage

1. Ask students the following questions, putting all temperatures that students mention on the board:
    - “What’s the hottest thing you’ve ever felt?”
    - “What’s the coldest thing you’ve ever felt?”
    - “What’s the hottest you personally have ever been?”
    - “Can you put a number to any of these experiences?” (Most will probably be in Fahrenheit).

2. Compare 70 degrees air and water. Discuss that it is about 70 degrees in the room right now. Have students put their finger in a beaker of water that is also 70 degrees. Does it feel the same?

3. Ask students, “What questions do you have about temperature so far?”

Explore

1. Students should come to the front of the room in small groups to feel the beakers.

2. Ask students:
    - “What is the difference between them?”
    - “What words would you use to describe these temperatures?”
    - “Are these words accurate descriptions? Why or why not?”

1. Explain that there are differents units for temperature. In the US, temperature is usually measured using the Fahrenheit scale (unit = degrees Fahrenheit), whereas scientists use the Celsius scale (unit = degrees Celsius).

1. Now, ask the following questions about the beakers:
    - “Which are getting warmer and which are getting colder?”
    - “Do the beakers heat up or cool down more quickly? Why?”

1. Take the temperature of the four beakers with a digital thermometer and put them up on the board. They should be something like this:
    - 40 degrees Fahrenheit
    - 60 degrees Fahrenheit
    - 80 degrees Fahrenheit
    - 90 degrees Fahrenheit.

2. Convert all four temperatures to Celsius and put them on the board in a table.

1. Make sure that Celsius is the first column of the table and Fahrenheit is the second column.

2. Have the students copy the table and add the data point 0, 32.

3. Explain that their goal is to figure out how to move from Celsius to Fahrenheit (or how the two sets of numbers relate to each other).

- Now, give a pep talk. Explain to the students that they are looking for patterns in the data. They might or might not actually come up with a formula or a representation for the data. That doesn't matter! What matters is finding a pattern. Explain that if the students get frustrated or worried, you will provide hint cards but that they can do it! Their goal is to think about the mathematical relationship between Celsius and Fahrenheit and write a sentence describing it. They could also represent it in any other way, as a point on a line, as a mathematical description (double and add 32), or anything else they can think of.

4. Distribute the following materials, scaffolded appropriately for your class:
    - Graph paper (possibly with axes labeled)
    - Calculators
    - A table of all the conversions from 0 degrees Celsius to 10 degrees Celsius. (For more advanced students, maybe provide a larger set of data).

5. If students get frustrated during this process, pass out a hint card.

6. Meanwhile, move around the room and ask the following questions to get them thinking:
    - "Is the space between a degree Celsius or a degree Fahrenheit bigger?"
    - "Is 50 degrees Celsius hotter or colder than 50 degrees Fahrenheit?"
    - "Is a Fahrenheit temperature always hotter than a Celsius temperature? Explain."

Explain

1. When students are ready, have them share their results for conversion from Celsius to Fahrenheit.

2. Once students have all presented, show them the formula.

3. Ask students to practice five conversions.

Elaborate

1. Give students the temperature on Mercury (427 degrees Celsius) and on Pluto (-229 degrees Celsius).

2. Ask students:
    - "What are the extremes on Earth versus these 2 planets?"
    - "What are the extremes in NYC?"
    - "What do those numbers mean? How many times bigger are they than the coldest thing you have ever experienced?"

3. Then, have the students convert them to Fahrenheit. Discuss whether or not the difference is meaningful at the extreme and why or why not?

Standards

CCLS - ELA Science & Technical Subjects

- - Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

CCLS - Mathematics

- - Reporting the number of observations.

NGSS - Cross-Cutting Concepts

- Cause and Effect
    - Cause and effect relationships may be used to predict phenomena in natural or designed systems.

NGSS - Disciplinary Core Ideas

- PS3.A: Definitions of Energy
    - Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. ETS1.B: Developing Possible Solutions
    - The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary)

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
    - Analyze and interpret data to provide evidence for phenomena.
- Developing and Using Models
    - Develop a model to predict and/or describe phenomena

NYC Science Scope & Sequence - Units

- Grade 6, Unit 1
    - Energy and Simple Machines
- Grade 6, Unit 2
    - Weather and Atmosphere
- Grade 7, Unit 2
    - Energy and Matter

NYS Science Standards - Key Ideas

- PS Key Idea 3
    - Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity
- PS Key Idea 4
    - Energy exists in many forms, and when these forms change energy is conserved.

NYS Science Standards - Major Understandings

-
    - A liquid has definite volume, but takes the shape of a container.
    - Heat can be transferred through matter by the collisions of atoms and/or molecules (conduction) or through space (radiation). In a liquid or gas, currents will facilitate the transfer of heat (convection).

NYS Science Standards - MST

-
    - Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.
    - Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Correlation and Causation

BOP Curriculum
bop-curriculum@nyharbor.org
Jan 12, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
	6-8th	1	Classroom	Math

Summary

In this lesson, students examine several sets of data and explore the idea of correlation and causation. Students create several stories for each pair of data and discuss which are plausible and which are not. The goal of the lesson is for students to discover the ambiguities around correlation and causation, and to question data.

Objectives

What is correlation?

Materials and Resources

Supplies

- Data sets
- Pencils

Before you get started

Tips for Teachers

- The goal of this lesson is to convince students that correlation may or may not imply causation, and that correlations can be strictly coincidental. As you teach this lesson, encourage students to question each other's assumptions.
- This lesson could easily be three days long. Depending on your time frame, you should feel free to linger on the Hot weather and crime part (a great intro to correlation) or spend a day graphing all sets of data before attempting the second part of the worksheet, or spend an extra day at the end designing an experiment (a model for this is Oyster Tank Set-up Part II: Design an Experiment).

Instruction Plan

Engage

Ask the students whether or not they think there is more crime in the city in the summer. Ask them what data they would need in order to support or contradict the claim that there is more crime in the city during summer months. Have them read the article attached and discuss whether or not there is evidence that there is more crime in the city during the summer.

Make sure to address the following questions:

1. Is there more crime because it is hot?
2. Is it hot because there is more crime?
3. Why are some people so interested in finding a connection between crime and temperature?
4. Do all kinds of crime rise in the summer or just some? What is your evidence?
5. If there was an unusually cool summer would crime still rise?
6. What factors other than temperature could cause crime to rise in the summer?

Discuss what a correlation means. Ask the question: Given unlimited resources, how could you demonstrate that temperature is not the cause of some increased crime observed during several summer months?

Other possible examples: If you eat in a healthy way, will you not get sick? What kind of data would you need? How could you prove a correlation? If you spend more time on your phone, will you get less homework done? For all these questions ask:

How do you know that one kind of data causes another kind?

What kind of evidence do you need to prove that?

Explore

Look at Data Set A in this folder. Then, have students complete the first part of the worksheet.

Bring the class back together to discuss the overall trend in the set of data that they examined.

Explain

Look at Data Set B. Notice the trend.

Finally, have the class choose a data set to do the following activity (Part III of the handout).

In their groups, have the students make up 4 stories for their two sets of data.

1. A causes B,
2. B causes A,
3. C causes A and B
4. This correlation is most likely a coincidence.

Have the students write each story with their groups. Move around the room and consider which stories you think make the most sense for the students to share.

Here are example stories for Data Set A. The stories need not be true--in fact they can be quite silly. The idea is to get the students to question their assumptions.

1. A causes B: A larger human population served by wastewater treatment leads to more nitrogen released into the river.
2. B causes A: More nitrogen in the drinking water causes people to poop more. There is a constipation epidemic sweeping the nation. People hear about the nitrogen in the NY water and move to NY so that they can poop.
3. C causes A and B: The population of NY is growing which causes more people to use the sewage treatment system. This leads to more nitrogen in the water.
4. Coincidence: Many people move to NYC. There is also lots of nitrogen in the water.

Elaborate

Have the students each present their stories, making sure that each presenting group presents all four scenarios. Ask the class to discuss as a whole what other information or data would be helpful in order to determine which story is true.

Evaluate

If you have time, have students return to their groups and brainstorm an experiment that might allow them to collect some of the missing data. Have them share with the class. This could easily be another lesson (see Oyster Tank Setup Part II: Experimental Design).

Standards

Correlation and Causation

PART I

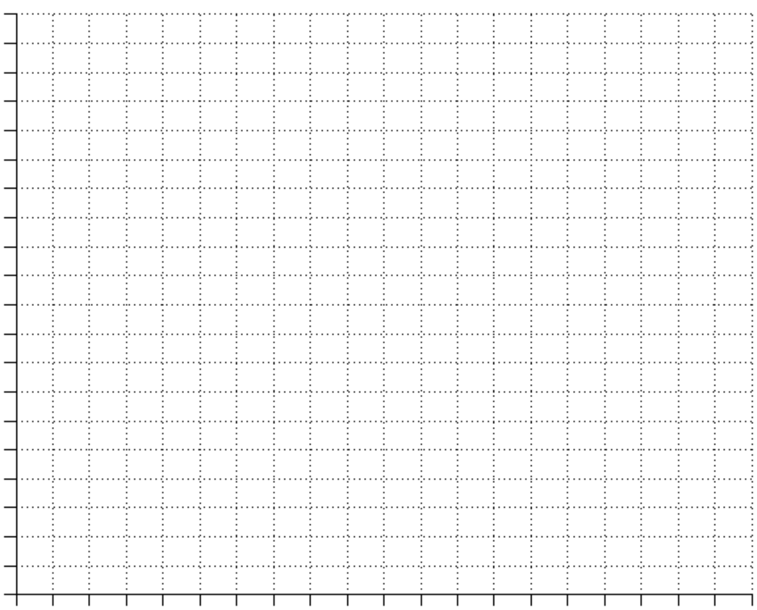
1)Focus on Data Set B. What are the two variables?

2) As the **year** increases, what does each of the other columns do? Possibilities include:
“Increases pretty much the whole time”
“Decreases pretty much the whole time”
“First increases, then decreases”
“No noticable trend”
etc.

Column 2: Column 3: Column 4:

3) Around what year is the maximum value for this column? Around what year is the minimum?

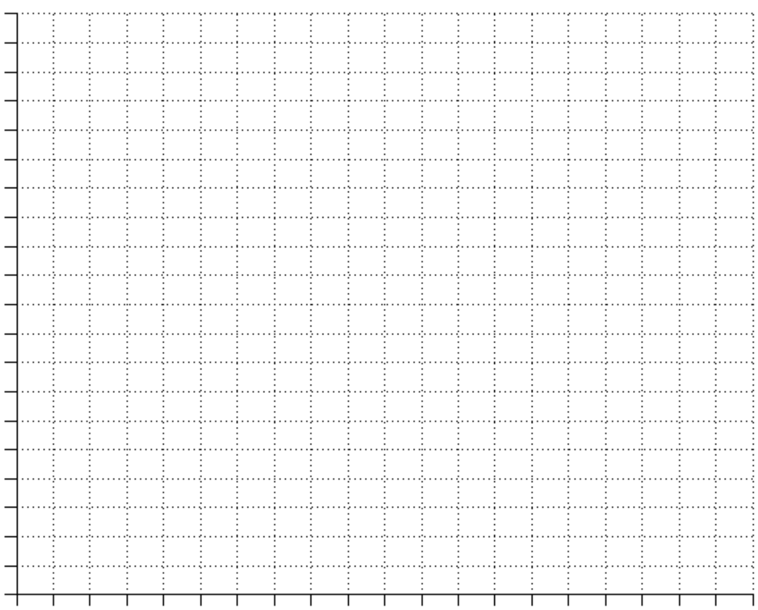
4) Graph 2 columns of your data set below (you pick which 2!).



5)Why did you choose those columns -- also known as variables -- to graph?

6) Which variable (column) did you put on the horizontal axis and which did you put on the vertical axis? Why?

7) Try swapping the horizontal axis with the vertical axis:



8) How do you like the graph now that you’ve swapped the horizontal and vertical axes? Is it clearer? Weirder? Better or worse, somehow? Why do you think so?

9) Make a general observation about the data by filling in the blanks:

I notice that

as ______________________________________,
[something happens with one of the variables]

______________________________________ .

[something happens with the other variable]

This is ___________________ true on the graph.
[always, sometimes]

PART II

Now look at Data Set B:

Now that you have had some practice with data, look at your SECOND data set and describe the overall trend that you see:

Because of _____________________, __________________________ is happening.

PART III
Pick either data set:

With your group, make up the following 4 stories.

1)A story where the first variable [column] causes the second:

2) A story where the second variable [column] causes the first

3) A story where something else entirely caused the trend seen in both sets of data

4) A story where any relationship between the two sets of data is a coincidence.

5) With your group, decide which of the stories you think is most likely, and explain why that is your new hypothesis.

6)What other information would you need to gather to test your new hypothesis?

Resource: Background

<u>Background information on Data Set B: Human population and nitrogen</u>
http://life.bio.sunysb.edu/marinebio/hrfhrbook/pdfs/23.pdf

"The quality of the Hudson River estuary has been negatively impacted for many years by the discharge of untreated sewage. The abatement of these discharges due to construction the upgrading of wastewater treatment plants (WTP) in the Hudson valley from the 1930s to the 1990s has significantly reduced loadings of suspended solids, oxygen demanding organics, floatables, and pathogens, with lesser reductions observed for nitrogen and phosporus. In response, dissolved oxygen has increased from critically low levels to summer averages that exceed 5 mg/L and pollution sensitive insects and marine borers have returned to the estuary. Sanitary quality has also improved with most of the Hudson today considered to meet swimmable water quality standards."

The amount of sewage discharged into the Hudson certainly will correlate with human population in its watershed, and much of the nitrogen loading of the estuary indeed can be traced to sewage discharge.

Upgrades to WTP so far have mostly addressed the problems of pathogens (by a process known as "primary treatment") and organic carbon (by a process known as "secondary treatment"). Loading organic carbon results in accelerated biological and chemical processes that ultimately reduce dissolved oxygen. Most likely some portion of the observed improvements in dissolved oxygen can traced to reduced carbon loading from WTP and other sources.

Upgrades to WTP so far have mostly <u>not</u> addressed the bulk of the problem of nutrient loading, such as phosphorus and nitrogen. Today these nutrients are sometimes described as the most significant pollution problem affecting the estuary. Yet another process, sometimes called "tertiary treatment" would be required in order to significantly reduce the nutrient load to the estuary from WTP. This process is not widely used around New York Harbor, and nutrient loading remains high. Nutrient loading distorts ecosystem processes with a number of undesirable effects, including periodically low dissolved oxygen in deeper water.

"**Trends in Municipal Wastewater Loads: 19OO-2OOO**
Population Served
During the course of the twentieth century, the total population served by municipal wastewater facilities has more than doubled from 3.4 million in 1900 to 8.5 million by 2000. This increase reflects the growth of the population of the New York and New Jersey metropolitan region and, beginning in about 1880, the increasing proportion of the population in the metropolitan drainage basin that was connected to urban sewerage collection systems."

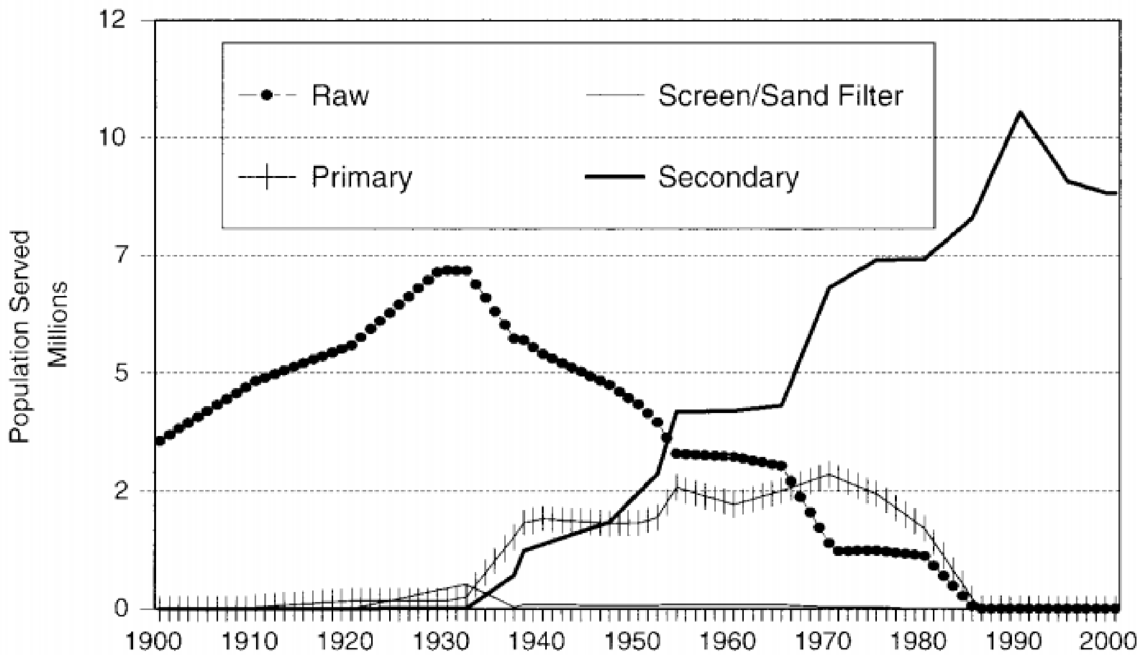
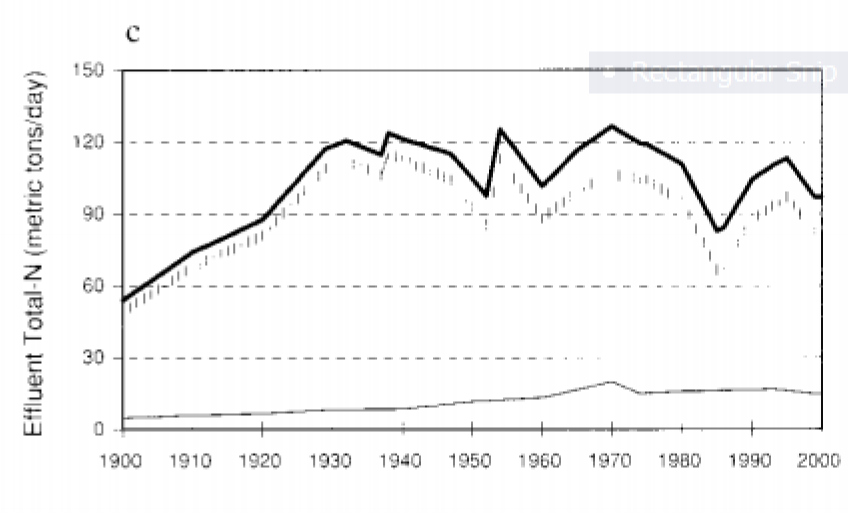


Figure 23.2. Trends of wastewater flow to the middle and lower Hudson River (combined) from ca. 1900–2000, including untreated flows, primary and secondary treatment flows, and total flows.

"Total Nitrogen (TN) loads.

Total Nitrogen (TN) loads from raw sewage discharges to the middle and lower Hudson basins increased from 60 mt/d in 1900 to a peak loading rate of almost 125 mt/d by 1938 (Fig. 23.3c). With the construction of primary WTPs in the late 1920s and1930s and subsequent upgrades to secondary treatment during the 1940s, 1950s, and 1960s, effluent TN loads by 1970 were virtually unchanged from l938. After upgrades to full secondary treatment, effluent loads to the estuary declined by 32 percent to approximagely 85 mt/d by the mid-1980s. Full secondary plants, although not specifically designed for the removal of nitrogen, typically can achieve about 40 percent removal of TN (Hetling et al., 2001|). Note however, that NewYork City WTP removals are approximately 20 percent or less, primarilv due to weak (that is, diluted) influent."



Part of the Hudson: Lower — Middle — Total

Background information on Data Set B: dissolved oxygen and fecal coliform bacteria
http://life.bio.sunysb.edu/marinebio/hrfhrbook/pdfs/23.pdf

Based on your take on the information that follows, you might ask your students how they would expect improvements in wastewater treatment since 1900 to affect fecal coliform bacteria concentration, dissolved oxygen concentration, or both.

You might even ask:

> Looking at the bacterial and DO data, when would you expect to find the most significant improvements were made to WTP within the 20th century?

"**Trends in aquatic health.**
Oxygen dissolved in the water column is necessary for respiration by all aerobic forms of aquatic life, including fish, crabs, clams, and insects. Dissolved Oxygen (DO) levels between 4.8 mg/L and 3.5 mg/L are generally protective of all but the most sensitive aquatic species, while levels below 2.8 mg/L may cause severe lethal and sublethal effects. (IJSEPA 2000). DO varies seasonally, typically being lowest in summer and highest in early winter and spring. Year to year variability can be affected by a variety of natural and anthropogenic factors, including weather, runoff, temperature and salinity stratification, tidal and gravitational circulation, algae blooms, the quality for water entering an area, and especially flushing rate and river flow (Clark et al., 1995). The bacterial decomposition of higher organic carbon loads from untreated sewage can deplete DO, especially in the warm summer months, rendering the water unfit for most aquatic life. DO is therefore used as one of the most universal indicators of overall water quality and a means of determining sewage impacts on habitat and ecosystem conditions."

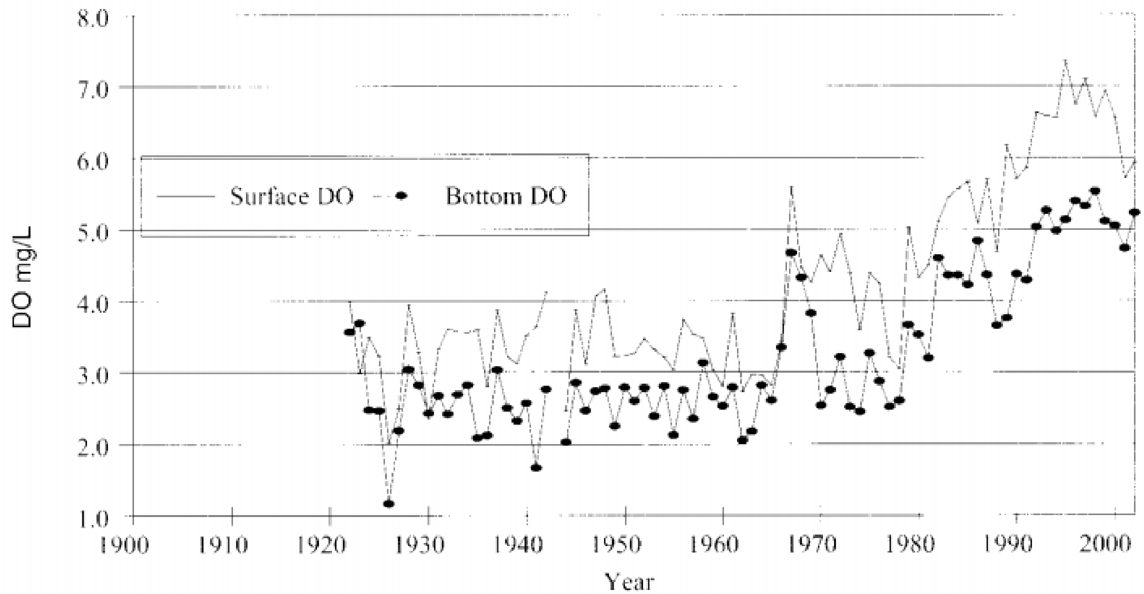


Figure 23.5. Dissolved oxygen trends in the Hudson River off of 42nd St., Manhattan, NY, ca. 1910–2002. Data represent surface and bottom summer average concentrations of 8–14 samples per summer.

"Trends in sanitary quality.
Fecal coliform bactcria are used by various water quality monitoring programs as indicators of sewage-related pollution. Elevated concentrations in the aquatic environment indicate the presence of fecal contamination and the potential presence of pathogenic bacteria, fungi, and viruses often associated with untreated wastewater pollution. New York State water quality standards use fecal coliform bacteria as indicators of the sanitary quality of area waterways for uses such as shell fishing, swimming, and secondary contact recreation.

"Declining concentrations of fecal colifom bacteria indicate that the sanitary quality of both the middle and lower Hudson River has also improved significantly in response to improved capture and treatment of sewage over the last three decades (Fig. 23.7). Undisinfected wastewater contains 10^7 cells/100mL of coliform bacteria…. Seasonal chlorination (May-September) using either sodium hypochlorite or chlorine gas started in the 1940s for the WTPs in Staten Island, and included all fourteen of New York City's WTPs in 1985 (personal communication, Diane Hammerman, NYCDEP)....In response, fecal colifrom levels off Manhattan have declined by two orders of magnitude, from almost 10,000 cells/100mL in the mid 1970s to less than 100 cells/100mL in the 1990s (Fig. 23.7)....

"Note, however, that data collected shortly after rain events show that coliform concentrations increase significantly due to CSOs."

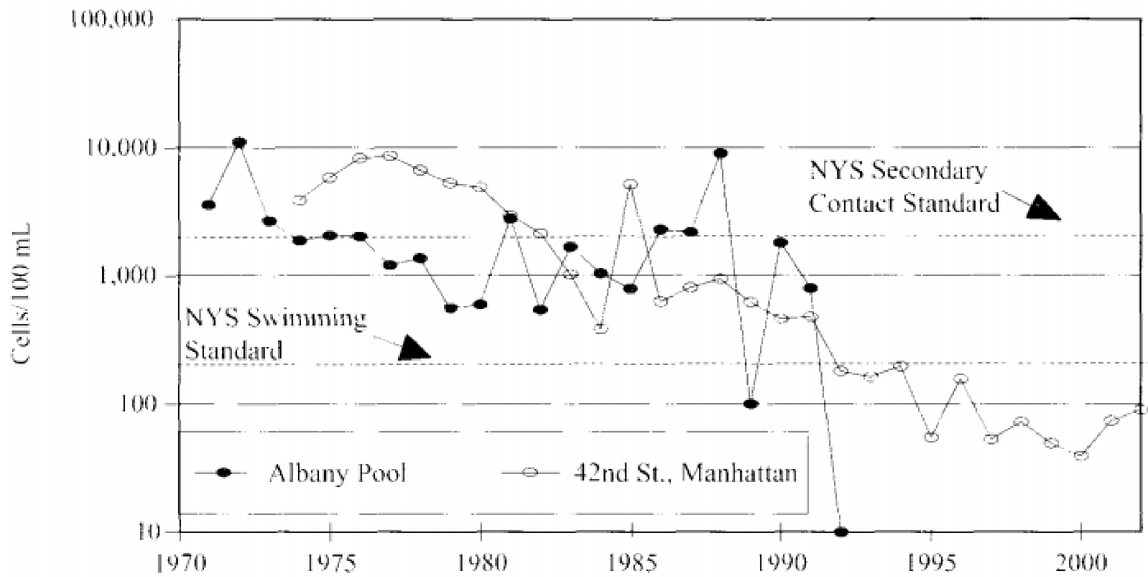


Figure 23.7. Fecal coliform bacteria trends (as summer geometric means) in the Hudson River in the Albany Pool near Glenmont, NY and off of 42nd St., Manhattan, NY. Albany Pool data represent 6–8 samples per summer, except for 1975, 1976, and 1987–92 which represent 4 or less samples per summer. Data collected off of Manhattan represent 8–14 samples per summer. The NYS Primary Contact or "Swimming" Standard of 200 cells per 100 ml and Secondary Contact Standard (e.g., for wading, boating, fishing) of 2,000 cells per 100 ml are also depicted.

Does Crime Rise In Tandem With The Mercury?

By

SEAN GARDINER

Updated July 26, 2010 12:01 a.m. ET

From the Wall Street Journal

Weather's effects on crime has long been the focus of study.

As far back as 1897, Willis L. Moore, chief of the United States Weather Bureau, commissioned a study on the correlation between crime and hot weather because he "was convinced that there was a close connection between atmospheric conditions and the physical and moral welfare of the people," according to a news story from that time. No reports on the results of that study could be found.

In 1935, famed lawman J. Edgar Hoover, then head of the Division of Investigation, the precursor to the FBI, concluded: "Compilations for the past several years indicate that offenses of murder and aggravated assault are more frequently committed in the hot summer months, while offenses of robbery and burglary are most frequently committed in the winter months."

Mr. Hoover's mixed findings aside, conventional wisdom has held that the hotter it gets outside, the more crime heats up.

But crime data reviewed by The Wall Street Journal shows that New Yorkers are about as likely to be victims of crime in December and October as they are during the hottest of the summer months.

The Journal reviewed the month-by-month totals of the seven index crimes—murder, rape, robbery, felony assault, burglaries, grand larcenies and stolen cars—compiled by the New York Police Department for the years 2007 through 2009. During that time, September, when adjusted to reflect 31 days of crimes, had the most index crimes, with an average of 10,574 per month. August was second, with an average of 10,506 crimes per month. October averaged only 10 fewer index crimes than August. July was next with 10,255 average crimes, followed by typically chilly December at 10,189.

Jerome McKean, an associate professor of criminology at Ball State University in Indiana, asserts that "there is a definite correlation" between an increase in temperature and an increase in crime. "The peak months for most forms of crime are July and August, especially for property crimes."

One of the reasons that property crimes—burglaries, grand larcenies and auto thefts—go up, the professor said, is because the most frequent perpetrators of such crimes aren't in school. Mr. McKean said the peak age for arrests for property crimes is 16. At the same time, more people take more trips and vacations during the summer months, making homes more vulnerable to burglars.

The month with the fewest crimes has been February. Even when adjusted to reflect 31 days of activity, February registered only 8,175 crimes per month, about 29% fewer than the average for September. March was second-lowest, followed by January.

The Journal also reviewed monthly homicide numbers in New York City between 2002 and 2009.

July has been the most deadly, with an average of 53.3 slayings in the city that month over the past eight years. June is second with an average of 53.0 homicides, followed by September at 50.5 (both June and September are adjusted figures based on 31 days), December at 50.3 and August at 49.9, according to the statistics.

When it comes to murder and other violent crimes, James Alan Fox, a professor of criminology at Northeastern University, said the correlation with temperature is not simple.

"It's not just a linear effect that as the temperature keeps rising, [violent] crime keeps rising," he said. "At some point when the heat becomes oppressive, crime no longer increases and starts to decline because people no longer fight the heat and they go inside."

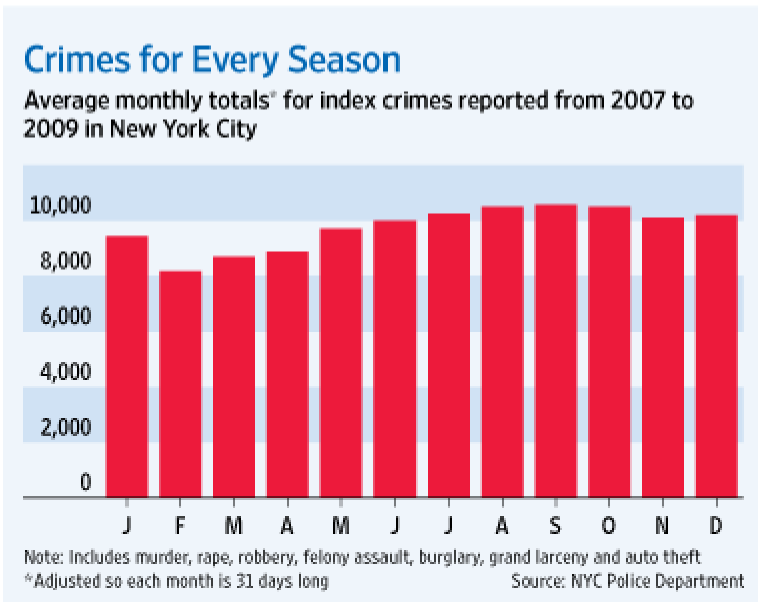
A study Mr. Fox conducted of violent crime outside of the home in Columbus, Ohio, for all of 2007 showed that violent crime is highest when the temperatures reach the mid-80s but starts dropping when the mercury climbs past 90 degrees.

That theory might account for the criminal-activity levels of recent weeks. The week of June 21 to June 27 saw the most index crime in New York City so far this year, 2,125. The average high temperature that week was 88.9 degrees, and the daily average temperature was 80.3 degrees. Two weeks later, July 5 to July 11, the high temperature had shot to an average of 94.0 degrees and the daily average temperature was 85.3 degrees, making it the hottest week of the year. Meanwhile, the crime total dipped by about 6%, to 1,998.

"It's not necessarily that people are short-tempered when it gets hot out, it's that there are more people out and about, which means more potential victims," he said.

Neither Mr. Fox nor Mr. McKean could account for the relatively high incidences of crime in the city in September and especially October.

"October isn't usually an extraordinary month," he said. "That's strange."



ENLARGE

Police officials also had no explanation for increased crime in October.

As for December being among the top crime months, Mr. Fox said he believes that the high number of murders in New York City may be due to an increase in domestic murders.

"During the holidays, people spend more time with their families and their extended families and that's not always a good thing," he said.

Mr. McKean said December is the one exception to the more heat, more crime theory.

"The usual pattern for crime increases is July, August and December.... We always get a little mini bump in December." Part of the reason for this, he said, is that "people sometimes do their Christmas shopping without paying for it."

DATA SET A
Human Population and amount of Nitrogen in the Hudson

Data Source: Data from Brosnan, T., A. Stoddard, and L. J. Hetling, 2006. Hudson River Sewage Inputs and Impacts: Past and Present in The Hudson River Estuary, Levinton & Waldman, editors.

Year	Human population served by wastewater treatment plants in the middle and lower Hudson River valley (in millions)	Total nitrogen discharged as sewage into the middle and lower Hudson River valley (megatons per day)
1900	3.42	54.14
1910	4.67	74.07
1920	5.54	87.67
1960	9.34	101.6
1970	10.66	126.55
1980	9.85	110.79
1999	8.5	97.25

DATA SET B
DISSOLVED OXYGEN AND FECAL COLIFORM BACTERIA IN HUDSON RIVER
Fecal coliform bacteria is bacteria that originates in the feces of mammals (in this case, humans)

Data Source: Data from Brosnan, T.M, Stoddard, A., and L.J. Hetling. 2006. Data published in "Hudson River Sewage Inputs and Impacts: Past and Present" in J. S. Levinton and J.R. Waldman (Eds.) The Hudson River Estuary; New York: Cambridge Press. Data Collection Location: Hudson River off of 42nd Street, Manhattan, NY

Year	Dissolved Oxygen - at the Surface (concentration measured in mg/L)	Dissolved Oxygen - at the Bottom (concentration measured in mg/L)	Fecal Coliform (cells per 100mL)
1974	5.95	2.92	3870
1975	6.22	3.68	5831
1976	6.35	3.09	8331
1977	5.33	2.78	8657
1978	5.00	3.04	6638
1979	6.34	4.06	5298
1980	5.49	3.50	4892
1981	5.62	3.63	2984
1982	6.38	4.95	2147
1983	6.33	4.43	1031
1984	6.31	4.20	384
1985	8.01	4.78	5179
1986	6.24	4.99	628
1987	6.54	3.83	810
1988	6.03	3.57	945
1989	7.33	4.19	625
1990	6.68	4.79	463
1991	5.69	4.94	481
1992	7.32	5.50	180
1993	8.11	5.58	163

1994	7.45	5.59	196
1995	8.27	5.44	55
1996	7.76	5.65	158
1997	7.80	5.45	53
1998	7.22	5.71	72
1999	8.27	5.64	49.5

Create Brackish Water for Your Oyster Tank

BOP Curriculum
bop-curriculum@nyharbor.org
Mar 2, 2018

Unit	Grade	Class Periods	Setting	Subject Areas
Oyster Tank Investigation	6-8th	1	Classroom	Science Math

Summary

Students work together to create brackish water with the correct salinity for their tank.

Objectives

- Experiment through trial and error.
- Calculate correct salinity for the oyster tank water.
- Analyze the process for getting to the correct salinity.

Materials and Resources

Supplies

- Classroom oyster tank (at least 5 gallons)
- Instant Ocean Sea Salt
- 10 one-gallon containers
- 10 hydrometers
- Variety of measuring cups, spoons, etc.

Before you get started

Preparation

One-gallon Containers:
- For the one-gallon containers needed for this lesson, we recommend Lee's Kritter Keeper, Small, because this size tank is useful for other BOP lessons and units.
- You could also use small buckets or one-gallon milk jugs with the top cut off.
- Whatever you choose, just make sure there is enough room in the container to add a gallon of water and stir in the salt.

Instruction Plan

Explore

1. In this activity, students will prepare the salinity mixture for the tank.

2. Each group gets a one-gallon container.
    - Note: You may want to pre-fill the containers with water or you may want to have the students fill up their own containers.

3. Each groups gets 1 cup of Instant Ocean Sea Salt.

4. Explain: You want the salinity of your classroom tank to be approximately 15ppt (parts per thousand).

5. Note: The easiest way to get to 15ppt is through trial and error. If you want to challenge the students mathematically, consider giving them the following information:
    - 1 cup of Instant Ocean mixed in 1 gallon of water = 1.023 sg (specific gravity) = 30-35ppt

6. Students are provided with a variety of measuring cups, spoons and tools to choose from.

7. Let the students experiment and work out how to get to 15ppt!
    - Note: You may want to advise students that they should start with a small amount of Instant Ocean and then use the hydrometer to measure the salinity. It is easier to incrementally add more Instant Ocean to get to 15ppt than to add too much and try to bring the salinity down.

8. Consider gathering the students' trial and error results and posting them so students can look for a pattern within the results and alter their experimentation accordingly. If students are using different tools (e.g. cups, teaspoons, etc.), you may want to standardize the results that are posted (for example grams of salt instead of cups and tablespoons. This will make it easier to see a pattern.

Group	Salt (grams)	Water (mL)	Salinity (ppt)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

1. When they are ready, check each group's salinity.

2. Once all groups have the correct salinity, each group pours their gallon of brackish water into the classroom oyster tank.
    - Consider making this into a bit of ceremony, as students embark on taking care of their oysters!

3. Discuss the process of getting the correct salinity.
    - Questions: How did it go? What did they notice? What questions came up? What surprised them?
    - Take notes on your students' thinking! These notes are extremely useful later in the year, and there is no way to re-create them later!

4. Each student gets an Oyster Tank Analysis worksheet and completes the "Mixing the Salt Water" section.

Standards

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence
- Grade 7, Unit 4
    - Dynamic Equilibrium: Other Organisms

Oyster Tank Analysis

Mixing the Salt Water

1. Describe the process your group went through to get the correct salinity in your gallon of tank water. What did you try? What went wrong? How did you resolve the problems that came up?

2. Write detailed directions for getting the correct salinity in a gallon of water. Write your directions so someone who has never done this before could easily do it.

Monitoring the Tank

3. What have you learned so far from your reading about what makes good water quality for an oyster to survive? Describe how this compares to your water quality results.

4. Describe the results of the oyster measurements. What was the range of oyster sizes?

Making Predictions

Choose a few of the most interesting questions below to answer:

1. Which parameter do you think will vary most at first? Which parameter do you think will vary the most over the year? The parameters your class tested are: temperature, dissolved oxygen, pH, salinity, ammonia, nitrate, phosphate and turbidity.
2. How many oyster spat do you think will die within the first month? Why?
3. Which parameter do you think will be most likely to create problems for our oysters?
4. How often do you think we should measure the size of the oysters? Explain why.
5. Based on everything you've seen and learned today, how often do you think we should maintain the tank? Check salinity levels? Monitor the water quality of the tank? Explain your thinking.
6. Is there anything else we should keep an eye on in our oyster tank? What? Why?

Decline of Shad in the Hudson River Estuary

BOP Curriculum
bop-curriculum@nyharbor.org
Mar 21, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
NY Harbor Populations Investigation	6-8th	2	Classroom	Science

Summary

Students use a variety of resources about shad to create their own timeline about shad's decline in the region.

Objectives

Enumerate several ways that human actions impact an iconic local species, shad.

Materials and Resources

Supplies

- Graph paper
- Rulers

Before you get started

Preparation

- Read through the Shad Resource and Note Taking handout.
- Decide which resource you would like to highlight at the beginning of the lesson in order to orient the students to the story of shad's decline.

Instruction Plan

Engage

1. Each student gets a Shad Resources and Note Taking handout.
2. Point the students towards your chosen resource (see "Preparation" above).
3. Each student individually makes observations and inferences about the resource looking for possible clues about the cause of shad decline.

Explore

1. Students get into small groups with their Shad Resources and Note Taking handouts.
2. Explain: Your goal is to create your own timeline based your inferences about and the information within the Shad Resources.
3. Students study the resources, looking for clues and information about when and how shad declined.
4. Students take notes in the space provided.

Elaborate

1. Looking back at their notes, groups decide which years their timeline should cover and on which points of information they will include on their timeline.
2. Groups decide how they are going to convey their chosen information (e.g. text and/or illustration).
3. Each group gets graph paper and rulers, so students may draw out their timeline. (Be sure to give each group several pieces of graph paper, so they can make drafts or they may decide they want to cut out images from the Shad Resources handout to illustrate their timeline.

4. Note: Even if you want students to eventually put their timelines on a powerpoint or presentation software, we suggest that they begin with graph paper so students may practice their scaling skills.

Evaluate

1. Groups share their timelines with the class.

2. Allow time for other groups to respond and ask questions.

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
  - Cause and effect relationships may be used to predict phenomena in natural systems.
  - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Energy and Matter
  - The transfer of energy can be tracked as energy flows through a designed or natural system
  - The transfer of energy can be tracked as energy flows through a natural system.
- Influence of Engineering, Technology, and Science on Society and the Natural World
  - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- Patterns
  - Graphs and charts can be used to identify patterns in data.
  - Graphs, charts, and images can be used to identify patterns in data.
- Stability and Change
  - Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems and System Models
  - Models can be used to represent systems and their interactions.
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

NGSS - Disciplinary Core Ideas

- LS1.A: Structure and Function
  - Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
- LS2.A: Interdependent Relationships in Ecosystems
  - Growth of organisms and population increases are limited by access to resources.
  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
  - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
  - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
  - Analyze and interpret data to provide evidence for phenomena.
- Constructing Explanations and Designing Solutions
  - Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.
- Engaging in Argument from Evidence

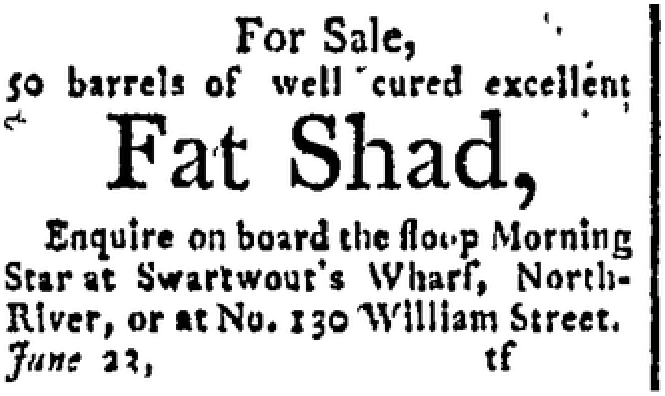
    - Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence

Shad Resources and Note Taking

Resource	Notes
 ***Shad Fishing in the Delaware River*** *— A fishweir consisting of wooden stakes arranged in a fence-like manner, and a weighted fish net, are being used to gather the shad so that they may be easily speared, or caught with bare hands.* *http://delawaretribe.org/blog/2013/06/27/lenape-fishing/*	

Resource	Notes
 For Sale, 50 barrels of well cured excellent Fat Shad, Enquire on board the floop Morning Star at Swartwout's Wharf, North-River, or at No. 130 William Street. *June* 23, tf *1794 - newspaper advertisement for barrels of cured shad. From the newspaper American Minerva.* http://www.hrmm.org/history-blog	

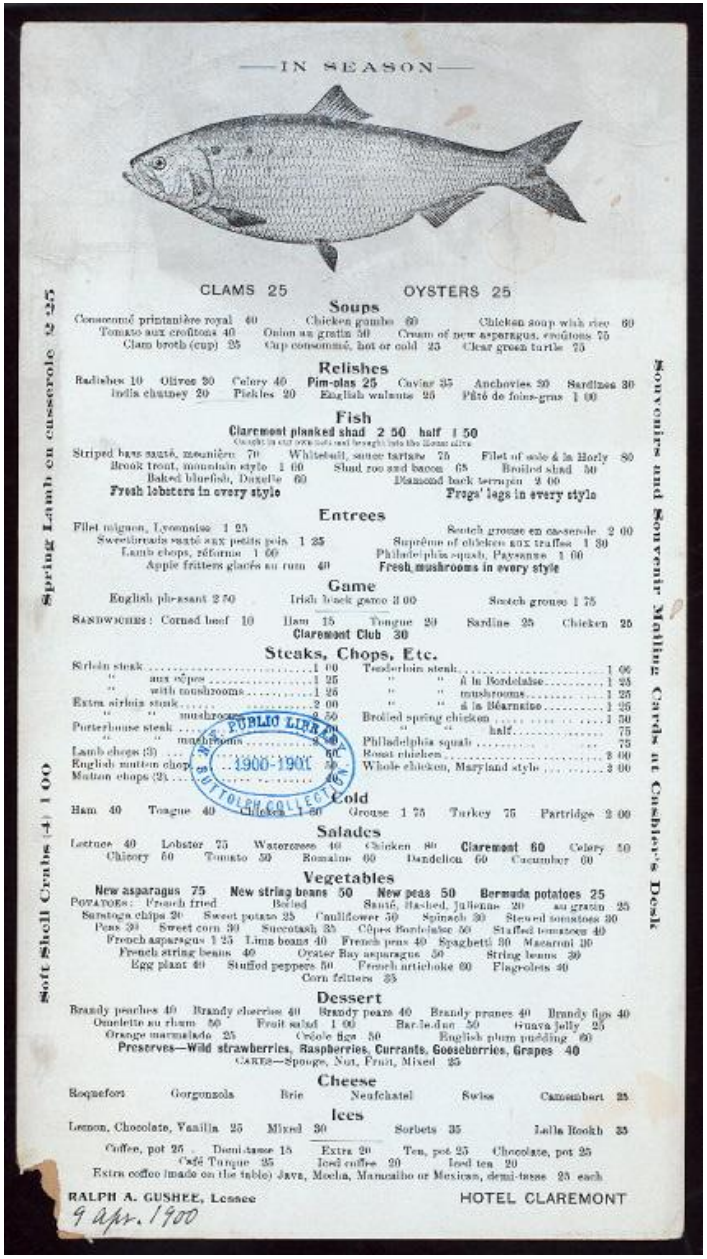
Resource	Notes

1867 Shad-Fishing In New York Bay -- Picking The Stake-Nets
https://digitalcollections.nypl.org/items/510d47e0-d69e-a3d9-e040-e00a18064a99

Resource	**Notes**

 *1884 - Selling Shad* https://www.flickr.com/photos/north-carolina-state-archives/6843326837/	

Resource	Notes



—IN SEASON—

Spring Lamb en casserole 2 25

Soft Shell Crabs (4) 1 00

Souvenirs and Souvenir Mailing Cards at Cashier's Desk

CLAMS 25 OYSTERS 25

Soups

Consommé printanière royal 40 Chicken gumbo 60 Chicken soup with rice 60
Tomato aux croûtons 40 Onion au gratin 50 Cream of new asparagus, croûtons 75
Clam broth (cup) 25 Cup consommé, hot or cold 25 Clear green turtle 75

Relishes

Radishes 10 Olives 30 Celery 40 **Pim-olas 25** Caviar 35 Anchovies 30 Sardines 30
India chutney 20 Pickles 20 English walnuts 25 Pâté de foies-gras 1 00

Fish

Claremont planked shad 2 50 half 1 50

Striped bass sauté, meunière 70 Whitebait, sauce tartare 75 Filet of sole à la Horly 80
Brook trout, mountain style 1 00 Shad roe and bacon 65 Broiled shad 50
Baked bluefish, Duxelle 60 Diamond back terrapin 2 00
Fresh lobsters in every style **Frogs' legs in every style**

Entrees

Filet mignon, Lyonnaise 1 25 Scotch grouse en casserole 2 00
Sweetbreads sauté aux petits pois 1 25 Suprême of chicken aux truffes 1 30
Lamb chops, réforme 1 00 Philadelphia squab, Paysanne 1 00
Apple fritters glacés au rum 40 **Fresh mushrooms in every style**

Game

English pheasant 2 50 Irish black game 3 00 Scotch grouse 1 75

SANDWICHES: Corned beef 10 Ham 15 Tongue 20 Sardine 25 Chicken 25
Claremont Club 30

Steaks, Chops, Etc.

Sirloin steak 1 00
" aux cèpes 1 25
" with mushrooms 1 25
Extra sirloin steak 2 00
" " mushrooms 2 50
Porterhouse steak ....
" " mushrooms ....
Lamb chops (3) ....
English mutton chop ....
Mutton chops (2) ....
Tenderloin steak 1 00
" " à la Bordelaise 1 25
" " mushrooms 1 25
" " à la Béarnaise 1 25
Broiled spring chicken 1 50
" " half 75
Philadelphia squab 75
Roast chicken 2 00
Whole chicken, Maryland style 3 00

Cold

Ham 40 Tongue 40 Chicken 1 50 Grouse 1 75 Turkey 75 Partridge 2 00

Salades

Lettuce 40 Lobster 75 Watercress 40 Chicken 80 **Claremont 60** Celery 50
Chicory 60 Tomato 50 Romaine 60 Dandelion 60 Cucumber 60

Vegetables

New asparagus 75 New string beans 50 New peas 50 Bermuda potatoes 25
POTATOES: French fried Boiled Sauté, Hashed, Julienne 20 au gratin 25
Saratoga chips 20 Sweet potato 25 Cauliflower 50 Spinach 30 Stewed tomatoes 30
Peas 30 Sweet corn 30 Succotash 35 Cèpes Bordelaise 50 Stuffed tomatoes 40
French asparagus 1 25 Lima beans 40 French peas 40 Spaghetti 30 Macaroni 30
French string beans 40 Oyster Bay asparagus 50 String beans 30
Egg plant 40 Stuffed peppers 50 French artichoke 60 Flageolets 40
Corn fritters 35

Dessert

Brandy peaches 40 Brandy cherries 40 Brandy pears 40 Brandy prunes 40 Brandy figs 40
Omelette au rhum 50 Fruit salad 1 00 Bar-le-duc 50 Guava jelly 25
Orange marmalade 25 Créole figs 50 English plum pudding 60
Preserves—Wild strawberries, Raspberries, Currants, Gooseberries, Grapes 40
CAKES—Sponge, Nut, Fruit, Mixed 25

Cheese

Roquefort Gorgonzola Brie Neufchatel Swiss Camembert 25

Ices

Lemon, Chocolate, Vanilla 25 Mixed 30 Sorbets 35 Lalla Rookh 35

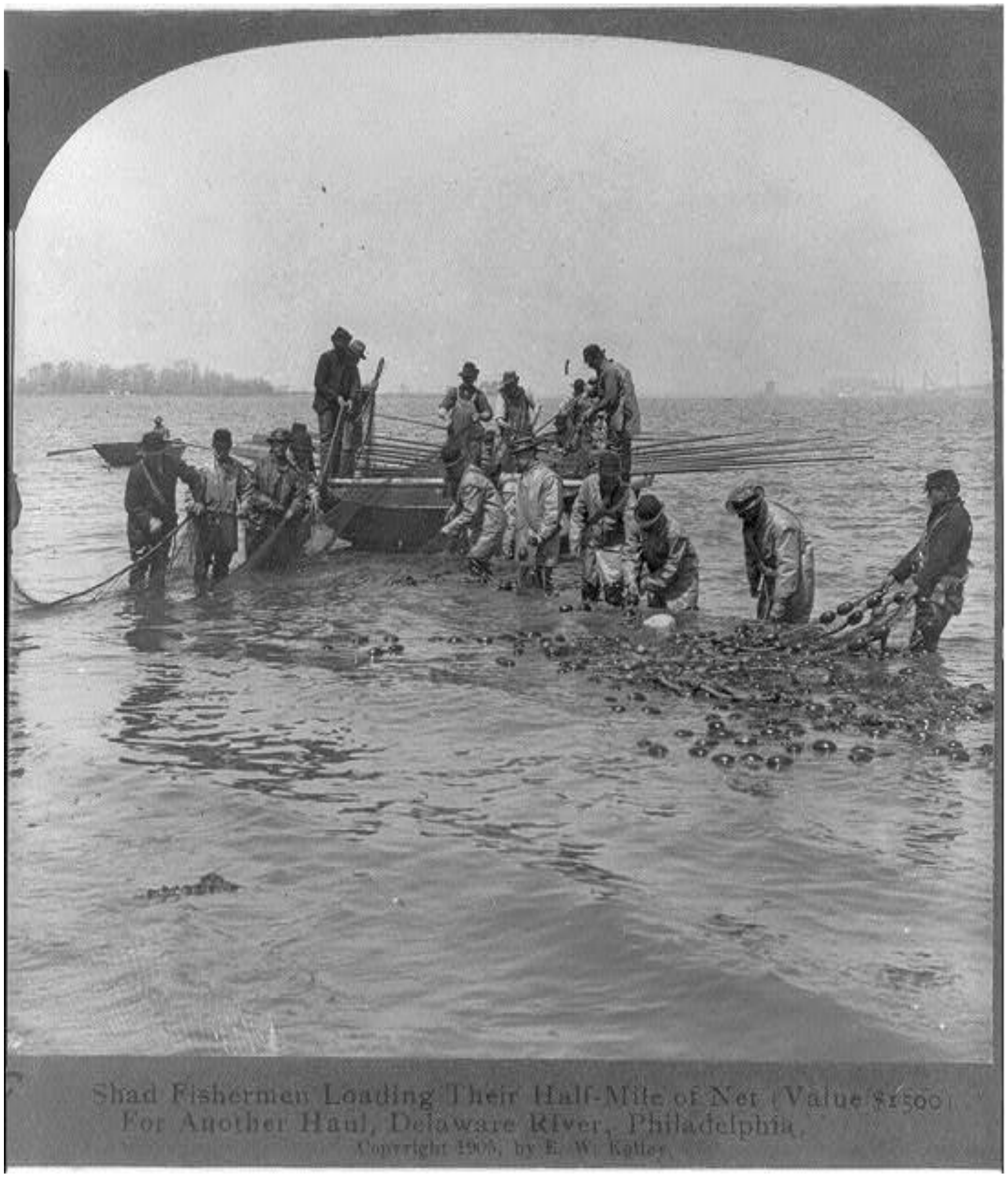
Coffee, pot 25 Demi-tasse 15 Extra 20 Tea, pot 25 Chocolate, pot 25
Café Turque 35 Iced coffee 20 Iced tea 20
Extra coffee (made on the table) Java, Mocha, Maracaibo or Mexican, demi-tasse 25 each

RALPH A. GUSHEE, Lessee HOTEL CLAREMONT

9 Apr. 1900

N.Y. PUBLIC LIBRARY 1900-1901 BUTTOLPH COLLECTION

1900 - Claremont Planked Shad and Shad roe [eggs] on the menu
https://digitalcollections.nypl.org/items/510d47db-4861-a3d9-e040-e00a18064a99

<table>
<tr><th>Resource</th><th>Notes</th></tr>
<tr><td>

c1905 - Shad fishermen loading their half-mile of net (value $1500) for another haul, Delaware River, Philadelphia
https://www.loc.gov/item/2006688458/</td><td></td></tr>
</table>

Resource	Notes
 *1915 - Photograph shows African American men and women with large net of shad by water* https://www.loc.gov/item/2016647797/	

Resource	Notes

 *c1935 - Shad and herring fishing* https://www.flickr.com/photos/north-carolina-state-archives/6843326645/	

Resource	**Notes**

 *1972 - Shad have traditionally been caught with stake nets in the lower Hudson and drift nets in the mid-Hudson and north. The stake nets were long, rectangular nets affixed to long wooden poles in the shallower areas of the Hudson River. Drift nets, also long and rectangular, were cast from the shad boats on a favorable tide. As the tide flowed the fish were caught in the nets which hung vertically like curtains with weights on the bottom edge. Nets must be pulled up and fish removed by hand before the tide changes.* https://midatlantictransition.org/articles/item/new-economy1-copy	

Resource	Notes

 *Juvenile fish caught in cooling intake of powerplant* https://www.riverkeeper.org/campaigns/stop-polluters/power-plants/power-plant-fish-kills/	

Text Excerpt	Notes

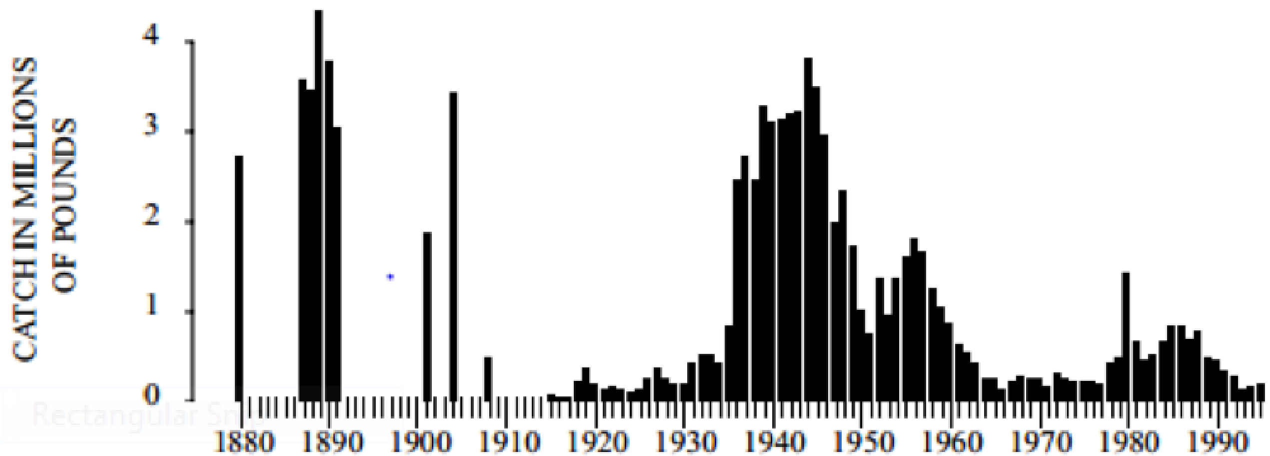
Hudson River American Shad The principal known cause of the decline [of shad] in Hudson River American shad was overharvest by ocean commercial fisheries and in-river commercial and recreational fisheries (ASMFC 2007a). Ocean harvest of American shad has ended, but losses to in-river harvest continue. Losses of young and adult shad to ocean commercial bycatch (unintended catches) may have been a factor in the decline, but the amount of such losses is essentially unknown. Young American shad in the river are also lost to various cooling water intakes. Habitat loss and alteration most likely affected historical abundance of American shad in the Hudson River Estuary. Substantial destruction of potential shad spawning and nursery habitat occurred from the late 1800s through the mid 1900s from dredge and fill in the upper third of estuary during development and maintenance of the navigation channel from New York City to Albany/Troy (Miller and Ladd 2004). This habitat alteration was probably a factor in shad decline in the late 1800s and early 1900s. However, major habitat alteration has not occurred over the last 50 years and it is unlikely that it has been a factor in the most recent stock decline. Such habitat loss however, may influence the rate of shad recovery. http://www.dec.ny.gov/docs/remediation_hudson_pdf/shadrecoveryplan.pdf	
American Shad Fishing on the Hudson River The shad fisheries remained … plentiful throughout the 1800s and into the early 1900s, with [fish caught] peaking in the 1940s (Hattala, 1997). However, over this time period the Hudson River changed dramatically, severely disrupting the shad's habitat. The river became heavily polluted as sewage was dumped into it, as well as industrial waste from a number of factories that lined the river, and the pollution prevented the fish from up taking oxygen. The Hudson was dredged and filled in order to allow large boats to pass through, disrupting the shallow water close to the bank that is a crucial for spawning as well as an environment for juvenile shad to develop in. Cooling operative plants began operating along the river, killing numerous shad (Kahnle & Hattala, 2010). http://pages.vassar.edu/hudsonvalleyguidebook/2013/06/03/american-shad-fishing-on-the-hudson-river/	
Protecting and Managing Migratory Fish Much of the [Hudson] river habitat has been destroyed during the last hundred years. When the Hudson's navigation channel was dredged, the dredged material	

was used to fill wetlands and shallows, a common practice until the 1970s. Between the Cities of Hudson and Albany, one-third of what used to be river was filled. Railroad construction in the mid-nineteenth century altered river habitat. Rip-rap walls were built along the riverbanks, and marshes and coves were cut off from the open river behind the railroad tracks, limiting the flow of water and nutrients and the movement of fish... Shad populations have been declining in the Hudson since the 1980s. Using studies conducted under the Estuary Plan, Department of Environmental Conservation biologists have traced the decline to over-fishing on the Atlantic coast … Other studies have shown that shad also may be severely affected by power plants located in areas of the river where fish spawn (lay eggs). Young shad are drawn into power plants along with the water used for cooling purposes, and are killed. http://www.dec.ny.gov/docs/remediation_hudson_pdf/hrep5year2.pdf	
Power Plant Operation on the Hudson River Power plants are found along the entire length of the lower Hudson River from Manhattan to Albany. The largest [power plants] are located in the middle reaches of the river … The oldest generating stations are those at 59th Street on Manhattan, which began … operation in 1918. From 1950-1970, power plants … were constructed at Albany, Danskammer and Lovett. From 1970-1976, several larger power plants … were constructed in the middle reaches of the river. Power plants operating along the Hudson remove water from the river for cooling purposes. Water is drawn from the river, passed through pumps and condensers and discharged back into the river … The major potential effects of [these] cooling systems include killing of organisms and changes in community structure or habitat. http://link.springer.com/chapter/10.1007%2F978-1-4612-4874-3_3	

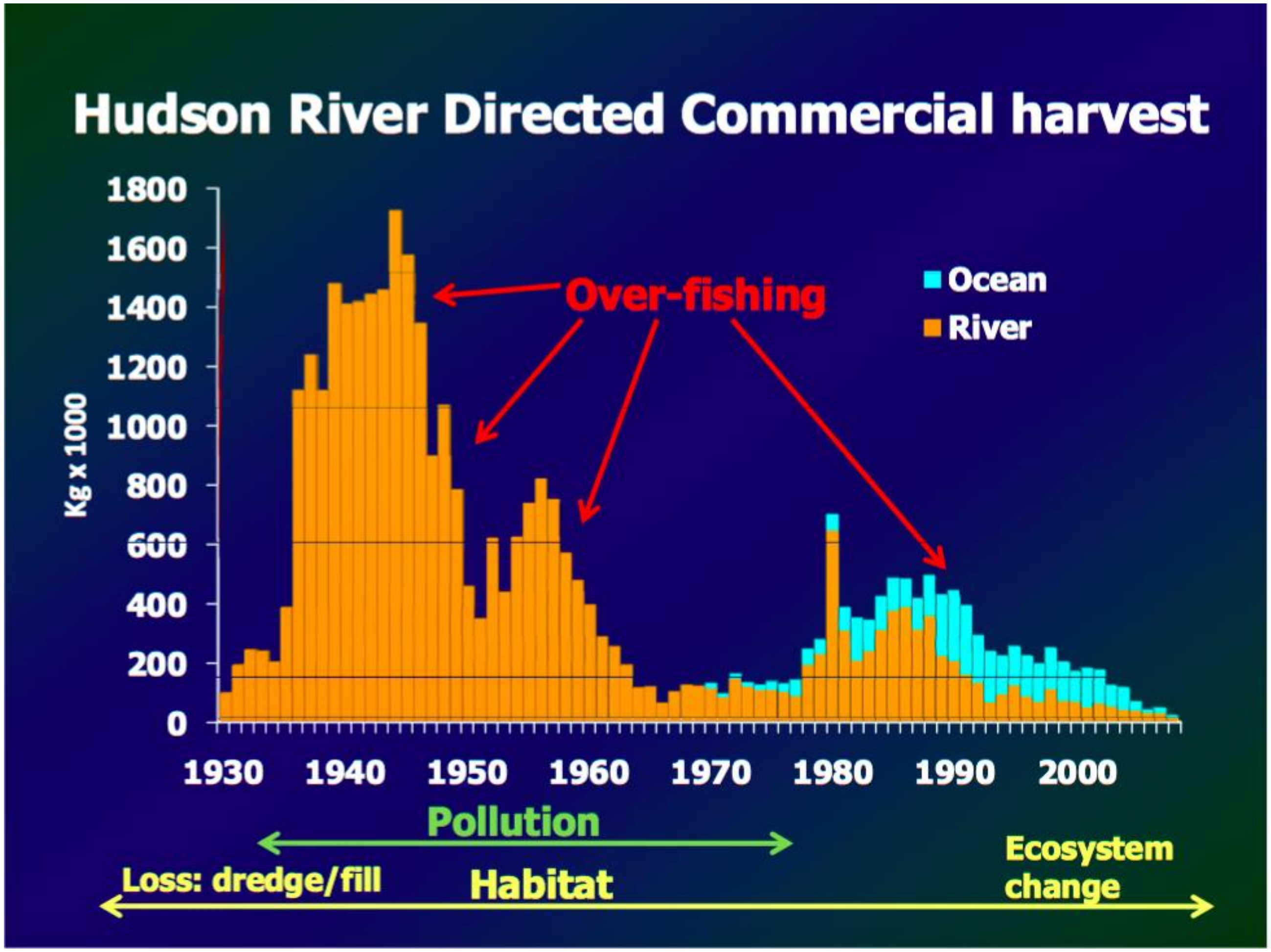
Text Excerpt	**Notes**
Hudson River Valley Institute History of Decline 1. Colonial times	

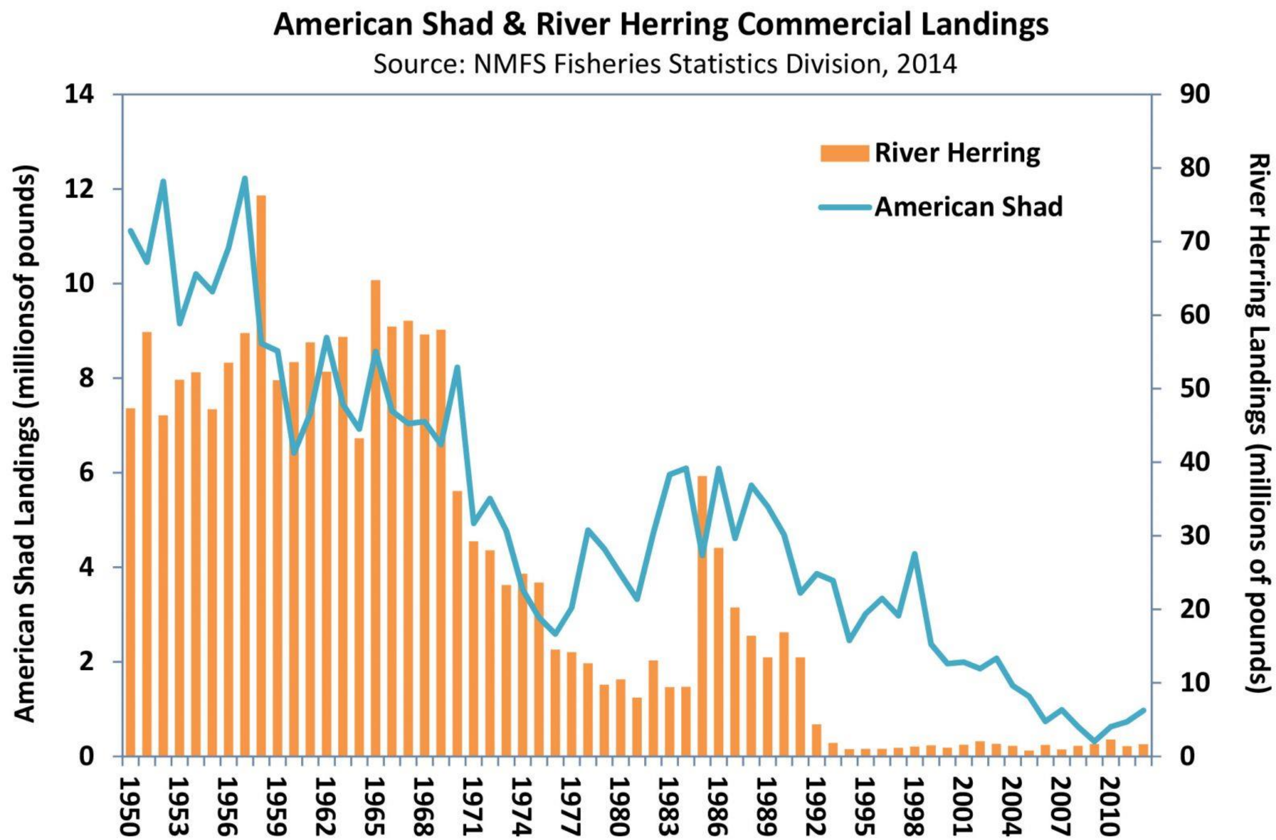
a. Extremely abundant b. Fed General George Washington's troops at Valley Forge (not Hudson, but Delaware River) 2. Mid 1800's a. Relative decline b. Pollution c. Increase in settling of area(s) d. Overfishing e. Mills dammed river 3. Late 1800's - shad revived, but unknown why 4. Modern times a. 1916 - decline - worst ever b. Late 1920's and 1930's - numbers increased c. 1942 - peak shad caught d. 1960 to present - decrease in numbers http://www.hudsonrivervalley.org/themes/shad.html	

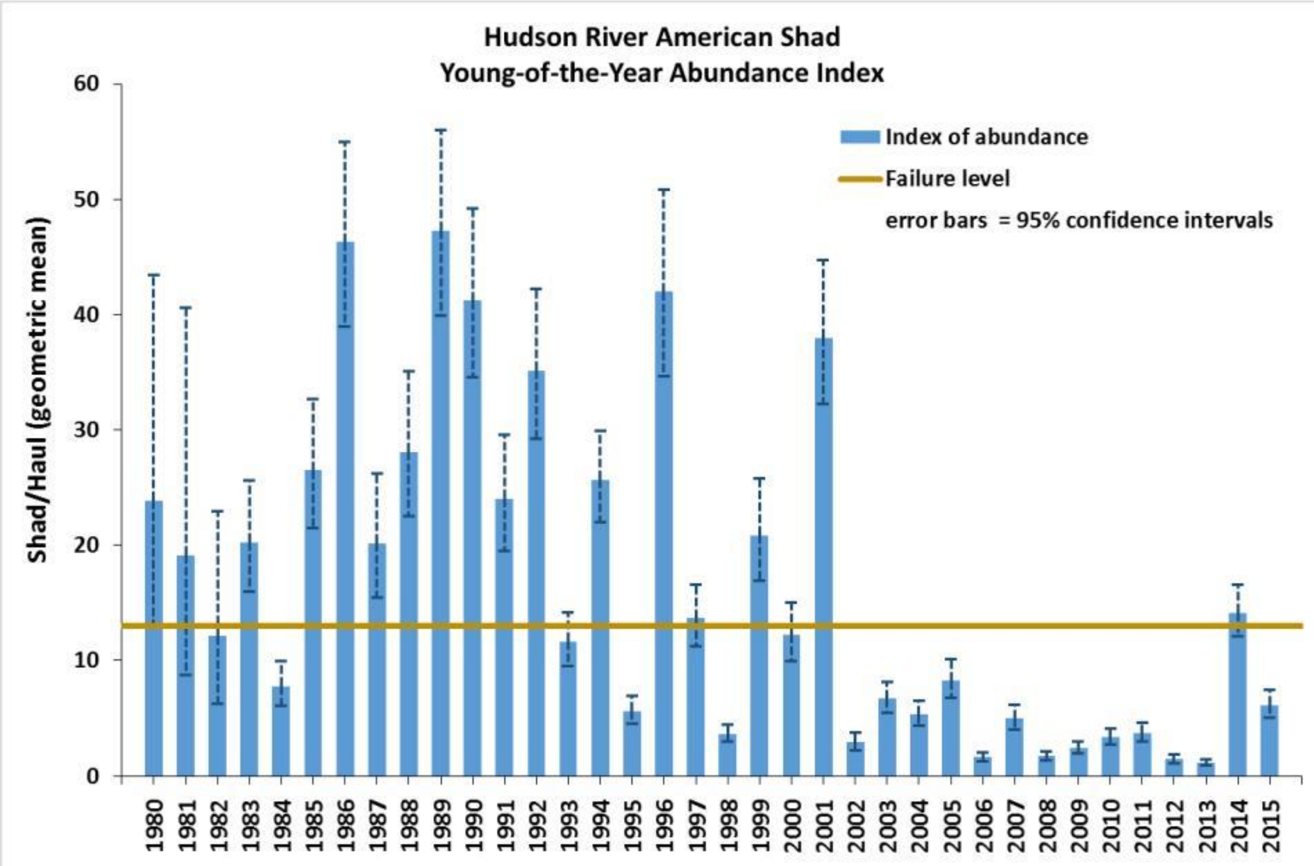
Graph	**Notes**



The blank spaces indicate the years that no data was available on the amount of shad caught. This graph shows the abundant shad catches, with peaks in 1890, the 1940s, and the 1980s. It also shows the decline that began after the peak season in the 1940s.
http://pages.vassar.edu/hudsonvalleyguidebook/2013/06/03/american-shad-fishing-on-the-hudson-river/

Graph	Notes
 https://www.riverkeeper.org/wp-content/uploads/2009/09/Ashad_NYHud_public_infoSept09.pdf	

Graph	Notes
 http://www.asmfc.org/species/shad-river-herring	

Graph	Notes
Shad "Young of Year" (Shad born within the past year)  http://www.dec.ny.gov/animals/26741.html	

Density and Oysters

BOP Curriculum
bop-curriculum@nyharbor.org
Aug 27, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	3	Classroom	

Summary

Students will watch a video of oysters filtering a tank to motivate their work. They will then do a lab where they will investigate which objects float and which objects do not. They will use that demonstration to discuss how oysters filter water.

Objectives

- What is density?
- How do we find the density of a substance?
- Why is the idea of density important to studying oysters?

Materials and Resources

Supplies

- Beaker of water
- Piece of a candle
- Small rock
- Oyster Shell
- Scale
- Graduated cylinders

Before you get started

Tips for Teachers

Computer with YouTube access/projector.

Tips for Teachers

- If your time is limited, rather than calculating density, you can simply give the students the densities of the objects and have them see if they float or sink.
- Make sure your graduated cylinders are wide enough to drop the objects in, so that you can see how much water they displace.
- For the object that floats (the candle), the students will need to push the candle until it is just submerged in order to calculate the volume. You can use a pencil for this.
- If students struggle with ratios, there is an ratio and proportions practice sheet with oyster connections that might be fun.

Background

An adult oyster can filter up to 5 liters or 1.3 gallons on water an hour. That's equal to 60 two-liter soda bottles a day, for just one oyster! Historically, oysters could filter the Chesapeake Bay's entire water volume in less than a week. Today, with 1% of the oyster population left in the Chesapeake Bay, it would take oysters nearly a year.

Oysters are filter feeders, meaning they eat by pumping large volumes of water through their body. Water is pumped over the oyster's gills through the beating of cilia. Plankton, algae and other particles become trapped in the mucus of the gills. From there these particles are transported to the oyster esophagus and stomach to be eaten and digested.

Once the oyster removes all nutrients, indigestible material is expelled as “pseudofeces” through the anus. The pseudofeces are expelled from the oyster’s shell via a rapid closing of valves. The expelled particles swirl through the water and resemble a smoke ring. These smoke rings are an indication that oysters are filtering the water and doing what they are meant to do. (http://baybackpack.com/blog/how_does_an_oyster_filter_water)

Instruction Plan

Engage

Engage

Watch this movie:

http://twistedsifter.com/2014/10/two-tanks-filled-with-same-water-one-has-oysters/

or

http://sploid.gizmodo.com/video-oysters-are-fantastic-at-filtering-dirty-water-1652540034

Why do you think the water with oysters is so much clearer than the water without oysters? What do you think the oysters are doing?

Explore

Explore

Explain that the way the oysters filter the water has to do with density and that students will do a density lab to explore it.

Show the students the candle, rock and oyster shell. Ask the students to make a hypothesis. Which objects do they think will float and which do they think will sink? Ask them WHY an object would float or sink?

Explain

Explain

There are two options for this section:

OPTION 1:

Pass out the “Density Lab” handout.

1. Define density: Mass/Volume. Define Mass and Volume.
2. Find the density of each object. Find the mass by weighing the object and the volume by seeing how much water it displaces in the graduated cylinder.
3. Calculate the density of each object.
4. Test your hypothesis
5. Discuss WHY an object would float or sink based on the density of water.

OPTION 2: (much shorter)

1. Define density: Mass/Volume. Define Mass and Volume.
2. Tell students the densities of the three substances: Oysters: 1.5-2 g/mL Candle Wax: .93 g/mL Rock: This varies based on the type. 2.3-5 g/mL (for an exact answer, look up the kind of rock you have or calculate the density)
3. Tell students that the density of water is 1 g/mL. Ask them to hypothesize based on the densities which will float and which will sink.
4. Have them test their hypothesis in a beaker of water. Finally, discuss WHY an object would float or sink based on the density of water.
5.

Elaborate

Elaborate

If oyster shells are more dense than water, they will sink. Why is this important? As oysters feed, they process water and filter through what is inside. Using their cilia, they draw water in and “sort” particles into two categories: food and waste. Any particles that they can’t eat, they release as pseudofeces. Due to the density of pseudofeces (which is made out of the same material as oyster shells), these then sink into the benthic layer below and no longer pollute the water. This is how oysters filter.

Screen Shot 2016-08-23 at 5.50.54 PM.png

Evaluate

Evaluate

Which of the following objects from the harbor do you think will be discarded and which will be food for the oyster?

1. Algae
2. Sewage
3. Plankton

4. Small pieces of plastic
5. Bacteria

Explain how density is important to the filtration that oysters do.

Standards

CCLS - ELA Science & Technical Subjects

-
  - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
  - Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
  - Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

CCLS - Mathematics

-
  - Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
  - Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
  - Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units.

NGSS - Disciplinary Core Ideas

- LS2.A: Interdependent Relationships in Ecosystems
  - Growth of organisms and population increases are limited by access to resources.
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
  - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- PS1.A: Structure and Properties of Matter
  - Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
  - Weather and Atmosphere
- Grade 6, Unit 3
  - Diversity of Life
- Grade 6, Unit 4
  - Interdependence
- Grade 7, Unit 4
  - Dynamic Equilibrium: Other Organisms
- Grade 8, Unit 4
  - Humans and the Environment: Needs and Tradeoffs

NYS Science Standards - Key Ideas

- LE Key Idea 1
  - Living things are both similar to and different from each other and from nonliving things.
- LE Key Idea 3
  - Individual organisms and species change over time.
- LE Key Idea 5
  - Organisms maintain a dynamic equilibrium that sustains life.
- LE Key Idea 6
  - Plants and animals depend on each other and their physical environment.
- LE Key Idea 7
  - Human decisions and activities have had a profound impact on the physical and living environment

NYS Science Standards - Major Understandings

-
    - Living things are composed of cells. Cells provide structure and carry on major functions to sustain life. Cells are usually microscopic in size.
    - Cells are organized for more effective functioning in multicellular organisms. Levels of organization for structure and function of a multicellular organism include cells, tissues, organs, and organ systems.
    - Multicellular animals often have similar organs and specialized systems for carrying out major life activities.
    - The excretory system functions in the disposal of dissolved waste molecules, the elimination of liquid and gaseous wastes, and the removal of excess heat energy.
    - Animals and plants have a great variety of body plans and internal structures that contribute to their ability to maintain a balanced condition.
    - All organisms require energy to survive. The amount of energy needed and the method for obtaining this energy vary among cells. Some cells use oxygen to release the energy stored in food.
    - Herbivores obtain energy from plants. Carnivores obtain energy from animals. Omnivores obtain energy from both plants and animals. Decomposers, such as bacteria and fungi, obtain energy by consuming wastes and/or dead organisms.H
    - Food provides molecules that serve as fuel and building material for all organisms. All living things, including plants, must release energy from their food, using it to carry on their life processes.
    - Foods contain a variety of substances, which include carbohydrates, fats, vitamins, proteins, minerals, and water. Each substance is vital to the survival of the organism.

Dissolved Oxygen and Oysters - Part 1

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 6, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Water Quality Lessons	6-8th	1	Classroom	

Summary

This pair of lessons can help you integrate reading into the process of inquiry. Students use concept maps to organize their ideas and questions about the complex relationships involving oysters and dissolved oxygen. Students then use a library of texts both to find information and to develop informed, follow-up questions that can be the basis for future investigations.

Objectives

N/A

Materials and Resources

Supplies

Ideally, each student can access the internet so as to read texts, closely examine diagrams, and watch videos as part of their research. If this is the case, provide digital access to the Resource: Oysters and Dissolved Oxygen Library. It's great to print it out as well, so students have the option to underline, annotate, etc. by hand. If you wish, provide very large sheets of paper for complex concept maps!

Before you get started

Tips for Teachers

You'll need to read the library in advance, or as much of it as you want to use, and make the best judgment about which texts/images/video are the best fit for your students. Ideally they will get a range of materials, including some that are fairly straightforward for them, as well as some that are a definite challenge. Before you start Day 2, you'll need to gather a list of statements from students' concept maps from Day 1. This process is described more fully in the Handouts section of Day 2's lesson. This pair of lessons will make more sense for students after introducing students to the general concept of dissolved oxygen, for example in the BOP lesson "Saturation and Dissolved Oxygen"

Preparation

N/A

Background

N/A

Instruction Plan

Engage

1. Hand out a *Concept Map* to each student

2. Ask your students to make a concept map starting with the categories:

- You
- Your friends
- Your phone

3. How many different true statements can you make that relate you, your friends, and your phone? (Here is an example of a concept map, to give an idea of true statements and links.)

4. What if you introduce a fourth thing into its own box, something that comes up a lot when you think about you, your friends, and your phone – what might that be? Snapchat? School? Selfies? – how does that figure into the concept map? What does that new thing lead to? What leads to it?

Explore

Tell your students:

Now we'll make a concept map relating

1. Oysters
2. Dissolved Oxygen

Put a few links on your concept map. They can be questions or statements.

Explain

Now you can give out Library on Dissolved Oxygen and Oysters – Part I.

This will be a good time to give your students a pep-talk! Tell them they've "got this," and then tell them again with different words. Tell them twice more, just for good measure. This can help them move beyond fears about reading and about sifting through large amounts of information.

You might also scaffold this process by reading over one short piece of text with them before they start on their own

Advise your students first to read only the heading of each text. Based on that, they can choose one to read first. Then they can take whatever time they need to start making sense of that reading. For starters, 5-10 minutes for figuring out:

What do you understand so far?

What are your questions so far?

What can you add to your concept map at this point?

- True statements that link oysters and dissolved oxygen, plus the name of the source of your information
- New questions about oysters, dissolved oxygen, or both
- New boxes that you think belong on the concept map – things that come up repeatedly and are a significant part of the story about oysters and dissolved oxygen (such as filter feeders, gills, plankton, light, eelgrass, diseases)

(Some students may need these prompts written on a handout or posted in the room where they can see and refer to them.)

At some point, they can decide to try a different reading. This flexibility allows for differentiation. You can decide to push your most capable readers, individually, to take on more.

Elaborate

Students use the library to add connections to their concept maps.

At some point, the map structure may become too crowded to read effectively. At that point, offer your students to option to just write a list of statements involving oysters and/or dissolved oxygen – statements they would write on a very large concept map if they had one. Alternatively, you can offer students very large paper to create very large concept maps.

Meanwhile, you can take this time to help students navigate the library. Meanwhile you can walk around the room, eavesdropping and trouble-shooting, and noting information such as:

1. What kinds of things are most interesting for your students in this library?
2. What misconceptions do they have, and can you figure out where those misconceptions originate?
3. Which readings are trickiest for them, and can you figure out what it is about the reading that presents obstacles?
4. Which readings seem to work best for them, and can you figure out why?
5. What are some of the specific reading challenges that individual students exhibit?

Evaluate

Ask your students:

Which text did you find the most useful today? What was particularly useful about it?

Which text did you find the least useful today? Did anyone find a good way to make use of that text? If so, what were your strategies for making sense of that text?

Standards

CCLS - ELA Science & Technical Subjects

-
    - Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
    - Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings.
    - Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
    - Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.

CCLS - Mathematics

-
    - Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

NGSS - Cross-Cutting Concepts

- Cause and Effect
    - Cause and effect relationships may be used to predict phenomena in natural systems.
- Energy and Matter
    - The transfer of energy can be tracked as energy flows through a natural system.
- Influence of Engineering, Technology, and Science on Society and the Natural World
    - Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

NGSS - Disciplinary Core Ideas

- LS1.C: Organization for Matter and Energy Flow in Organisms
  - Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- LS2.A: Interdependent Relationships in Ecosystems
  - In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
  - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- PS3.D: Energy in Chemical Processes and Everyday Life
  - Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary)
  - The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary)

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
  - Analyze and interpret data to provide evidence for phenomena.
- Asking Questions and Defining Problems
  - Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
- Constructing Explanations and Designing Solutions
  - Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.
- Engaging in Argument from Evidence
  - Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
  - Interdependence
- Grade 7, Unit 2
  - Energy and Matter
- Grade 7, Unit 4
  - Dynamic Equilibrium: Other Organisms
- Grade 8, Unit 4
  - Humans and the Environment: Needs and Tradeoffs

NYS Science Standards - Key Ideas

- LE Key Idea 1
  - Living things are both similar to and different from each other and from nonliving things.
- LE Key Idea 3
  - Individual organisms and species change over time.
- LE Key Idea 6
  - Plants and animals depend on each other and their physical environment.
- LE Key Idea 7
  - Human decisions and activities have had a profound impact on the physical and living environment
- PS Key Idea 3
  - Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity
- PS Key Idea 4

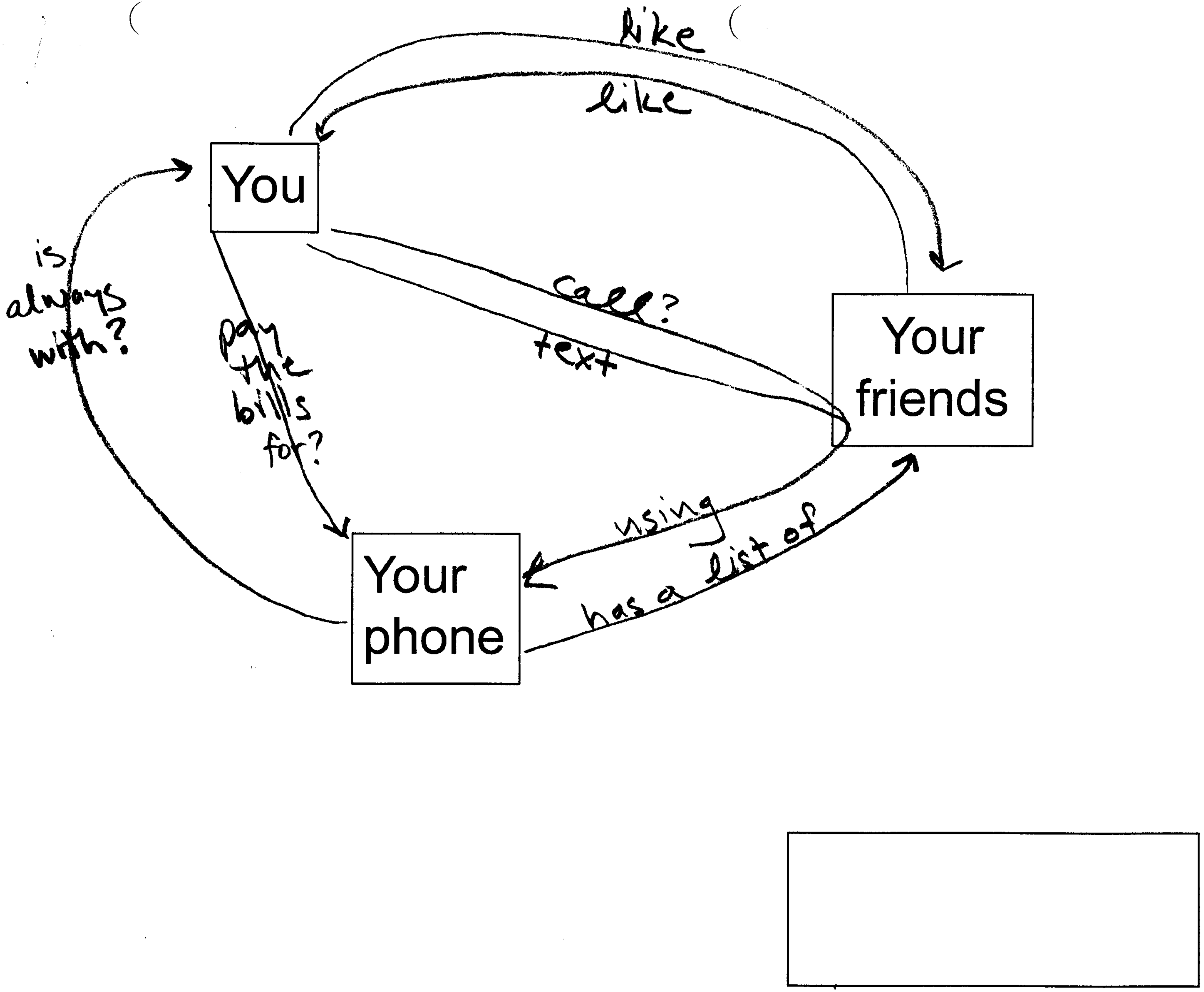
- Energy exists in many forms, and when these forms change energy is conserved.

NYS Science Standards - Major Understandings

- Multicellular animals often have similar organs and specialized systems for carrying out major life activities.
- Tissues, organs, and organ systems help to provide all cells with nutrients, oxygen, and waste removal.
- In all environments, organisms with similar needs may compete with one another for resources.
- Changes in environmental conditions can affect the survival of individual organisms with a particular trait. Small differences between parents and offspring can accumulate in successive generations so that descendants are very different from their ances- tors. Individual organisms with certain traits are more likely to survive and have offspring than individuals without those traits.
- Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.
- The major source of atmospheric oxygen is photosynthesis. Carbon dioxide is removed from the atmosphere and oxygen is released during photosynthesis.
- A population consists of all individuals of a species that are found together at a given place and time. Populations living in one place form a community. The community and the physical factors with which it interacts compose an ecosystem.
- Since the Industrial Revolution, human activities have resulted in major pollution of air, water, and soil. Pollution has cumulative ecological effects such as acid rain, global warming, or ozone depletion. The survival of living things on our planet depends on the conservation and protection of Earth's resources.
- Solubility can be affected by the nature of the solute and solvent, temperature, and pressure. The rate of solution can be affected by the size of the particles, stirring, temperature, and the amount of solute already dissolved.
- Temperature affects the solubility of some substances in water.

NYS Science Standards - MST

- Students will access, generate, process, and transfer information using appropriate technologies.
- Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.



You
Your friends
Your phone
like
like
call?
text
pay the bills for?
is always with?
using
has a list of

Dissolved Oxygen and Oysters - Part 2

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 6, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Water Quality Lessons	6-8th	1	Classroom	ELA

Summary

This pair of lessons can help you integrate reading into the process of inquiry. Students use concept maps to organize their ideas and questions about the complex relationships involving oysters and dissolved oxygen. Students then use a library of texts both to find information and to develop informed, follow-up questions that can be the basis for future investigations.

Objectives

N/A

Materials and Resources

Supplies

Ideally, each student can access the internet so as to read texts, closely examine diagrams, and watch videos as part of their research. If this is the case, provide digital access to the Resource: Oysters and Dissolved Oxygen Library. It's great to print it out as well, so students have the option to underline, annotate, etc. by hand. If you wish, provide very large sheets of paper for complex concept maps!

Before you get started

Tips for Teachers

You'll need to read the library in advance, or as much of it as you want to use, and make the best judgment about which texts/images/video are the best fit for your students. Ideally they will get a range of materials, including some that are fairly straightforward for them, as well as some that are a definite challenge. Before you start Day 2, you'll need to gather a list of statements from students' concept maps from Day 1. This process is described more fully in Handouts. This pair of lessons will make more sense for students after introducing students to the general concept of dissolved oxygen, for example in the BOP lesson "Saturation and Dissolved Oxygen"

Preparation

N/A

Background

N/A

Instruction Plan

Engage

Ask your students:

1. Yesterday, what were a few new links you added to the concept map from your readings?
2. What are some of the new questions you have after doing that?
3. Which were your favorite texts from yesterday, and why?

Explain

Tell your students:

Today we'll go even deeper into the relationships between oysters and dissolved oxygen, by looking at a larger library of texts. The process for using the texts is exactly like yesterday. The differences are:

- You know more now
- You have some new questions now
- You're getting more and longer texts to choose from now -- but you still use them the same way, a little at a time

Elaborate

Students receive Library on Dissolved Oxygen and Oysters -- Part II. They continue their research, filling in more links on their concept maps.

If students are stumped, try giving them a different note-taking format. For example, they could underline all the phrases about oysters in a particular passage, and then sort them into categories, such as relevant/irrelevant, and then maybe new/not new ideas for our class.

Evaluate

Before they do this part, it's a great idea to provide students with a list of statements they can work from, gathered from their concept maps from Day 1.

Ask your students to:

Take two (or more) true statements from our concept maps, and put them together to make a follow-up question. For example:

Statement: oysters need dissolved oxygen.

Statement: it looks like there is less dissolved oxygen in deeper water.

Question: Does this mean that oysters need to live in shallower water?

If your students end on really great, informed questions like this one, point that out, explain how that kind of question is different from a completely naive question -- noting that both kinds are crucially important -- and congratulate them!

Point out that science is as much about asking great questions as it is about finding answers and, if you can, promise to come back to some of their questions in future lessons.

At least you can keep adding to both lists -- you might call the two lists "Initial Questions" and "Follow-up Questions" -- and keep both running lists posted permanently as a guide to the class' investigations and developing thinking.

At best, plan to run future lessons exploring one or more of their informed questions in greater depth. You could do that using the same set of texts or a different set of texts, interviews with local experts, field observation, classroom experiments, and probably many other approaches, too!

Standards

CCLS - ELA Science & Technical Subjects

- - Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

CCLS - Mathematics

- - Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

NGSS - Cross-Cutting Concepts

- Scale, Proportion, and Quantity
  - Phenomena that can be observed at one scale may not be observable at another scale.
- Stability and Change
  - Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

NGSS - Disciplinary Core Ideas

- PS1.A: Structure and Properties of Matter
  - Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
  - Weather and Atmosphere

NYS Science Standards - Key Ideas

- PS Key Idea 2
  - Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.
- PS Key Idea 3
  - Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity

NYS Science Standards - Major Understandings

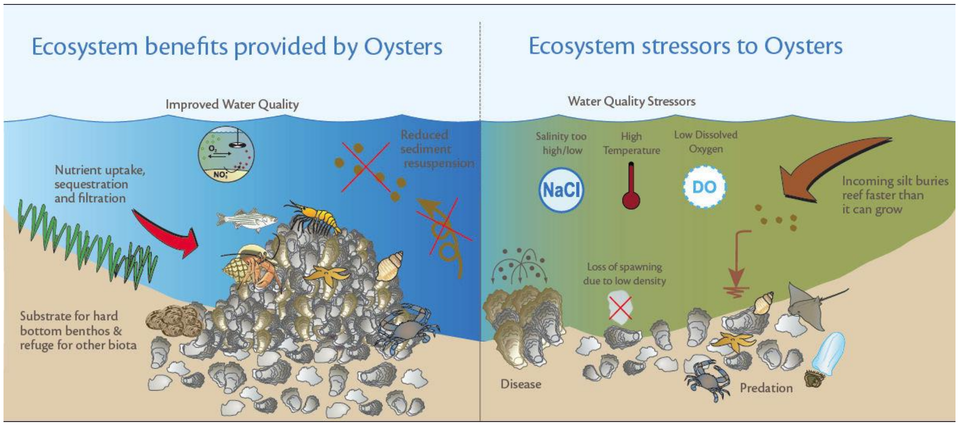
- - Water circulates through the atmosphere, lithosphere, and hydrosphere in what is known as the water cycle.
  - Substances have characteristic properties. Some of these properties include color, odor, phase at room temperature, density, solubility, heat and electrical conductivity, hardness, and boiling and freezing points.
  - Solubility can be affected by the nature of the solute and solvent, temperature, and pressure. The rate of solution can be affected by the size of the particles, stirring, temperature, and the amount of solute already dissolved.

NYS Science Standards - MST

- - Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science

Oysters and Dissolved Oxygen Library -- Part I

1. **Ecosystem benefits and stressors:**



http://chesapeakebay.noaa.gov/oysters/oyster-reefs

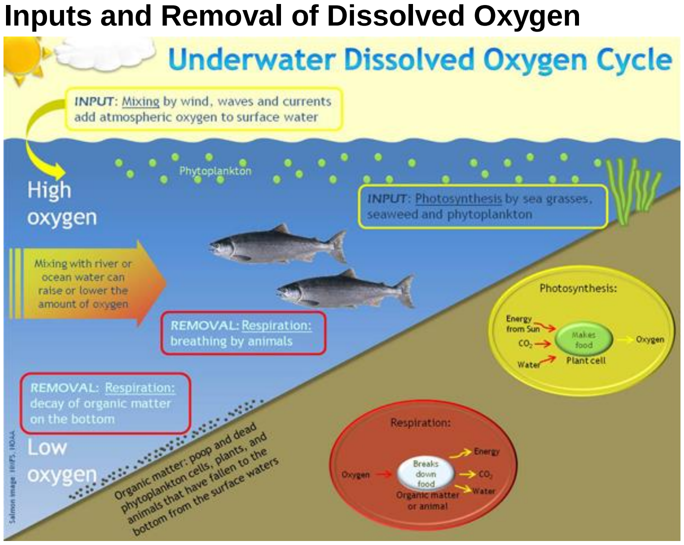
2. **Why people measure dissolved oxygen**

> **What can we learn about Narragansett Bay by measuring dissolved oxygen?**
> Dissolved oxygen in the surface water can tell us about photosynthesis and the air-sea exchange. In the deep water, dissolved oxygen is a good indicator of water quality. Low dissolved oxygen indicates a stressed environment. Water with low dissolved oxygen cannot support healthy communities of plant and animal life

http://omp.gso.uri.edu/ompweb/doee/science/physical/choxy4.htm

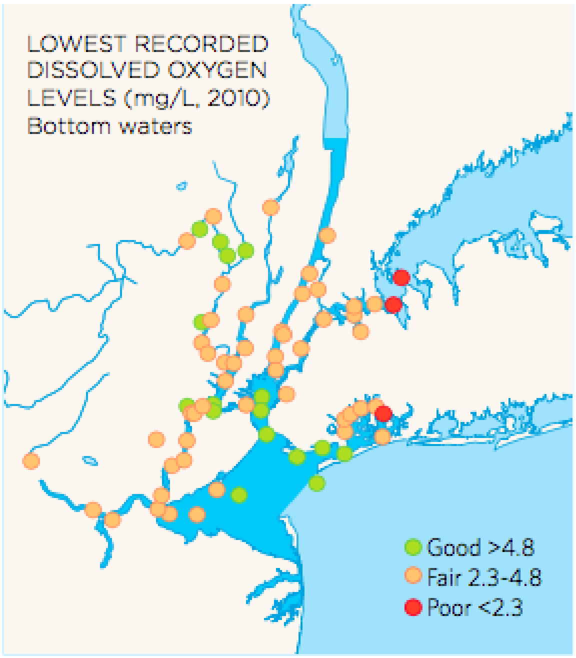
3. **How the bottom of an estuary can become hypoxic**
   Watch "Hood Canal Animation #1: Creation of normal conditions" through 1:11
   http://www.nanoos.org/education/learning_tools/hypoxia/estuarine_hypoxia.php

4. **Inputs and Removal of Dissolved Oxygen**



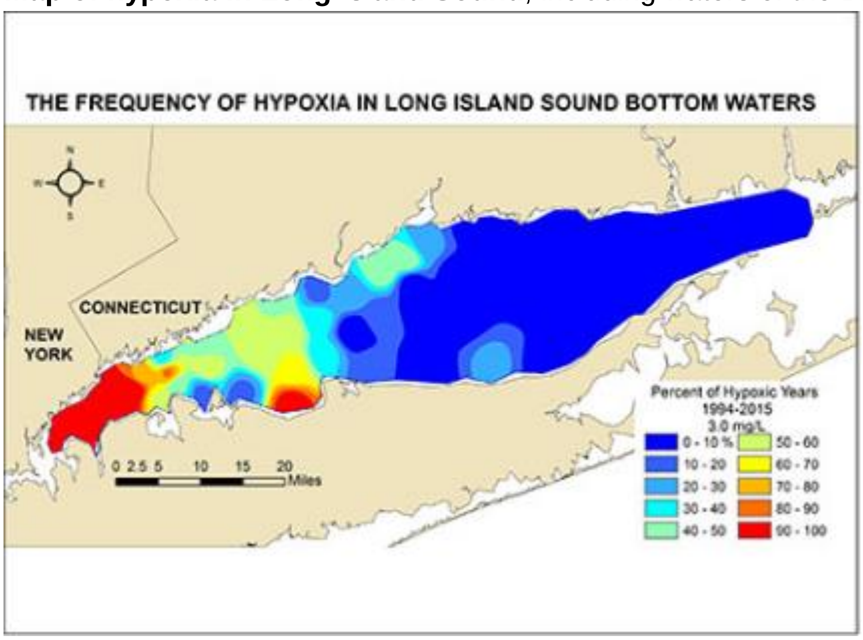
http://www.nanoos.org/education/learning_tools/hypoxia/oxygen_underwater.php

5. **Lowest Recorded Dissolved Oxygen Levels**



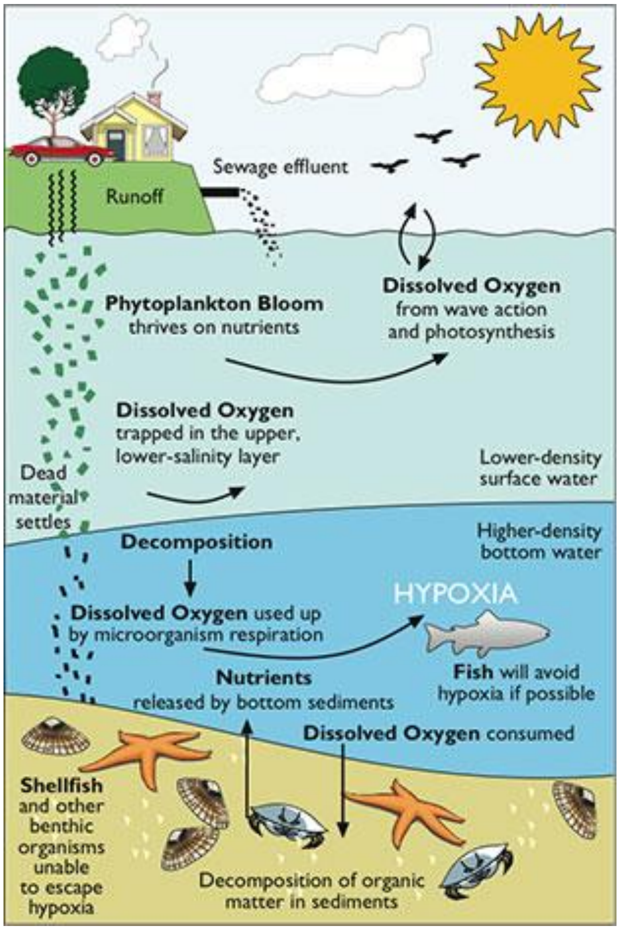
Small map on the left side of page 24
http://www.harborestuary.org/pdf/StateOfTheEstuary2012/SOE_Rprt.pdf

6. **Map of hypoxia in Long Island Sound**, including waters of the Bronx and Queens



http://longislandsoundstudy.net/2016/03/frequency-of-hypoxia-2/

7. **Causes of hypoxia**



http://www.riclimatechange.org/impacts_coastal.php

Oysters and Dissolved Oxygen Library -- Part II

8. **Ecosystems on the edge: low oxygen**
   How dissolved oxygen can drop at night, making oysters more vulnerable to disease. The article is probably more useful than the video.
   http://ecosystems.serc.si.edu/low-oxygen/

9. **The State of The Estuary 2012**
   Read page 9, “Oyster reefs and eelgrass beds”
   and pages 23-24, “Nutrients and dissolved oxygen”
   about the Hudson River Estuary
   http://www.harborestuary.org/pdf/StateOfTheEstuary2012/SOE_Rprt.pdf

10. **Breath of Life**
    Focus on the first page of this document, “Breath of Life,” which describes the dissolved oxygen situation in Chesapeake Bay, and how it affects things that live there. http://www.eco-check.org/pdfs/do_letter.pdf

11. **What is Hypoxia?**
    Poster that describes hypoxia in the Long Island Sound
    http://longislandsoundstudy.net/wp-content/uploads/2010/03/hypoxia-w_text2003-chart.pdf

12. **Changing Hudson Project: Dissolved Oxygen**
    This is a thorough, advanced reading about dissolved oxygen in the Hudson River Estuary ecosystem http://www.caryinstitute.org/sites/default/files/public/downloads/curriculum-project/1C1_dissolved_oxygen_reading.pdf

Oysters and Dissolved Oxygen Library -- Part III

-- detailed local DO information

13. How dissolved oxygen changes over time in in the Hudson River Estuary:

Oxygen dissolved in the water column is necessary for respiration by many forms of aquatic life, including fish, crabs, clams, and insects. DO varies seasonally, typically being lowest in summer and highest in early winter and spring. From year to year, DO levels can be affected by weather, runoff, temperature and salinity differences between the surface and the bottom, tidal and gravitatiorral circulation, algae blooms, and especially flushing rate and river flow.

When bacteria break down the waste from untreated sewage, this can bring down the DO, especially in the warm summer months, making the water unfit for most aquatic life. DO is therefore used as one of the most universal indicators of overall water quality and a means of determining sewage impacts on the ecosystem.

Adapted from: http://life.bio.sunysb.edu/marinebio/hrfhrbook/pdfs/23.pdf

14. Problems with low dissolved oxygen in the East River:

Although the East River's water quality has steadily improved, it still has problems with eutrophication, turbidity, and low levels of dissolved oxygen. As suspension filter feeders, oysters have a great capacity for water filtration. On a per-area basis, oyster reefs are estimated to remove 25 times more nitrogen than salt marshes do (Waldman 1999). Oysters remove phytoplankton, particulate organic carbon, sediments, pollutants, and microorganisms from the water and they use most of the organic matter that they filter (Tolley et al.). By improving water quality, oysters can enhance biodiversity by making the habitat more suitable for other species. For instance, by consuming phytoplankton, oysters increase the amount of light that reaches the water ecosystem. Since sea grass beds are mainly limited by light availability (Greening and Janicki 2006), oyster restoration can contribute to the restoration of sea grass habitats….

Oysters are generally hardy creatures (Waldman 1999) but... their development and mortality are influenced by salinity, current velocity, and dissolved oxygen levels. Oysters generally tolerate salinity levels between 15-25 ppt….Current velocity can affect oyster growth because currents bring food and oxygenated water to the reefs (Brumbaugh et al. 2006).

Generally, dissolved oxygen levels should consistently be above 5.0 mg/l or above. In its current state, the Lower East River barely meets this requirement during the summer and the Upper East River has dipped below this threshold (NYCDEP 2004); this affects the timing and location of oyster restoration.

Adapted from: http://www.columbia.edu/itc/cerc/danoff-burg/RestoringNYC/RestoringNYC_EastRiver.html

15. Some parts of New York City's waters have improved more than others, in terms of dissolved oxygen:

Significant improvements in water quality have been observed for several decades throughout much of the Hudson-Raritan Estuary, because cities and companies are not dumping as much waste into the water as they used to. This has reduced the numbers of pathogenic bacteria and increased dissolved oxygen (DO) concentrations.

In contrast to these improvements, DO in bottom waters of the western Long Island Sound (WLIS) appears to have decreased in the last two decades. Although there is no consensus as to why hypoxia in WLIS may have recently become more severe, several related hypotheses have been suggested, including:
-- more excess phytoplankton growing, dying, and decomposing (eutrophication)
-- less mixing between saltier, denser water at the bottom and less salty, less dense water near the surface
-- changes in wastewater loads.

Since the mid-1980s surface DO supersaturation has increased, bottom minimum DO has decreased, and the difference between the surface and the bottom has increased in WLIS. Other areas of the Hudson-Raritan Estuary, such as Jamaica Bay and Raritan Bay, show similar evidence of declining water quality and may be experiencing increasing eutrophication.

WLIS is deeper than Jamaica Bay and Raritan Bay. So in WLIS, there is a bigger difference between the temperatures at the surface and at the bottom. This might also make it harder for oxygen to get to the bottom of WLIS.

There may also be increases in upstream and nonpoint source loads.
Adapted from http://link.springer.com/article/10.2307/1353004#page-1

16. How sewage disposal has affected the Hudson River Estuary since the 1970s:

For much of the twentieth century, untreated sewage entered the Hudson River Estuary (HRE), where bacteria decomposed the waste and, in the process, used up a lot of the dissolved oxygen. When sewage treatment improved, between the 1970s and the 1990s, the problem changed. Instead of raw sewage, there is treated sewage entering the HRE, and that contains a lot of plant nutrients such as nitrogen and phosporus. These nutrients can promote the growth of phytoplankton, which eventually die and decompose. Bacteria decompose the phytoplankton and, in the process, use up a lot of the dissolved oxygen.

This problem is greatest when the water is not flushed quickly from the HRE. The water sticks around longer when the tidal action is smaller (about twice a month, at neap tides), and when the river flow is lesser (depends on the weather, but happens predictably in August)
Adapted from http://life.bio.sunysb.edu/marinebio/hrfhrbook/pdfs/10.pdf

Estimation with Invertebrates

BOP Curriculum
bop-curriculum@nyharbor.org
Aug 25, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	1	Classroom	Math

Summary

This lesson allows students to investigate how scientists count quantities that are hard to measure exactly. They create their own method and compare it to BOP's method.

Objectives

Students will explore different methods of counting invertebrates and evaluate BOP's protocol.

Materials and Resources

Supplies

- Picture of Tiger
- Pictures of Settlement tiles
- BOP Protocol 4

Before you get started

Background

An ongoing discussion in the scientific community is how to quantify and count things that don't fit into simple boxes. The invertebrates that populate BOP settlement tiles are a great example. How can we count organisms when we don't know where the organisms begin and end? How can we standardize our data on invertebrates? This lesson seeks to answer these questions.

Instruction Plan

Engage

1. Give the direction to "Count the stripes on the tiger's face." Creatively avoid providing any decisive information, and encourage students to write down the question and come up with a provisional answer – all of which will be discussed together very soon! Reassure them that they need a system for counting, but there is no incorrect system. Tell them you're very interested to see what methods they'll come up with! Refuse to answer any other questions or give any instructions (What constitutes a stripe? What color? Do the dots by the eyes count as stripes? etc.)

Once students complete this activity, discuss it. Ask about some pros and cons of different methods / choices. Congratulate original thinking and risk-taking, even if the results aren't so practical. Some example statements:

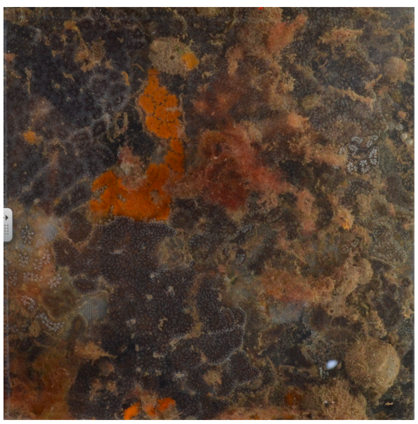
1. I counted all the black stripes, I decided every black mark counted as a stripe.

2. I counted stripes of all colors but only if they were longer than they were wide.
3. I didn't count the marks around the eyes and ears (etc.)

Explore

Show the students two pictures of settlement tiles: There are two examples below. OR, you can have them draw from photos they took on their field visits.

1. Ask the students to write down a list of questions they have when you ask them the following question: HOW MANY ORGANISMS ARE ON THE TILE?



Possible Student Questions:

What is an organism?

How do you know where one organism starts and another stops?

Are the small brown things organisms?

How do you decide what an organism is?

Share, clarify what the different approaches are, and discuss some pros and cons of each.

Also, what new questions have come up? Anybody have any answers?

Teacher says : Instead, here is another way. Once you understand it, tell us what you think of it!

Explain

Hand out the BOP Protocol technique: notes below

1. Note: Keep the tiles just below the surface of the water so the organisms are in their natural state. They will stay alive longer and be easier to recognize.

1. Identify the number of each tile (1 – 4) and locate the top of each tile.

1. Photograph each tile. Make sure each tile fills up the camera screen as completely as possible without chopping off any of the tile surface. Use a towel or umbrella while photographing to reduce the glare.

1. Lay the 25-point grid on the tile.

1. Closely observe the organism that is located at each point on the grid, in the center of the cross-hatch (see below).

1. If it looks like there is more than one organism in the center, choose the organism that is more dominant.

1. There are 25 points for each of the four tiles – so there is a total of 100 points where you need to identify an organism.

1. Use the Species ID Guide (on the tablet or the hard copy) to help you identify each organism.

1. If you cannot identify an organism make a note of the tile and grid-point in the “Other Observations” section of this protocol. More detailed analysis of the photographs can be done back at school.

Have students practice this technique on two different tiles photos. Use the photos from the opening of the lesson.

Elaborate

Compare the count you just got to the count that you got when you just counted the organisms.

Questions to discuss with students:

1. What are the pros and cons of the protocol technique?
2. What questions do you have about the protocol?
3. What are the pros and cons of the method you came up with on your own?

Evaluate

In your opinion, has BOP made a good decision about how to measure the life on a tile? Explain using specific evidence from the class discussions.

Standards

CCLS - ELA Science & Technical Subjects

-
  - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
  - Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.

CCLS - Mathematics

-
  - Reporting the number of observations.
  - Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

NGSS - Cross-Cutting Concepts

- Patterns
  - Graphs, charts, and images can be used to identify patterns in data.
- Scale, Proportion, and Quantity
  - Phenomena that can be observed at one scale may not be observable at another scale.
- Structure and Function
  - Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

NGSS - Disciplinary Core Ideas

- ETS1.C: Optimizing the Design Solution
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- LS1.A: Structure and Function
  - All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).

NGSS - Science and Engineering Practices

- Constructing Explanations and Designing Solutions
  - Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.
- Developing and Using Models
  - Develop a model to predict and/or describe phenomena

NYC Science Scope & Sequence - Units

- Grade 6, Unit 3
  - Diversity of Life
- Grade 7, Unit 4
  - Dynamic Equilibrium: Other Organisms

NYS Science Standards - Key Ideas

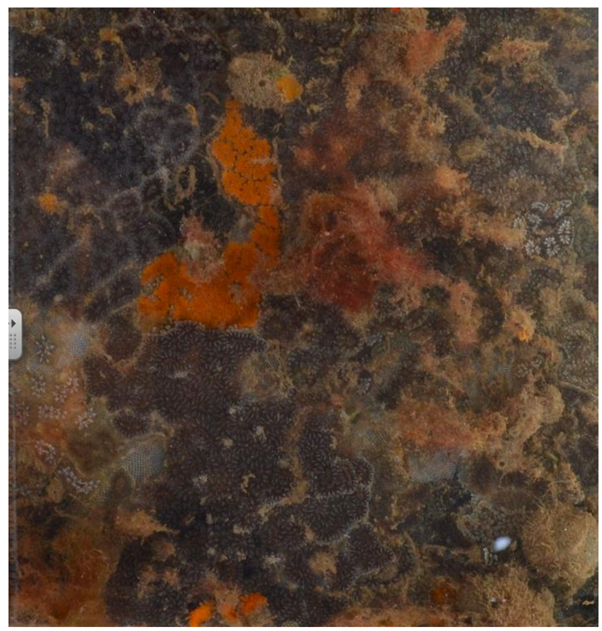
- LE Key Idea 1
  - Living things are both similar to and different from each other and from nonliving things.
- LE Key Idea 5
  - Organisms maintain a dynamic equilibrium that sustains life.

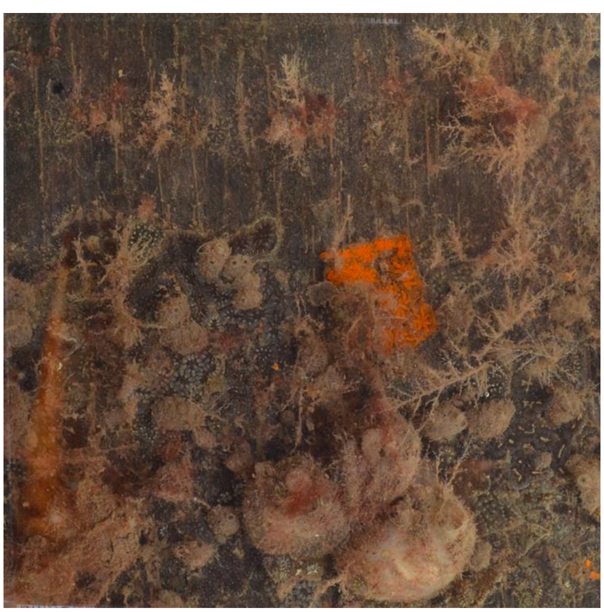
NYS Science Standards - Major Understandings

-
  - Living things are composed of cells. Cells provide structure and carry on major functions to sustain life. Cells are usually microscopic in size.
  - Some organisms are single cells; others, including humans, are multicellular.
  - Cells are organized for more effective functioning in multicellular organisms. Levels of organization for structure and function of a multicellular organism include cells, tissues, organs, and organ systems.
  - An organism's overall body plan and its environment determine the way that the organism carries out the life processes.

NYS Science Standards - MST

-
  - Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.
  - Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.





Exoskeletons, Shells & Endoskeletons Lab

Clarissa Lynn
clarissa@cpe2.org
Jun 20, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Teacher-Authored Lessons	6-8th	2	Classroom	Science

Summary

Explore anatomy in form and function while exploring NY Harbor Populations! Think about the advantages and disadvantages between shells, exoskeletons and endoskeletons.

Objectives

- Students dissect organisms in order to form observations and inferences about exoskeletons, endoskeletons, and shells.
- Students identify similarities and differences between exoskeletons, endoskeletons and shells (the hard parts).
- Students understand that exoskeletons, endoskeletons and shells have advantages and disadvantages.

Materials and Resources

Supplies

- Clam/oyster shucker or screwdriver
- small skewers or toothpicks
- tweezers
- dissection trays
- shrimp with head and tails on, mollusks, whole smoked sardines with head on (all dissection specimens purchased from supermarket),
- magnifying glasses or hand lens
- microscope and slides (optional)

Before you get started

Tips for Teachers

Give kids expectations about their sketches. Encourage labeling.

Give kids expectations about the dissection process, but plan on having an extra specimen in case the students break the organism down to a "mash of flesh and parts". Talk about why mushing it all up is not productive.
Take your time and let the kids have time too. Debriefing is important.

Preparation

Prepare groups to maximize student engagement.

Prepare trays and kits that include all supplies for each group (except the organisms– keep them in the fridge until ready to use!)

Background

Students will have so many questions about the NY Harbor Populations they encounter at the ORS. This lesson began when students were asking, "what is an exoskeleton?" And, "Does the shrimp have a shell?"

Instruction Plan

Engage

What are some examples of hard parts on organisms? Ask students to make lists of all the organisms they can name that have either exoskeletons, endoskeletons, shells. You may define endoskeleton as “internal skeleton”.

Explore

Explain the class procedure. 3 stations: Shell, Exoskeleton, Endoskeleton. Each group will rotate through the three stations. At each station, read the info card and then dissect an organism. Also see examples of these “hard parts” from additional organisms. Students complete the graphic organizer to record observations and inferences about advantages and disadvantages of the various hard parts. As expertise and time permits, you may have students study tissue under magnification.

Explain

Students use the info sheets and teacher conferencing during the dissection to clarify understanding that shells are not living, they are mineral and can grow on the edge as the mantle produces more calcium carbonate, that exoskeletons are made from secretions of chitin from skin and cannot grow, and that bones are made up of cells and therefore can grow from the middle.

Elaborate

how might this thing you noticed provide advantages, or expand the possibilities for this animal? How might it provide disadvantages, or limit the possibilities for this animal? If that feels abstract, maybe frame it as: what can a crab do that an oyster can't? What can an oyster do that a crab can't? And then perhaps, how could you design a better oyster shell / crab exoskeleton in a way that would give an advantage to the crab/oyster or let it do something more effectively?

Evaluate

Exit Slip

Write a paragraph comparing and contrasting 2 out of 3 of the “hard parts” we studied. Include specific details from our lab and discussion.

Use your lab sheet for evidence.

Standards

NGSS - Cross-Cutting Concepts

- Structure and Function
  - Structures can be designed to serve particular functions.
  - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Objectives:

- Students dissect organisms in order to form observations and inferences about exoskeletons, endoskeletons, and shells.
- Students identify similarities and differences between exoskeletons, endoskeletons and shells (the hard parts).
- Students understand that exoskeletons, endoskeletons and shells have advantages and disadvantages.

Materials:
Clam/oyster shucker or screwdriver, small skewers or toothpicks, dissection trays, shrimp, mollusks, fish (all dissection specimens purchased from supermarket), magnifying glasses or hand lens, microscope and slides

Engage: What are some examples of hard parts on organisms? Ask students to make lists of all the organisms they can name that have either exoskeletons, endoskeletons, shells. You may define endoskeleton as “internal skeleton”.

Explore: Explain the class procedure. 3 stations: Shell, Exoskeleton, Endoskeleton. Each group will rotate through the three stations. At each station, read the info card and then dissect an organism. Also see examples of these “hard parts” from additional organisms. Students complete the graphic organizer to record observations and inferences about advantages and disadvantages of the various hard parts. As expertise and time permits, you may have students study tissue under magnification.

Explain: Students use the info sheets and teacher conferencing during the dissection to clarify understanding that shells are not living, they are mineral and can grow on the edge as the mantle produces more calcium carbonate, that exoskeletons are made from secretions of chitin from skin and cannot grow, and that bones are made up of cells and therefore can grow from the middle.

Elaborate: how might this thing you noticed provide advantages, or expand the possibilities for this animal? How might it provide disadvantages, or limit the possibilities for this animal? If that feels abstract, maybe frame it as: what can a crab do that an oyster can't? What can an oyster do that a crab can't? And then perhaps, how could you design a better oyster shell / crab exoskeleton in a way that would give an advantage to the crab/oyster or let it do something more effectively?

Evaluate: Exit Slip
Compare and contrast 2 out of 3 of the “hard parts” we studied.
Use a venn diagram or t-chart.

Follow up writing: What are the advantages and disadvantages of shells, exoskeletons and endoskeletons? Include specific details from your dissection and/or the info sheets.

NGSS

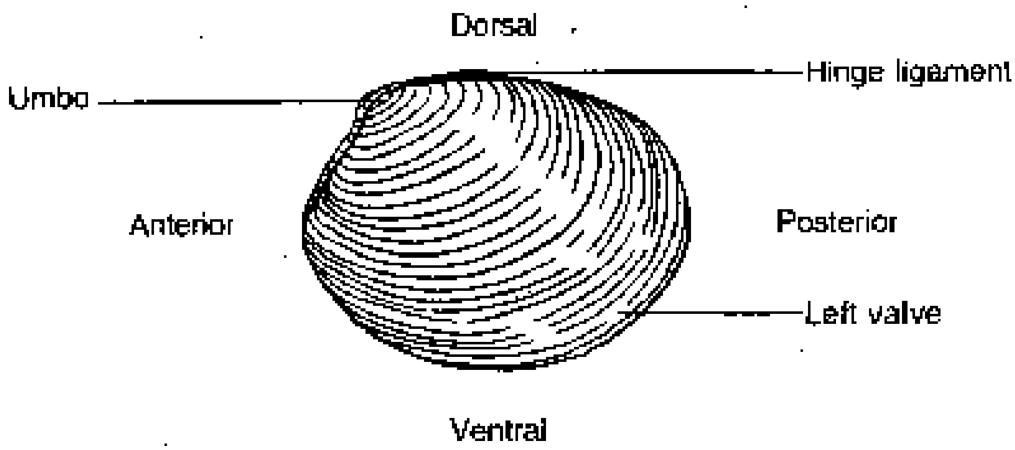
Name: _______________ Date: _____________

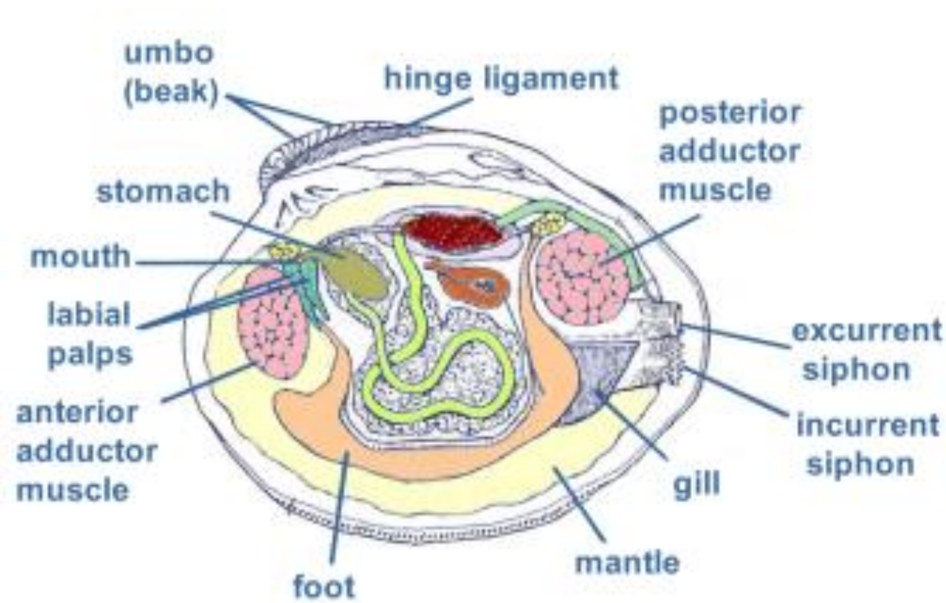
Hard Parts Lab Investigation: How do shells, exoskeletons and endoskeletons compare?

	Shells	**Exoskeleton (external skeleton)**	**Endoskeleton (internal skeleton)**
Sketch or Describe Observations			
Advantages: What can you *infer* are the advantages of...			
Disadvantages: What can you *infer* are the disadvantages of...			

Shells

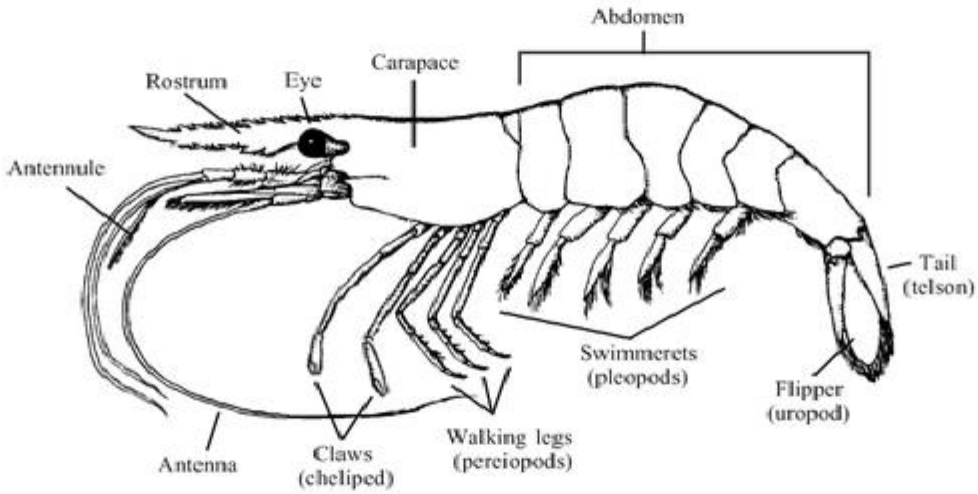
Shells grow, but only at the edges. That's because they're not made of cells (which could grow from the middle), but they are shaped in such a way that growing at the edges actually makes more room for a growing animal. So we get these beautiful spiral snails, and 'growth rings' on mussel and oyster shells -- because each new round of growth is shaped the same as the last one, only larger.

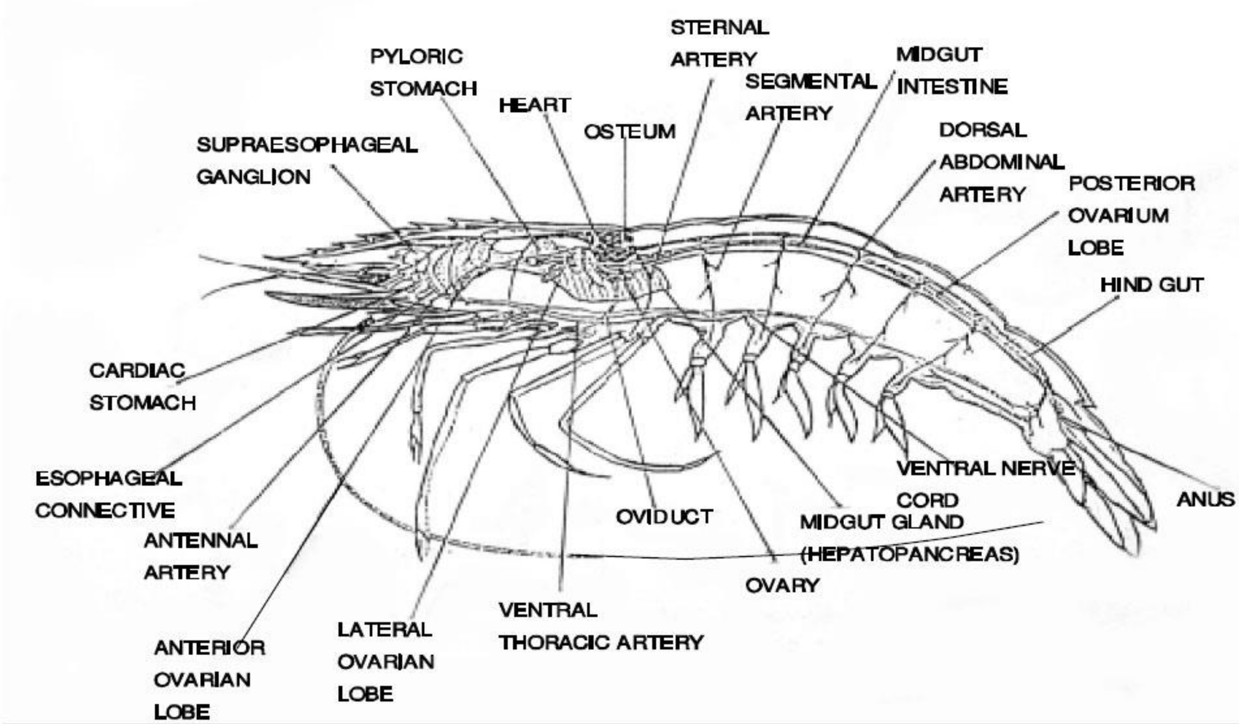




Exoskeletons

The bodies of arthropods are supported, not by internal bones, but by a hardened exoskeleton made of chitin, a substance produced by many non-arthropods as well. In arthropods, the nonliving exoskeleton is like a form-fitting suit of armor. It is produced by the "skin" and then hardens into a protective outer-covering. The key thing about exoskeletons is that they're not made up of cells and can't grow, so an animal (or diatom!) with an exoskeleton has to molt. The need to molt creates some interesting tradeoffs. This exoskeleton is handy in some ways (it provides protection and prevents water loss), but is limiting in others. In order to grow, all arthropods must shed the exoskeleton and produce a new, larger one.





Anatomy of white shrimp

Skeletons

Bones are spectacular because although they seem hard and solid, they're actually living tissue, cells galore, and that means they can change size and shape, they can grow in all directions, and they can also shrink or hollow out, under the right conditions. That's why there's so much to learn from studying bones, for example, in archeology -- because they change inside the living animal, in response to the way the animal uses them.

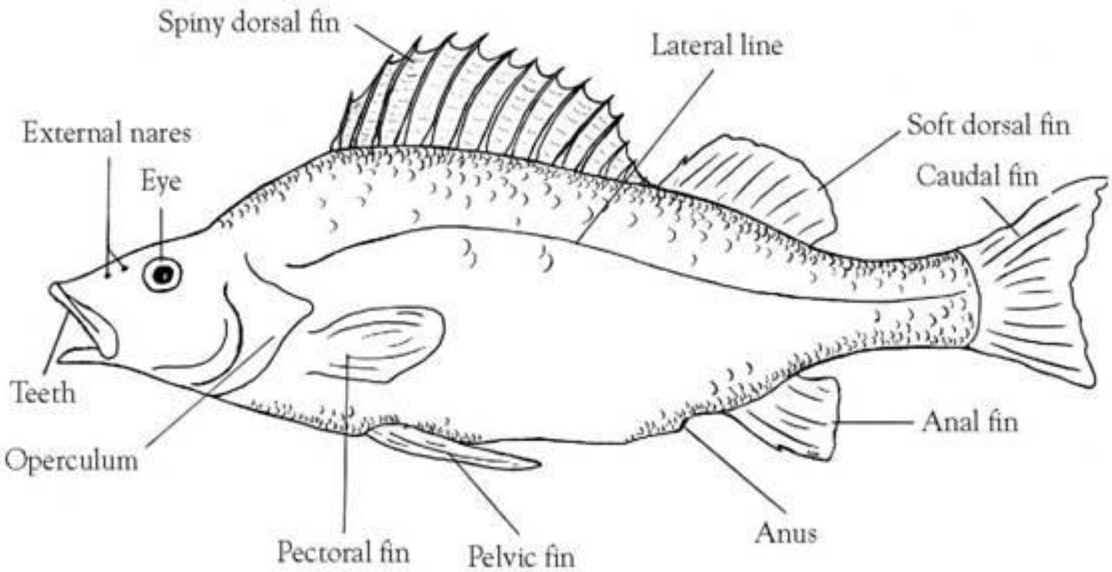
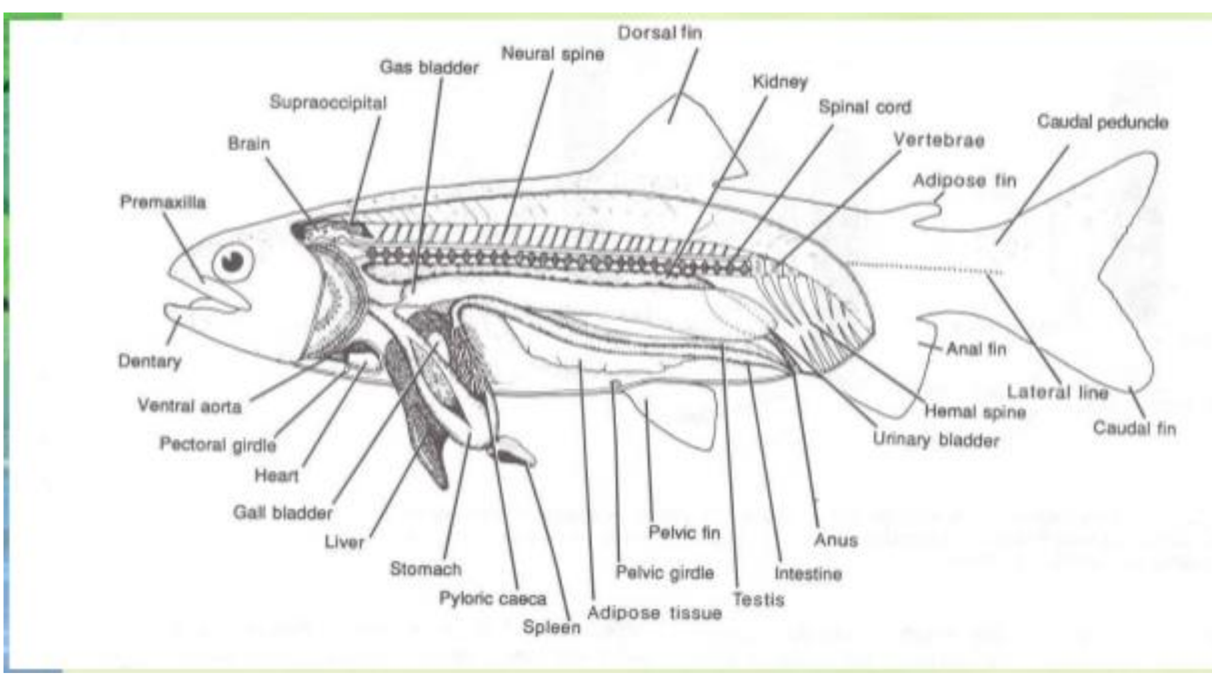


Figure 1



Shells, ExoSkeletons, Skeletons

What are some examples of hard parts on organisms?

Make a list of all the organisms they can name that have either exoskeletons, endoskeletons, shells.

Endoskeleton = “internal skeleton”

Lab Overview

3 stations: Shell, Exoskeleton, Endoskeleton.
Each group will rotate through the three stations.
At each station, read the info card and then dissect an organism.
Also see examples of these “hard parts” from additional organisms.
Complete the graphic organizer to record your observations and inferences.

Some Reminders -- and Groundrules

- Does it make sense to cut up the organism into tiny pieces or mash it all up into a ball of flesh? Why or why not?
- How do you think you can work best together?
- Take turns
- Move slowly
- Use the info sheets to help you understand what you are looking at.

- Sketch what you see or take notes to describe your

Exit Slip

Compare and contrast 2 out of 3 of the “hard parts” we studied.

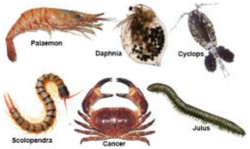
Use a venn diagram or t-chart.

Comparative Skeletal Analysis Day 2

Do Now: What was the coolest or most surprising thing that you observed or learned yesterday?

Comparative Skeletal Analysis Chart

SHELLS (MOLLUSCA)	EXOSKELTONS (ARTHROPODA)	ENDOSKELETONS: (CHORDATA)



COMPARATIVE SKELETAL ANALYSIS: WRITE UP

How are shells, exoskeletons and endoskeletons similar and different? Use specific details from our lab and reading in your response.

Transitional Phrases to COMPARE AND CONTRAST:

Similarly…	Yet…
In the same way…	though...
Likewise…	Nevertheless… otherwise...
In the same manner…	Nonetheless… on the contrary...
In like manner….	after all… in
By the same token…	contrast...
In similar fashion...	But…

notwithstanding...

However… on the other hand ...

Exit Slip

3 things you learned

2 things you enjoyed

1 question you still have

Extension Activities for the Field

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 7, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	1	Field	ELA Math Science Social Studies

Summary

These short activities are designed to complement ORS (Oyster Restoration Station) monitoring expeditions.

Materials and Resources

Before you get started

Tips for Teachers

- In the field, it is important to keep students engaged at all times. Students who finish more quickly, can be a distraction to others. Use these activities to keep students engaged and active while outdoors.
- Note: the extension activities are color coded based on category.

Instruction Plan

Explore

Site Conditions

Soft Sediment Sampling (15 min)

Learn about the composition of the sediment at your field site by taking a benthic sample. Use either a homemade core sampler (PVC tube) or a bucket grab sampler (Ekman) to collect sediment. Observe sediment using a field microscope to compare the different types of particles present.

Site Conditions

Nature Walk (15 min)

Observe, collect, and press leaves in the area. Observe and identify trees. Sketch an animal.

Site Conditions

Scavenger Hunt (15 min)

Students find, document, and take data on specific plant species and/or other features of the site.

Teacher Tip: This must be prepared in advance, based on specific features of the specific ORS site. Possible hunt items include:

- A CSO
- A bird: what kind is it? What is it doing?)
- Something there are many of: now count them
- The vehicles you see
- A nearby person: how are they using the space?
- A human-made object in the water: what is it?
- An insect: sketch it.
- A living thing that is green.
- A non-living thing.
- The nearest trash can.
- A living thing that crawls.
- Something floating in the water.
- Something they think was there before they were born.
- Something they think arrived or was placed there during their lifetime.
- Students could also map the hunt items.

Site Conditions

Map it (15 min)

Students map the site using either a pre-prepared outline or from scratch.

Site Conditions

Photograph it (10 min)

Students document the site in photographs. One option is to use off-line apps to label and create a landscape view of the site.

Site Conditions

Narrate it

Students document the site via audio recording. Students could also shoot short videos to document the site.

Site Conditions

Naturalist's Journal (15 min)

Students chart their observations and inferences about the site.

Teacher Tip: It might be interesting to compare students' Journals across different seasons. Students could be directed to focus on a particular type of observation and/or inference, e.g.:

- Observe abiotic factors, and draw inferences about how each abiotic factor might impact the ecosystem within the estuary.
- Choose 3 interesting observations and draw inferences about how they migh affect oysters.
- Chart qualitative observations and quantitative observations.
- Sit and listen to the city around you. Record as many different sounds as you can. Include both natural and human-made sounds.
- Sit and smell the city around you. Record as many different smells as you can. Include both natural and human-made smells.
- Sit and look at...etc.
- Survey the trees.
- Collect traffic data. Then draw inferences about ways that air pollution might affect the water.
- Collect boat traffic data (# boats/unit time)

Site Conditions

Imagine the past

After completing a Naturalist's Journal-type assignment, students write: How might this place have been different 50, 100, 200, or 400 years ago? What might account for these differences? What organisms might have been found here at different moments in the past? Students might represent their idea of the past of this site in pictures, maps, and/or descriptions.

Site Conditions

Take Inspiration (15 min)

After completing a Naturalist's Journal and/or Imagine the past-type assignment, students write a poem or other piece of creative writing inspired by the site. One possibility is to write a short story that illustrates what they think life might have been like in this place at a particular moment in the past.

Site Conditions

The Built Environment (15 min)

Students sketch the skyline, a building, or a scene of relatively long-lasting human-made structures. They describe the subject in detail and then answer: what impact do they think it has on the living creatures in the coastal area?

Site Conditions

Why here? (15 min)

Students write what they know about the site. Then they answer the question: Why here? What are the advantages of studying this particular place? What are the disadvantages?

Site Conditions

On the other side

Students compare and contrast two sides of the waterbody, e.g. How is the Manhattan side of the East River similar to and different from the Queens side?

Site Conditions

Terrestrial Monitoring

Monitor all the species you can, for example: birds, squirrels.

Mobile Organisms

Deploy Fish Trap (note: contingent upon DEC permits) (10 min)

To gather data on larger mobile organisms (>1 inch) students and teachers can deploy a fish trap attached to or near the oyster cage for a period of 12-48 hours (any longer could result in fish mortality). This would be a standard single opening trap ranging in size from 3 to12”. Fish trap could be constructed by teachers or students using our standard 14 gauge vinyl coated mesh. Another option would be to use a seine or trawl net however this would likely require wading, which few if any sites allow.

Teacher Tip: Encourage the group to think carefully about the placement of the trap in relation to any shoreline hazards

Mobile Organisms

Crustacean Anatomy (15 min)

In this activity, students can examine the body plans of different types of crustaceans in more detail. After performing a basic sort of the mobile invertebrate found within the mesh netting, choose 2–3 different types of crustaceans – amphipods, isopods or crabs (refer to the species ID guide and remember that amphipods are flattened laterally, along the length of their bodies, whereas isopods or pill bugs, are flattened dorso-ventrally). Show students the basic crustacean body plan diagram and discuss the segmentation into head, thorax and abdomen. Using handheld field microscopes, describe the form of the body parts for the different species chosen and discuss their possible functions. For example, consider the size of the animal, the size of the body part in relation to the rest of the body, where the animal was found and how mobile it is in the sample dish.

Teacher Tip: This activity will be most interesting if very different species are found in the sample, particularly caprellid species.

Sessile Organisms

A Life Less Mobile (15 min)

Find an example of a solitary ascidian, barnacle or mussel on a tile. Think about how these animals might be adhering to the surface and discuss the process of adhesion and settlement (using additional supporting documents). How does an animal get its food if it can’t move around? Closely observe some of the animals and watch for any movement (of siphons in an ascidian, shell opening in a mussel, feeding appendages in a barnacle). Remove a tile from the water and gently push a solitary ascidian such as Molgula manhattensis and observe water coming out of the siphons; note that there are 2 siphons and discuss how water is pumped through its body and filtered.

Teacher Tip: Keep very still and the animals fully submerged whilst observing them initially as you will be more likely to see feeding activity

Sessile Organisms

Growing with the flow

Examine the surfaces of tiles that were facing ‘outwards’ from the shore, into the flow direction, and compare the dominant cover found to that found on tiles facing ‘inwards’ on the shore. What types of organisms are found on each? What physical (abiotic) and biological (biotic) factors do you think might influence any differences in the organisms found? How many of these are filter feeders? Does this number differ according to the direction the ties are facing?

Teacher Tip: This activity will be more valuable if a pre-field class on harbor ecology and/or invertebrate biology has been completed

Sessile Organisms

Draw it (10 min)

Students create a life drawing of an ORS organism.

Sessile Organisms

Different Substrates (10 min)

Use different materials for tiles and compare growth of sessile organisms.

Human Relationships with the Site

Site Stewardship: Garbage (15 min)

Document and then collect trash at the site.

Teacher Tip: Remind students that some kinds of trash should be picked up by adults, e.g. broken glass, needles, and any other sharps or likely sources of pathogens.

Human Relationships with the Site

Get to Know the Locals (15 min)

Students interview site users, such as fishermen, park visitors, etc. And/or students prepare a survey or questionnaire to administer to as many people as they can who frequent the site.

Human Relationships with the Site

Who cares about this site? (15 min)

Students chart their observations of human activities at the site (e.g. boat tours) and inferences about the major interests associated with each activity (e.g. jobs, recreation). Then students reflect on what activities they would like to see made possible on their waterfront, and what would need to happen in order to make those activities possible.

Student leadership within the class

Each One Teach One

Students teach a classmate how to use a specific piece of equipment. Students then practice using that tool.

Teacher Tip: This could be scaffolded with a prepared handout that shows:

- Images of tools (e.g. calipers in one picture, sling psychrometer in the next)
- What does that tool do?
- What is the procedure for using that tool?

Student leadership within the class

Advance Team

Selected students set up each protocol station while the teacher retrieves the ORS from the water.

Student leadership within the class

How It's Done (10 min)

Students review safety protocols and expectations, and delegate roles within their small groups.

Student leadership within the class

Sell It!

Students create a poem, song, or commercial to inform the community about BOP's goals and/or the purpose of having BOP as part of our school.

Research Skills

Design An Experiment

Inspired by their surroundings, students identify a problem or question they think can be solved through experimentation. Then they propose hypotheses and procedures for testing those hypotheses.

Research Skills

KWL @ORS, Illustrated (15 min)

After completing one protocol, students draw a picture of the thing that interested them most while doing that protocol. They can include a sketch of their tools and equipment. Then students write: two statements about what they know about what they observed, two questions they still have about what they observed, and two solutions or resources they can use to find out more about what they observed.

Teacher Tip: Alternatively, the assignment could start with a focus on just questions, and ask the students to brainstorm as many questions as they can think of within three minutes. Another variation on KWL is See-Think-Wonder

Research Skills

Design an experiment

Inspired by their surroundings, students identify a problem or question they think can be solved through experimentation. Then they propose hypotheses and procedures for testing those hypotheses.

Research Skills

Dig Deeper (15 min)

Students read an article or other text prepared by the teacher. The assignment might include discussion prompts and/or questions to answer in writing

Teacher Tip: This must be prepared in advance. Copies must be available at the site. Possibilities include:

- Photographs of the site from different time periods
- Primary source descriptions of the site from different time periods or perspectives
- Secondary sources, e.g. an excerpt from The Big Oyster

Research Skills

Do You Agree? (15 min)

After completing one of the assignments that calls for inferences, students can trade papers and write about a classmate's inferences: Do you agree with your classmate (e.g. that the lack of greenery on land may affect the oysters in the water)? Write a response using evidence from the site to support your position.

Standards

Fecal Coliform and Numerical Extrapolation (Is it safe to drink?)

BOP Curriculum
bop-curriculum@nyharbor.org
Aug 29, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Water Quality Lessons	6-8th	2	Classroom	

Summary

This lesson opens with a hands-on lab demo about "parts per million." The students watch as food coloring gets more and more diluted until there is one part of food coloring per million parts of liquid. Then, the students learn a bit about fecal coliform. Finally, students do an activity where they determine whether or not water is safe to drink by using unit conversions and looking at actual situations.

Objectives

- Convert units
- Describe "parts per million"

Materials and Resources

Supplies

- Test tube well with at least 6 test tubes in each
- Food coloring
- Calculators

Before you get started

Tips for Teachers

- For the dilution activity, you can do it either as a class or have student groups do it together. You can also modify the worksheet, depending on how much scaffolding your students need. They can complete only the questions, only the table, or both.
- Many assumptions were made and much rounding was done in order to allow the math to be done more easily. This lesson is meant to be an open inquiry activity.
- If you would like to teach unit conversions explicitly, I would recommend this method: However, I think students would strongly benefit from needing to work together and struggle in order to figure out how to convert the units on their own. If unit conversion needs to be taught, make it a different day.
- For this lesson, give them the time and space to struggle with the units and answer the questions on their own.

Background

Enterococcus is often measured in parts per million or parts per billion. This lesson looks at how big a part per million is.

“Fecal coliform (enterococcus) bacteria are the most common microbiological contaminants of natural waters. Fecal coliform live in the digestive tracts of warm-blooded animals, including humans, and are excreted in the feces. Although most of these bacteria are not harmful and are part of the normal digestive system, some are pathogenic to humans. Those that are pathogenic can cause disease such as gastroenteritis, ear infections, typhoid, dysentery, hepatitis A, and cholera.

A fecal coliform test is used to determine whether water has been contaminated with fecal matter. The presence of fecal coliform indicates the possible presence of organisms that can cause illness.”

http://www.clemson.edu/extension/natural_resources/water/publications/fecal_coliform.html

Instruction Plan

Engage

Dilution Demo:

1. Put one drop of food coloring into a test tube with 9 drops of water. That is your first solution.
2. Then take one drop of that solution and put it into another test tube with 9 more drops of clear water. That is your second solution.

3. Complete this process four more times until you have 6 solutions or 1 part food coloring per million parts water.

Explore

Students get and complete How Big is a Part Per Million? (see Tips for Teachers above.)

Explain

1. Explain: Parts per million is the most commonly used measurement for fecal coliform and that it is the same as 1g/m3. One common safe standard for drinking water is that drinking water is safe if there is one enterococcus or less per 100mL of water (about one part per billion). The common safe standard for swimming is 60 enterococcus per 100 mL.
2. This is a good time to consider one part per million and how the solution looked clear. Ask students if they would be able to identify if water is clean by looking at it.
3. Discuss situations that students might encounter where the water quality might not be good. How would they know?
4. Explain: Water must be tested to ensure good water quality.

Elaborate

1. Students get YOU Are a Water Quality Detective!
2. Students will examine 3 situations and decide whether or not the water is safe to bathe in and to drink.
3. Explain: The drinking water standard is very high. Should the swimming standard be as high? What should the swimming standard be?

Evaluate

1. Follow up with a class discussion.
2. Examine the students results.
3. Explain: Water quality testing is complex and has no easy answers. Enterococcus is only an indicator, it does not signify all of the microbes in the water.
4. Discuss other mitigating factors (do particles settle on the bottom, what if the pooper was sick, what if you got water in your eye, etc.)

Standards

CCLS - ELA Science & Technical Subjects

- - Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

CCLS - Mathematics

- - Write and evaluate numerical expressions involving whole-number exponents.

NGSS - Cross-Cutting Concepts

- Influence of Engineering, Technology, and Science on Society and the Natural World
  - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

NGSS - Disciplinary Core Ideas

- ESS3.C: Human Impacts on Earth Systems
  - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
  - Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
  - Analyze and interpret data to provide evidence for phenomena.

NYC Science Scope & Sequence - Units

- Grade 8, Unit 4
  - Humans and the Environment: Needs and Tradeoffs

NYS Science Standards - Key Ideas

- LE Key Idea 6

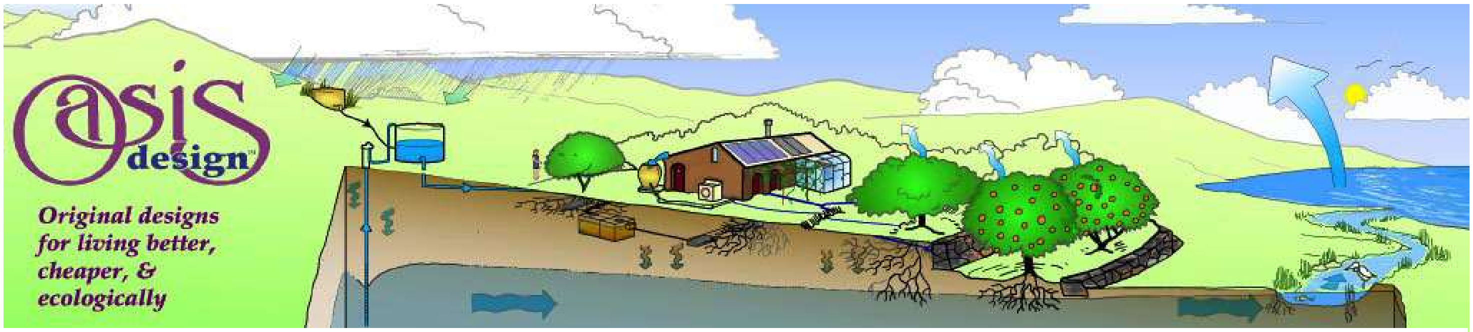
    - Plants and animals depend on each other and their physical environment.
- LE Key Idea 7
    - Human decisions and activities have had a profound impact on the physical and living environment

NYS Science Standards - Major Understandings

-
    - Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.
    - The environment may contain dangerous levels of substances (pollutants) that are harmful to organisms. Therefore, the good health of environments and individuals requires the monitoring of soil, air, and water, and taking steps to keep them safe.
    - In ecosystems, balance is the result of interactions between community members and their environment.
    - The environment may be altered through the activities of organisms. Alterations are sometimes abrupt. Some species may replace others over time, resulting in long- term gradual changes (ecological succession).
    - Since the Industrial Revolution, human activities have resulted in major pollution of air, water, and soil. Pollution has cumulative ecological effects such as acid rain, global warming, or ozone depletion. The survival of living things on our planet depends on the conservation and protection of Earth's resources.

NYS Science Standards - MST

-
    - Students will access, generate, process, and transfer information using appropriate technologies.
    - Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.
    - Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.



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You are here: **Home** > Water Central> Fecal coliform measurements

Fecal Coliform Bacteria Counts: What They Really Mean About Water Quality

Alternative measurements of bacteriological water quality can help you understand general and fecal coliform bacteria counts and relate them to the real world. Understanding water quality can help you design and use systems better.	**On this page:** • Few people understand the commonly used measurements for microbiological water quality • Policy is being made and facilities built with incomplete understanding • Alternative measurements that broaden understanding • Examples of using these units to understand reality better • Do your own tests • Unit derivation notes for the scientifically inclined • More information

Few people understand the commonly used measurements for microbiological water quality...

What the heck does it mean that there are "52 MPN fecal coliforms/100ml of water?

Is it good to drink? To wash dishes in? To bath in? Irrigate with?

The average person, or even engineers and scientists who don't have a public health or microbiology background wouldn't have a clue.

In fact, these units are so obscure that even people who work with them every day for years and make important decisions based on test results often have little sense of how to relate contamination either to cause or effect in a quantitative way.

- If a kid sneaks a swim in an un-chlorinated 50,000 gallon drinking water tank without wiping their butt, what is the likely level of contamination?
- If there is a bear poop bleeding into the edge of a swiftly flowing river (250 gallons per minute), how likely are you to get sick from drinking the water?
- If you irrigate your fruit trees with kitchen sink water, how likely is a kid to get sick from eating the dirt under the trees?

Most public health professionals would say that there would be a hazard. But they would be hard pressed to come up with an assessment of the size of the hazard that was accurate within a factor of a hundred. Many would be off by a factor of ten thousand. (Read on and then see how these questions are worked out below).

Concentration blindness

Further obscuring the picture, **almost all standards are expressed in terms of concentration, not total quantity** of organisms.

A spokesman for the Santa Barbara sewage treatment plant once calmly explained that discharge of untreated sewage to the ocean during intense rainfall was not an issue, because *"the dilution factor is so great."* This is an exceptionally clear case of "concentration blindness."

50,000 kilograms of fecal matter flushed to the ocean in a billion gallons of storm water is no less harmful to swimmers than 50,000 kilograms in a million gallons of sewer water. The amount of water that carries it to the ocean is irrelevant considering the relative size of the ocean—what matters is how much feces are being added. If anything, feces delivered in a giant slug of fresh water are worse, as the large flow of less dense fresh water might tend to float on the surface where exposure is more likely.

However, according to standards for effluent, which are based on concentration, the latter scenario appears a thousand times worse.

Indicator connection varies

General coliforms, E. Coli, and Enterococcus bacteria are the "indicator" organisms generally measured to assess microbiological quality of water. However, these aren't generally what get people sick. Other bacteria, viruses, and parasites are what we are actually worried about.

Because it is so much more expensive and tedious to do so, actual pathogens are virtually never tested for. Over the course of a professional lifetime pouring over indicator tests, in a context where all standards are based on indicators, water workers tend to forget that the indicators not the thing we actually care about.

What are these indicators?

- **General coliforms** indicate that the water has come in contact with plant or animal life. General coliforms are universally present, including in pristine spring water. They are of little concern at low levels, except to indicate the effectiveness of disinfection. Chlorinated water and water from perfectly sealed tube wells is the only water I've tested which had zero general coliforms. At very high levels they indicate there is what amounts to a lot of compost in the water, which could easily include pathogens (Ten thosand general coliform bacteria will get you a beach closure, compared to two or four hundred fecal coliforms, or fifty enterococcus).
- Fecal coliforms, particularly E. coli, indicate that there are mammal or bird feces in the water.
- Enterococcus bacteria also indicate that there feces from warm blooded animals in the water. Enterococcus are a type of fecal streptococci. They are another valuable indicator for determining the amount of fecal contamination of water. According to studies conducted by the EPA, enterococci have a greater correlation with swimming-associated gastrointestinal illness in both marine and fresh waters than other bacterial indicator organisms, and are less likely to "die off" in saltwater.

The more closely related the animal, the more likely pathogens excreted with thier feces can infect us.

Human feces are the biggest concern, because anything which infects one human could infect another. There isn't currently a quantitative method for measuring specifically human fecal bacteria (expensive genetic studies can give a presence/absence result).

Ingesting a human stranger's feces via contaminated water supply is a classic means for infections to spread rapidly. The more pathogens an individual carries, the more hazardous their feces. Ingesting feces from someone who is not carrying any pathogens may gross you out, but it can't infect you. Infection rates are around 5% in the US, and approach 100% in areas with poor hygiene and contaminated water supplies.

Keep in the back of your mind that **the ratio of indicators to actual pathogens is not fixed**. It will always be different, sometimes very different. Whenever you are trying to form a mental map of reality based on water tests, you should include in the application of your water intuition an adjustment factor for your best guess of the ratio between indicators and actual pathogens.

"Best guess?!" I can imagine precision obessessed regulators cringing. Well, it can hardly be better to ignore the fact that the number and virluence of pathogens present in samples with the same number of fecal coliform indicators can be different by a factor of ten to a hundred or more, simply because checking for the pathogens themselves is too cumbersome.

These are the factors to include in your mental **indicator to pathogen adjustment factor**:

- Feces of non-human origin are of less concern to humans (this is why spreading manure on your vegee garden is not considered insane)
- Feces from human populations with higher infection rates are of greater concern (a currently low rate is not a reason to condone a *new* fecal to oral disease transmission route—which will raise the infection rate over time)
- All treatment methods and environmental conditions affect pathogens and indicators differently. For example, chlorinated sewage effluent may have zero indicators and zero pathenogenic bacteria, but be laden with nearly all its original viruses.
  Pathogens (and indicators) can "hide" from treatment inside suspended solids. If treated water is turbid, the saftey of the water and the suspended solids can be very different. If the samples don't capture the suspended solids, the reading will be low.

^ Top ^ Few understand units | Policy w/o understanding | Alternative measurements | Examples | Do your own tests Add to cart

Policy is being made and facilities built with incomplete understanding of hazards

Important public health and engineering decisions are often made with a fuzzy idea of the hazards.

There is a tendency to tighten policy and overbuild facilities until the number of coliforms per 100ml at some point in the process is zero. If the actual sense of the hazard is not in focus, seeking the simple assurance of a zero reading is understandable.

However, this is a poor design guide compared to real understanding. Consider:

- A sewage treatment plant which removes indicator bacteria may not remove viruses; **it will test safe but not be safe in reality.**
- A beach front community with septics in Santa Barbara is being pressured to hook up to sewers, because a study found about 80 human fecal coliforms per 100 ml in the lagoon water. Sounds awful, whatever it means. But what it means is there was a half-teaspoon of human feces in the 30,000 or so gallons of the lagoon. All the feces for the duration of the study could have come from one disposable diaper, and not from the septics at all. **Millions of dollars might be spent on sewer connections for no benefit.**
- A study which turned up 84,000 fecal coliform bacteria per 100 ml of kitchen sink water did not consider the possibility that indicators were multiplying and there wasn't really that much feces (or pathogens) in the water. If they realized this equates to about a teaspoon a day of feces down the kitchen sink, they might have paused to consider if this much poop was really being dumped in the kitchen sink. But based on this study, **the law did not allow kitchen sink water greywater systems, but it might be OK in reality.**

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Alternative measurements that broaden understanding

In order to incorporate water quality considerations into my designs in a quantitative way, I first had to convert the measurements to units I could understand. Most other water quality measurements are ratios: parts per million, or billion.

The beauty of this kind of measurement is that by multiplying the concentration by the volume of water it is possible to figure out how much actual stuff you're talking about, as in the kitchen sink and beachfront septics examples above.

It turns out that one fecal coliform bacteria per 100 milliliters closely equates to one part per billion of feces, or one milligram per cubic meter (you can see how I did the conversion below).

One part per billion of fecal matter is an infintesimal amount of contamination; about a grain of sand in five 55 gallon drums, or about what someone drinks in three years. However, this is worth worrying about; it fails the minimum standard for drinking water quality in most of the developed world, which is zero general coliforms per 100mL.

Converting to concentration and absolute quantities enables you to estimate what could account for a given level of contamination, or what level of contamination would result from a given action. For example, a buttwipe (ahem) diluted in a swimming pool of water yields a feces concentration of about 1 part per billion.

Measuring organisms per 100 mL, you can't easily relate a case of contamination either to cause or effect in a quantitative way.

Without further ado, here is a table which shows conventional units and standards, and their conversion to parts per million, parts per billion, and the novice-friendly units of of buttwipes or turds per swimming pool...

Standards, unit conversions, and examples of Fecal Coliform levels in water

	Conventional units (*under-standable only to microbiologists*)	**Conversions to new novice user-friendly units**				Approximate conversion to units understandable by other scientists	
	Fecal coliforms/ 100 ml	Buttwipes/ swimming pool	Buttwipes/ Bathtub	Turds per swimming pool	Buttwipes/ bottle	mg feces /m3 water ppb feces	g feces/ m3 h20 ppm feces
Typical first world standards							
For drinking water coliforms are to be less than 1 per 100 ml	**1**	**1**	0.001			**1**	0.001
	10	10	0.010	0.001		10	0.010
surface water in watershed for unfiltered drinking	50	50	0.050	0.005	0.001	50	0.050
shellfish growing waters	70	70	0.070	0.007	0.001	70	0.070
Full contact/swimming. Many bathtubs probably are out of compliance	200	200	0.200	0.020	0.002	200	0.200
	1,000	1,000	**1.000**	0.100	0.010	1,000	**1.000**
Partial contact/boating, same as for treated sewage discharge	2,000	2,000	2.000	0.200	0.020	2,000	2.000
Sample measurements							
Typical level in chlorinated waters I've tested	0	0	0.000	0.000	0.000	0	0.000
Level often found in water used untreated for drinking in third world	100	100	0.100	0.010	0.001	100	0.100
Level in crystal clear Santa Ynez river water we swam in all day	2,500	2,500	2.500	0.250	0.025	2,500	2.500
First flush puddle of urban runoff in center of Mexican village	3,360	3,360	3.360	0.336	0.034	3,360	3.360
Typical greywater readings from Arizona greywater study	4,000	4,000	4.000	0.400	0.040	4,000	4.000
High reading from Arroyo Burro beach in Santa Barbara.	10,000	10,000	10.000	**1.000**	0.100	10,000	10.000
First flush of river in Michoacan, Mexico, after seven month dry season	25,600	25,600	25.600	2.560	0.256	25,600	25.600
Level in bath water according to CA Dept Health services study	400,000	400,000	400.000	40.000	4.000	400,000	400.000
Possible reading in raw sewage	5,000,000	5,000,000	5000.000	500.000	**50.000**	5,000,000	5,000.000
Pure feces	3,000,000,000	off the top of the scale				1,000,000,000	

To find the conversion factor from any unit to any other, find the **bold number 1's**, then read across to the other column.

For example:

- 1 fecal coliform/ 100ml = 1 ppb = 0.001 ppm = 1 buttwipe per swimming pool = 0.001 buttwipe per bathtub
- 1 turd/ swimming pool = 10,000 mg feces/ m3

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Examples of using these units to understand reality better

Back to the questions we opened with:

If a kid sneaks a swim in an un-chlorinated 50,000 gallon drinking water tank without wiping their butt, what is the likely level of contamination?

Layperson version: 50,000 gallons is twice as big as a swimming pool. One buttwipe per swimming pool is the drinking standard, so half a buttwipe per swimming pool does not exceed the drinking standard.

Scientist version: 50,000 is about 200 m3. A buttwipe is about 100 mg. So there is about 0.5 mg per m3, which does not exceed the drinking standard.

Additional considerations: If the kid is known to have an infectious condition, the cause for alarm is greater. Also, the amount of fecal matter may not be average, it probably won't all come off in the water, and the part of it that does will not be evenly distributed. Most likely, the particles will sink to the bottom or top. If the geometry of the inlets and outlets is designed optimally, almost none of it will make it into the water distribution system.

If there is a bear poop bleeding into the edge of a swiftly flowing river (25,000 gallons per minute), how likely are you to get sick from drinking the water?

Layperson version: That's a swimming pool every minute. If The bear poop takes 1000 minutes, (16 hours) to dissolve, that's a thousandth of a turd per swimming pool - ten times the drinking standard.

Scientist version: The bear bowel movement is 1,000,000 milligrams. The flow is about 100 m3 per minute, times 1000 minutes = 100,000 m3 of water. 1,000,000 divided by 100,000 is 10 mg feces/ m3 - ten times the drinking standard.

Additional considerations: A bear poop is probably bigger than a human poop. However, bear pathogens are less likely to infect humans. The swift flow will probably distribute the fecal matter pretty evenly through the water column before long, without much settling. This illustrates a feature of rivers: while on average they are likely to be clean, infectious level pulses of pathogens are likely to come through.

(Note: you can estimate flow by multiplying the width times the depth of the channel times half the speed of the surface. Ten meters wide, two meters deep on average and a meter per second is about ten cubic meters per second)

If you irrigate your fruit trees with kitchen sink water, how likely is a kid to get sick from eating the dirt under the trees?

A risk assessment analysis of this scenario is viewable in the Arizona Water CASA greywater study. Note that they assume from the high level of indicators that there is a level of pathogens in the water corresponding to nearly a *gram a day of fecal matter* entering the kitchen sink. This could be accounted for by ten people wiping their butts with thier hands only and washing them off in the kitchen sink—an unlikely scenario, I dare say. (If nothing else, few houses have ten people in them!) Also, note that they assume that 100% of the dirt the child eats will come from the greywater-irrigated area, 365 days in a row.

Considering that even with these wild assumptions, the risk was on the order of 1 in 10,000 of the kid getting sick, the risk is probably not significant.

For more examples of water test results & interpretations see: Water test results- Maruata

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Do your own tests

Much of what I learned about microbiological water quality came from doing hundreds of tests myself (see Water quality testing *(download)*). I use coliscan plates and an chicken egg incubator. What this system lacks in precision is made up for by the fact that you can afford to test many more samples, so you can begin to understand what is going on. (The total setup to do 100 coliscan "easy gel" tests costs less than $200, enough for only ten lab tests on a good day).

A primary goal in the testing I do is to refine my water intuition and understanding. I'm not so interested in knowing what the exact number of bacteria is at one point in the flow at that moment. What I want to know is what is affecting bacteria levels and how they are changing with time or at different points in the flow.

Instead of grabbing one twenty dollar test from a water tank, I'll test the water the spring as far in as I can reach, at the outlet of the spring box, the bottom of the spring box, the inlet to the tank, the outlet to the tank, the kitchen tap, and in a drinking glass.

If you picked a random rural home system and did this series of tests, you'd could easily find that the bacteria levels varied by a factor of ten. One costly, highly precise test from a certified lab—the standard approach—lends a false sense of accuracy to the results. If you did *two* such tests a few hours or a few feet apart they could easily be out of agreement by a wide margin.

Numerous tests provide a rich information stream from which you can learn a lot about what makes bacteria levels rise and fall.

Once you know that, of course you can make a better system.

For potable water, the accuracy of results is more critical, and you need a more sensitive test. I use coliscan membrane filtration tests and Hach presence absence with MUG tests for design of potable systems. Then, if I need certified results, I send one last sample to a certified lab.

^ Top ^ Few understand units | Policy w/o understanding | Alternative measurements | Examples | Do your own tests Add to cart

Unit derivation notes for the scientifically inclined

The numbers were jiggled so the alternative units came out to be even orders of magnitude from the conventional units and each other.

In some cases the number used was close to the middle of the range, in others it is off the average by 30% or more. Overall, the alternative measures which are represented as equivalent on the table are within a factor of two or three of actual equivalency.

This degree of precision is in line for this area of study.

The conventional measurements use indicator organisms. There is a few orders of magnitude difference in coliforms per gram of feces for different mammals, so *the precedent for allowing imprecision of a large order is well established.*

Here's the assumptions and math:

- These are typical numbers of fecal coliform bacteria per gram of wet feces: dog=23 million, human 13 million, pig 3.3 million, cow a quarter million)
- Since human feces and easy math are of greatest concern, I assumed 10 million fecal coliform bacteria per gram. This assumption builds into the conversion an overstatement of a factor of 1.3 if the bacteria are of human origin.
- Thus, one coliform bacteria weighs one ten millionth of a gram. Diluted in 100ml=100g of water, that's one part per billion.
- 100 m3 water per swimming pool (a typical swimming pool is more like 75 m3 or 20,000 gallons)
- An average buttwipe is 0.1 gram (based on a few measurements which averaged 0.13 grams)
- Bowel movement is 1000g (one source gave 1113g as the average daily production of feces)
- A bath is 100 L; this is about 8" of water in an average bathtub. Full capacity is about twice this, depending on the displacement of the bather(s).
- 1 turd = 10,000 buttwipes =1,000 grams = 1,000,000 milligrams
- 1 swimming pool = 1000 bathtubs=100,000 bottles = 100 cubic meters = 100,000 liters

Buttwipes/ swimming pool	Buttwipes/ Bathtub	Turds per swimming pool	buttwipes/ bottle
=.1 g/ 100m3	=.1 g/ 100 L	=1000 g feces 100 m3	=0.1g/ 1L

If you want to get into these numbers more deeply, see Water quality testing *(download)*, a download packet which includes the editable spreadsheet the calculations were done in.

^ Top ^ Few understand units | Policy w/o understanding | Alternative measurements | Examples | Do your own tests Add to cart

See also:

- Water quality testing *(download)* Add to cart a download packet on how to do your own simple, inexpensive water tests
- Water Storage *(book)* Add to cart designs for protecting water during storage
- Water Storage Extras information on bacterial regrowth in water system
- Water test results- Maruata test results from all kinds of water in a Mexican village, with discussion
- Discussion of a study of lagoon contamination from septic tanks in a beach front community
- Wild Water Wisdom *(article)* Add to cart describes how natural purification works in surface waters
- Slow sand filters for potable water treatment

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How to Safely Convert From One Unit to Another

We can convert from **km/h** (kilometers per hour) to **m/s** (meters per second) like this:

A kilometer has 1000 meters, and an hour has 3600 seconds, so a kilometer per hour is:

- 1000 / 3600 = 0.277... m/s

How did I know to make it **1000 / 3600**, and not **3600 / 1000** (the other way around)?

The trick is to do the conversions as fractions!

Example 1:

Let's start with a simple example: **convert 3 km to m** (3 kilometers to meters). There are 1000 m in 1 km, so the conversion is easy, but let's follow a system.

The system is:

- Write the conversion as a fraction
- Multiply
- Cancel any units that are both top and bottom

You can write the conversion as a **fraction that equals 1**:

$$\frac{1000\text{ m}}{1\text{ km}} = 1$$

And it is safe to multiply by 1 (does not affect the answer) so we can do this:

$$3\text{ km} \times \boxed{\frac{1000\text{ m}}{1\text{ km}}} = \frac{3000\text{ km} \cdot \text{m}}{1\text{ km}}$$

The answer looks strange! But we aren't finished yet ... we can "cancel" any units that are both top and bottom:

$$\frac{3000\ \cancel{\text{km}} \cdot \text{m}}{\cancel{1\ \text{km}}} = 3000\ \text{m}$$

So, 3 km equals 3000 m. Well, we knew that, but i wanted to show you how to do it **systematically**, so that when things get harder you will know what to do!

And **the trick** is to know that you will cancel when you finish, so make sure you write the conversion the correct way around (so you can cancel afterwards).

Doing it **wrong** (with the conversion upside down) gets this:

$$3\ \text{km} \times \frac{1\ \text{km}}{1000\ \text{m}} = \frac{3\ \text{km} \cdot \text{km}}{1000\ \text{m}}$$

And that doesn't let us do any cancelling!

Example 2:

Let's use this method to solve the **km/h** to **m/s** conversion from the top of the page.

We will do it in two stages:

- from km/h (kilometers per hour) to m/h (meters per hour), then
- from m/h (meters per hour) to m/s (meters per second).

1. From km/h (kilometers per hour) to m/h (meters per hour)

$$\frac{1\ \text{km}}{\text{h}} \times \boxed{\frac{1000\ \text{m}}{1\ \text{km}}} = \frac{1000\ \text{km} \cdot \text{m}}{1\ \text{h} \cdot \text{km}}$$

Now "cancel out" any units that are both top and bottom:

$$\frac{1000\ \cancel{\text{km}} \cdot \text{m}}{1\ \text{h} \cdot \cancel{\text{km}}} = \frac{1000\ \text{m}}{1\ \text{h}}$$

2. From m/h (meters per hour) to m/s (meters per second)

Now, to go from m/h (meters per hour) to m/s (meters per second) we put the "3600 seconds in an hour" conversion "upside down" because we want an "h" on top (so they will cancel later) :

$$\frac{1000\text{ m}}{1\text{ h}} \times \boxed{\frac{1\text{ h}}{3600\text{ s}}} = \frac{1000\text{ m} \cdot \text{h}}{3600\text{ h} \cdot \text{s}}$$

Then "cancel out" any units that are both top and bottom:

$$\frac{1000\text{ m} \cdot \cancel{\text{h}}}{3600\ \cancel{\text{h}} \cdot \text{s}} = \frac{1000\text{ m}}{3600\text{ s}}$$

And so our anwer is:

$$\frac{1000\text{ m}}{3600\text{ s}} = \mathbf{0.2777...\ m/s}$$

Doing it **wrong** (with the the 3600 seconds/hour the other way around) gets this:

$$\frac{1000\text{ m}}{1\text{ h}} \times \frac{3600\text{ s}}{1\text{ h}} = \frac{1000 \times 3600\text{ m} \cdot \text{s}}{1\text{ h} \cdot \text{h}}$$

And there is nothing to cancel!

So we know we made a mistake, and can correct it.

All In One Go

With experience you can do it in one line like this:

$$\frac{1\text{ km}}{1\text{ h}} \times \boxed{\frac{1000\text{ m}}{1\text{ km}}} \times \boxed{\frac{1\text{ h}}{3600\text{ s}}} = \frac{1000\ \cancel{\text{km}} \cdot \text{m} \cdot \cancel{\text{h}}}{3600\ \cancel{\text{h}} \cdot \cancel{\text{km}} \cdot \text{s}} = \frac{1000\text{ m}}{3600\text{ s}}$$

Or even "all in one go" (crossing out as you go) like this:

$$\frac{1\ \cancel{\text{km}}}{1\ \cancel{\text{h}}} \times \boxed{\frac{1000\text{ m}}{1\ \cancel{\text{km}}}} \times \boxed{\frac{1\ \cancel{\text{h}}}{3600\text{ s}}} = \frac{1000\text{ m}}{3600\text{ s}}$$

Example 3

Now let's use this method to do a real-world conversion.

What is 60 mph (miles per hour) in m/s (meters per second) ?

$$\frac{60 \text{ mile}}{\text{h}} \times \boxed{\frac{1609 \text{ m}}{\text{mile}}} \times \boxed{\frac{1 \text{ h}}{3600 \text{ s}}} = \frac{60 \times 1609 \cancel{\text{mile}} \cdot \text{m} \cdot \cancel{\text{h}}}{3600 \cancel{\text{h}} \cdot \cancel{\text{mile}} \cdot \text{s}} = 26.82 \text{ m/s}$$

Summary

The important points are:

- Write the conversion as a fraction (that equals one)
- Multiply it out (leaving all units in the answer)
- Cancel any units that are both top and bottom

Question 1 Question 2 Question 3 Question 4 Question 5 Question 6
Question 7 Question 8 Question 9 Question 10

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Field Expectations

BOP Curriculum
bop-curriculum@nyharbor.org
Jan 31, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Introductory Lessons	6-8th	1	Classroom	Science

Summary

As a class you will review the written expectations for being in the field during ORS monitoring. Students have an opportunity to reflect upon the expectations.

Objectives

- Describe at least three expectations for field work
- Articulate their hopes and fears about working in the field

Materials and Resources

Before you get started

Tips for Teachers

- It is very important to clearly state the expectations for your students before you go in the field for your first Oyster Restoration Station expedition! Clear expectations is an important part of a safe and productive field experience.
- Modify the Field Expectations Contract as need be to fit your school and situation. Make it as complete as possible.
- The field should be treated as another classroom; a place of learning.
- Keep your schedule in the field tight and organized. There should not be any down-time in the field. If the students need to eat lunch, consider giving them a maximum of 30 minutes. The students are there to monitor their ORS and have a great time doing it!
- If you are requiring the students to bring certain items in the field (e.g. water bottle, clipboard, jacket, etc.) take the time to check for these things before you leave and give each student a preparedness grade.
- Don't ask your students to do anything that you're not willing to do (e.g. get your clothes or hands dirty, touch a squirmy worm, etc.)

Instruction Plan

Engage

1. Explain: Today we are going to review the expectations for your work in the field during the Oyster Restoration Station (ORS) expeditions.
2. Each student gets a BOP ORS Info Sheet.
3. Review the info sheet and what it means to monitor the ORS.
4. Have the students make a list of questions about the ORS. Save these questions and revisit right before or after your first ORS visit.
5. If you want to go into more depth, you can also hand out the BOP Oyster Restoration Station Field Manual and Data Sheets at this point.
6. If you have any of your own photos of the ORS or monitoring activities, this is be a great time to show them to your students. Each student gets a Field Expectations Worksheet and complete #1-2.

Explore

1. Hand out the Field Expectations Contract

2. Read the contract outloud. You can read it, you can have students take turns reading or a combination of both.
3. Emphasize or elaborate on important points.
4. Consider using the Field Expectations Images to supplement your reading of the contract. This slideshow has a handful of example images that go along with various point in the contract. Add to and personalize the slideshow with images that will resonate with your students.
5. Each student completes #3 on the Field Expectations Worksheet.
6. Save this worksheet and revisit after your first ORS expedition. Give the students time to answer their own questions and concerns.

Elaborate

1. Consider having the students “illustrate” one point or one section of the contract in a way that suits them best.
2. Allow the students to choose from a variety of assignments/mediums (e.g. drawing, photography, music, writing, etc.).

Evaluate

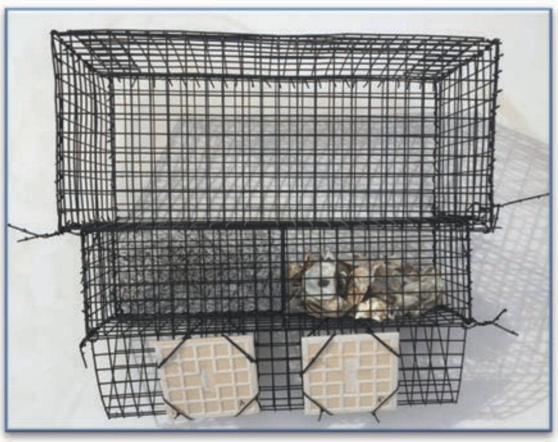
1. Students bring the contract home, read it over with their parents/guardians, and bring it back signed.
2. Keep the signed copies in the classroom.
3. We highly recommend pulling out the contracts before each ORS expedition for a brief review.

Standards

Oyster Restoration Station (ORS) Basic Training

What is an Oyster Restoration Station?

- The ORS is an in-situ experimental platform at the end of a line used for monitoring **oyster growth, biodiversity, and succession of sessile organisms** in New York Harbor.
- The standard ORS measures approximately 24” wide x 22” high x 10” deep
- The ORS is made of 14-gauge vinyl coated galvanized steel mesh.



- The three components of the ORS are, from top to bottom:

Oyster cage=10”x10”x24”

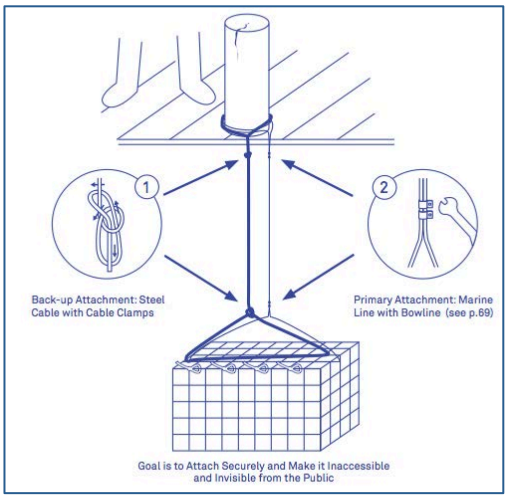
Mobile Trap=6”x6”x23”

(2) Settlement panels=6”x23"

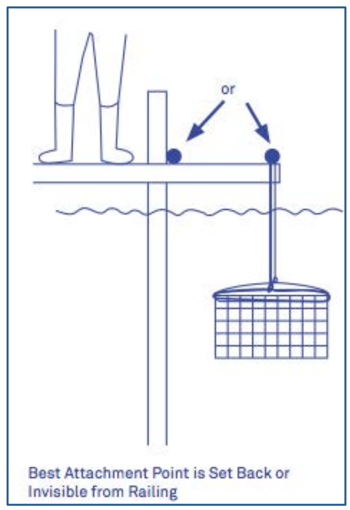
- There are exactly 10 tagged substrate shells in the oyster cage and some additional number more of untagged substrate shells. There will be any number of individual live oysters growing on these shells. The number of live oysters growing on each shell will diminish over time due to competition for space, environmental factors, and natural mortality.
- There are two substrate types inside the mobile trap - soft mesh and cured oyster shell – used for monitoring biodiversity.
- There are four ceramic tiles on the settlement panels. These are used for monitoring sessile organisms.

How do I install my ORS?

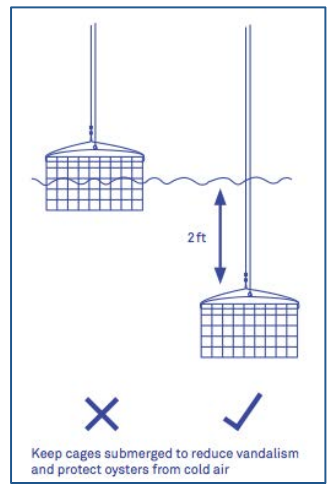
An ORS can be installed on any vertical shoreline (piers, bulkheads, floating docks) with more than three feet of depth at mean low tide. The ORS should be attached at such a depth that it is fully submerged at all times. The ORS is attached by two separate ropes or lines – one of these should be taught and one should be slack such that the slack line serves as back-up in case the taught line frays and breaks. The attachment point is usually at the base of the railing, through an eye bolt or cleat. The attachment should be neat and discreet and preferably out of view from the public. The ORS is NOT suitable for installation on rocky shoreline or beach.



Always attach with two lines



Out of public reach/view



Always submerged

ORS installation sites should be well supervised and not prone to vandalism. A site coordinator must take responsibility for periodically checking on the ORS. A site coordinator can be an individual ORS owner who lives nearby or the local property owner, park manager, or stewardship group. All ORS installation sites must be pre-approved by Billion Oyster Project, who holds all requisite NYS DEC licenses, NYC Parks permits, and use agreements from local property owners as needed. BOP does not operate in NJ waters at this time.

Getting Started....

1. Attend an ORS basic training ✓
2. Learn/practice the 5 protocols ✓
3. Request and establish your site
4. Register your ORS
5. Install your ORS at your site
6. Train your team
7. Conduct monitoring expeditions with your team (at least four per year)
8. Check on your ORS (once per month)
9. Attend Annual BOP Symposium

Field Expectations Contract

Teacher Responsibilities

- Keep you in a safe environment in class and in the field
- Facilitate the monitoring of your Oyster Restoration Station
- Help you develop critical thinking skills

Student Responsibilities

- Respect for Self
  - Be prepared for class.
  - Be on time.
- Respect for Others
  - No foul language or shouting.
  - Keep hands, feet, and objects to yourself.
  - Listen when others are speaking.
  - Raise your hand and wait to be called on before speaking.
- Respect for Outdoor Environment
  - Put all garbage in a garbage can. **<u>Please do not litter!!!</u>**
  - Recycle and compost when appropriate.
  - Respect all wildlife. **Please do not feed or scare animals!**
  - Respect the vegetation. Do not unnecessarily pick or trample plants.
  - Respect the built environment. No scraping, tagging or graffiti.

Preparedness

Each day you are in the field you will be graded on having the following items with you:

- clipboard
- reading book
- water bottle
- snack
- extra outer layer
- pencil
- field bag (backpack or messenger bag)

Required Clothing & Supplies

- ☐ **Water Bottle –** Part of staying comfortable and safe outside is making sure you have enough water. We often do not have access to drinks, so bring your refillable bottle.
- ☐ **Old Clothes & Shoes –** If you are going shopping for the new school year don't throw away your old clothes. Keep a pair of old jeans and an old sweatshirt around to wear in the field. We do get dirty sometimes.
- ☐ **Waterproof or Water Repellent Jacket –** A big part of staying warm is having an insulated, outer layer that can keep water out. If the jacket and insulation are non-cotton, so much the better.
- ☐ **Hat, Gloves, Scarf –** Baseball hats protect you from the sun. Knit hats and scarves will keep you warm because you lose a lot of your body heat from your head and neck. You need gloves to do your writing when it's cold!
- ☐ **Book bag –** You need a sturdy, good-sized bag. No plastic bags, purses or handbags! The book bag needs to hold your work for the day, a book to read on the subway, your water bottle and extra layers of clothes.

Suggested Clothing & Supplies

- □ **Long Underwear –** We will be outside when the temperature is low. In order to stay warm, especially if it is damp outside, you should wear non-cotton or synthetic long underwear under your clothes. *The less cotton the better because cotton absorbs water and can make you cold!*
- □ **Wool or Synthetic Socks –** Nothing is worse then cold feet!! Your cotton socks will make your feet cold if they get wet. It's also a great idea to bring an extra pair of socks to change into at the end of your day in the field.
- □ **Sunglasses & Sun Block –** Even if you have dark eyes or skin you are still susceptible to the ultraviolet rays of the sun. These items will help protect you on the sunnier days, even if it is not hot out.

<u>What it means to be In The Field…</u>

- You must **eat breakfast** before school. No breakfast = crankiness.
- You **may not** buy lunch (or anything else) once we have left the school building.
- You must bring a **water bottle** with you in the field.
- **Do not** wear new clothes and shoes. Wear things that can get **dirty and wet**.
- You must have a **full-size** school bag. No plastic bags or purses.
- You should use the restroom before you leave the school.
- As a class we will **wait for the light**. Do not cross the street in front of your teacher. Stay with the group at all times!
- You must stay with the class **at all times**. If you leave the class group you will be considered truant and for safety purposes the principal and truancy police will be notified.
- You are to be on your **best behavior** while in the field. All school rules and policies apply.

- -

CONTRACT

We have read and agree to the above Field Expectations

Student Signature: ______________________________________ **Date:** _________________

Parent/Guardian Signature: ____________________________________ **Date:** _______________

Field Expectations Questions

1. Based on what you know so far, what part of the Oyster Restoration Station (ORS) monitoring are you most looking forward to?

2. Write at least three questions you have about your first ORS expedition.

3. Write at least three questions or concerns you have about the BOP Field Expectations

Field Simulation - Oyster Measurements

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 13, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	1	Classroom	

Summary

Students will practice both identifying live versus dead oysters and measuring oyster spat in a series of competitive challenges.

Objectives

- Quickly identify live vs dead oysters.
- Use a caliper to the tenth or hundredth of a centimeter.
- Reflect on their work.

Materials and Resources

Supplies

10 oyster substrate shells with oyster spat (baby oysters) settled on them – available from Billion Oyster Project Stopwatch Poster-sized version of Live vs Dead Oyster Spat Time Trial Calipers (at least 10, but the more you have available the better) Index cards

Before you get started

Tips for Teachers

It is very helpful to have and extra adult or two (who knows how to use a caliper) in the room for this lesson. The best way for students to learn how to use a caliper is for them to practice and have someone check their work. Try to get some other teachers or volunteers into your room to help with this! You need to make sure all ten of your spat-on-shell substrate oysters are numbered (1-10) in some way. You must go through all ten substrate shells shortly before the lesson and count the number of live spat oysters on each substrate shell, so you know how to assess the students' work. If the spat-on-shell are wet or muddy, plan accordingly. Leave time to rinse them off before class or provide paper towels to students so they are not distracted from their real work by the messiness.

Preparation

N/A

Background

Identifying live versus dead oyster spat

Dead oyster spat can be identified with a light tap on the top shell. If the shell is visibly gaping open, if there is softness or movement in the shell, or if bubbles are discharged when the shell is lightly pressed, this means the oyster is dead.

Dead oyster spat will also sound hollow when lightly tapped. To double check that an oyster is dead gently try to pry them open with your fingernail. A dead oyster will generally open very easily. Often a dead oyster is filled with mud and therefore can be mistaken for being alive. The 'fingernail check' is especially useful to make sure that the oyster is truly dead.

Instruction Plan

Engage

1. In this activity, groups will race each other to see who can identify live oyster spat with the greatest speed and accuracy.
2. Display a poster-sized version of *Live vs Dead Oyster Spat Time Trial.* You need to be able to write on it.
3. Split the class into (ideally) 10 groups, so that you have one spat-on-shell for each group.
4. Hand out one copy of the *ORS Field Science Manual* to each group. (You only need the section within Protocol 2 entitled "Identifying live versus dead oyster spat.")
5. Each group gets a spat-on-shell. This is their practice shell.
6. With this first shell, the students have as long as they need to identify the live vs dead oysters and count the number of live oyster.
7. Circulate around the room, answer questions and point students to the directions in the *ORS Field Manual*. The teacher can help students identify the live vs. dead spat.
8. Make sure all students are comfortable identifying the difference between live and dead oyster spat. Then, record the students' results of number of live oysters on the poster.
9. Explain: Groups will do the same thing with the remaining nine spat-on-shell. And at the end, we will see who did the fastest and most accurate work.
10. The groups rotate their spat-on-shell, so every group has a new one. Do not let the students touch their new spat-on-shell yet!
11. Now, get ready with the stopwatch.
12. When you say "Go!" the students in each group pick up their spat-on-shell and count the live vs dead oysters.
13. As each group finishes, record their time on the poster.
14. Once every group has finished with their spat on shell record their count of live oysters. (Remember, you have counted all the live oysters before class, so you should know the correct answer for each shell.)
15. Repeat this until all the spat-on-shell have been counted by each group.
16. Declare a winner!
17. Ask: Do you think it's important to work quickly when we count live oyster spat in the field? Why or why not? Look for good ideas about both possibilities, for instance – yes, there are a lot of oysters to count and it's good to work efficiently. And yes, it's important to collect accurate data, and to take the necessary time to do so,
18. Solicit from students what other questions they are left with about oyster spat after completing this activity. It's important to keep track of these questions, ideally to post or share them with students on an ongoing basis.

Explain

1. In this activity, the students learn or are reminded how to read a caliper.
2. Each group gets a spat-on-shell. This is their practice shell.
3. Each group gets least one pair of calipers. The more calipers the better!
4. Decide whether from here on out, how many decimals you want to the students to measure to.
5. Project or hand out one or more of the caliper pictures in the *Caliper Images* powerpoint and review how to use a caliper.
6. Circulate around the room to help students with their measurement practice. (It is very helpful to have knowledgeable extra adults on hand for this portion of the lesson.)

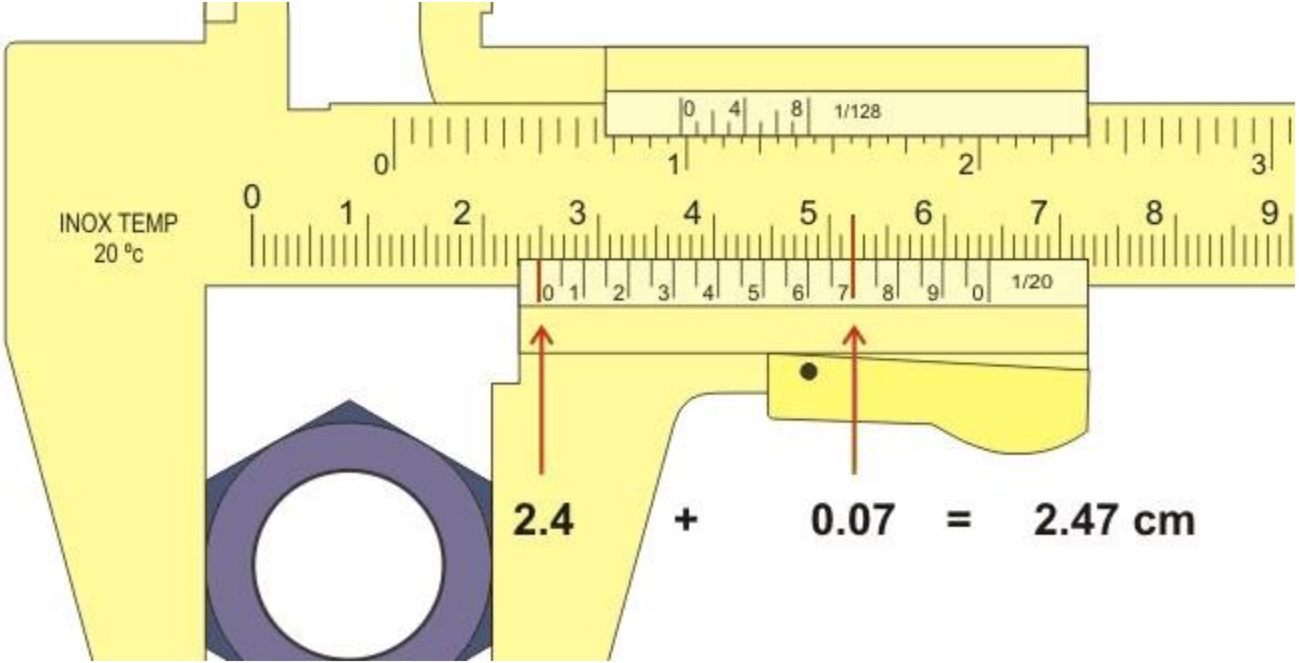
Elaborate

1. In this activity, students will practice measuring oyster spat in their groups.
2. Each group gets one spat-on-shell.
3. Each student gets a bunch of index cards.
4. Each member of the group take turns measuring the same oyster spat and writes the answer on one of the index cards.
5. Everyone should "hide" their measurements and results from their group members for the moment.
6. After each member of the group take a s turn measuring the same oyster, the students count to three and reveal their measurements to each other.
7. If all group members have the same measurements they call you over to verify and they get a gold star/prize.
8. If there is a discrepancy among their measurements, then the students take the time to measure the same oyster spat again, this time working together, to find the correct answer.
9. Groups repeat this exercise with as many oyster spat as possible.

Evaluate

1. Students write a paragraph or journal entry with a quick reflection on the lesson.
    1. What skills did you work on today?
    2. What questions about oyster spat are you left with?
    3. Do you have any questions or concerns about completing this protocol in the field?

Standards



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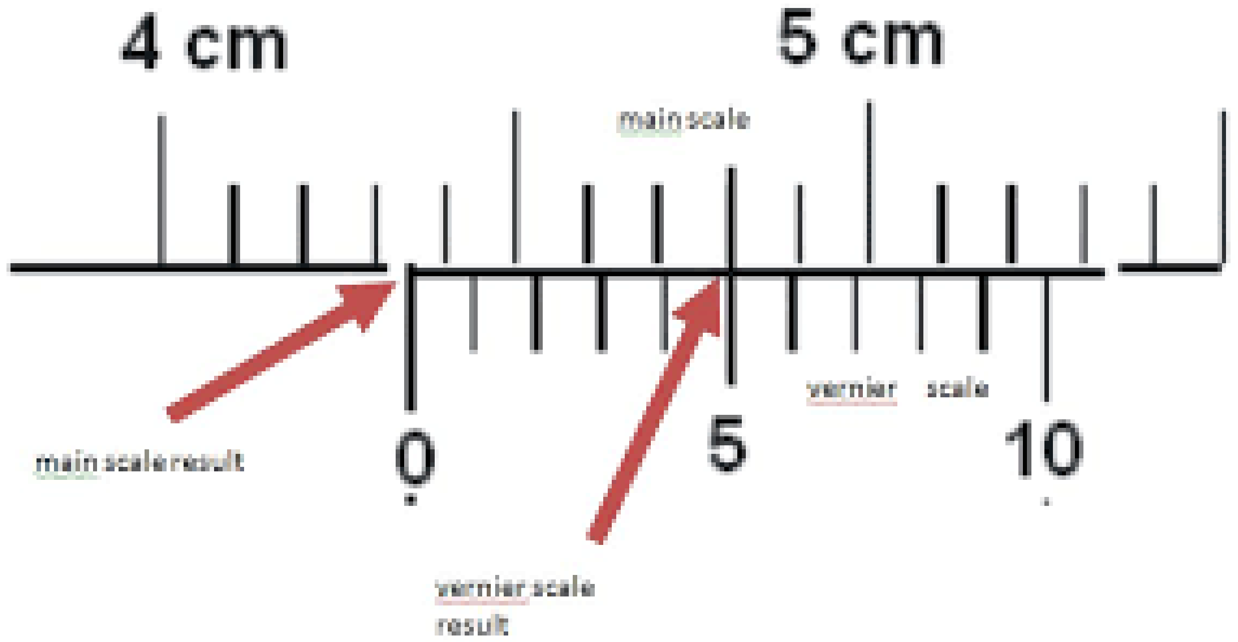
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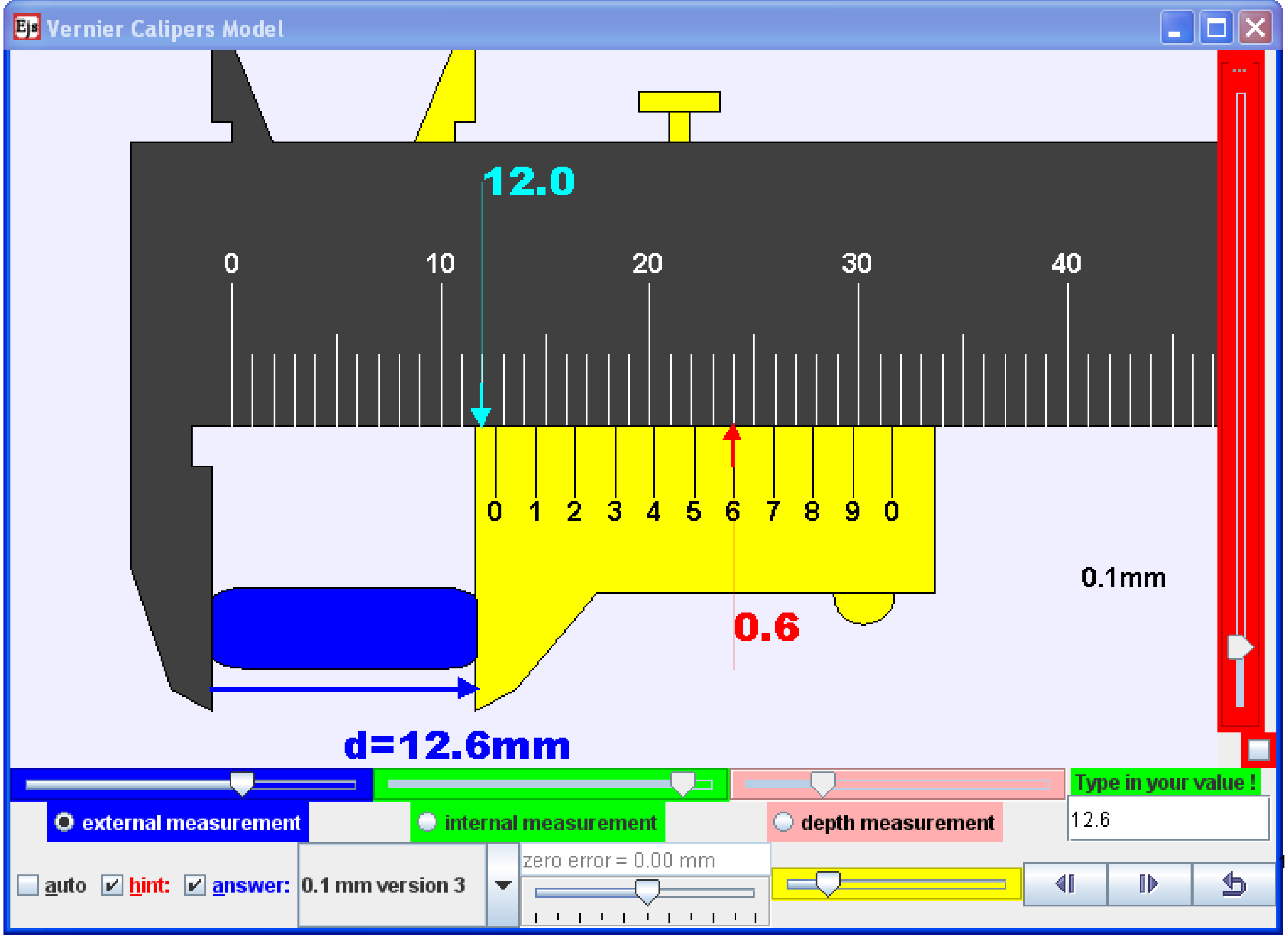

Vernier Calipers Model
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external measurement
internal measurement
depth measurement
auto
hint:
answer:
0.1 mm version 3
zero error = 0.00 mm

151

Resource: Live vs Dead Oyster Spat Time Trial

	Shell 1	Shell 2	Shell 3	Shell 4	Shell 5	Shell 6	Shell 7	Shell 8	Shell 9	Shell 10	Time\ # live spat
Group 1											
Group 2											
Group 3											
Group 4											
Group 5											
Group 6											
Group 7											
Group 8											
Group 9											
Group 10											

Follow-up Questions

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 8, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	2	Classroom	

Summary

If you've taken your students to their Oyster Restoration Station multiple times this year, and in the process led them through a long-term original research process, this would be a good lesson for you. It's designed as a debrief of the final visit to the ORS.

Materials and Resources

Supplies

Prepare a set of memorabilia from earlier field visits and work on the long-term research project this year, such as: Lists of students questions, sorted at least roughly by date Photographs of this class in the field earlier this year Photographs of things they've seen and done in the field and/or during their long-term research project from earlier this year Examples of student work in the field and/or on their long-term research project from earlier this year Supplies that were used in the field and/or during their long-term research project (e.g. water quality testing materials)

Before you get started

Tips for Teachers

This lesson is for a class that has visited their ORS several times during the year, is working on a long-term original research project associated with their field experience, and recently visited the ORS for the final time this school year. Before teaching the lesson, you'll need to prepare memorabilia from earlier field visits this year, such as previous lists of student questions, photographs, other examples of student work, and supplies that were used (e.g. water quality testing materials), to help jog students' memories of their field work over the course of the year.

Instruction Plan

Engage

Ask your students:

What did you notice in the field yesterday? Write a paragraph or two and/or sketch something that stands out to you from yesterday's field experience.

Then ask students to share their recollections. Keep track of their comments on a board, or in your own notes, as they share.

Encourage students to respond to one another's recollections with additional thoughts or questions, and keep track of these as well. Probably the quickest way to keep track is in your own notes. With practice, it gets easier to take notes and lead a discussion at the same time.

Explore

Distribute the memorabilia of students' field and long-term research experiences, such as previous lists of student questions, photographs, examples of student work, and supplies that were used (e.g. water quality testing materials). You may want to organize memorabilia stations and let the students rotate through different parts of the collection.

Distribute the Handout “What were we thinking about?”

Give students time to review those memorabilia and begin the first section of the Handout.

Then they can return to their seats and complete the remainder of the Handout. Partway through it, they will need to gather in small groups. One way to do that is to form groups as students complete the individual portion. That way, some groups get more time than others, but no one has to wait very long to start working with their group, and everyone has as much time as they need to work individually.

The last part of the Handout, about unanswered questions, is actually the most important part. The rest is designed to get students thinking about and remembering their questions, curiosities, and wonderings! If you have lists of student questions from earlier in the year, that will be a great help.

Explain

Tell your students:

Today you will identify the most important or interesting follow-up questions from this year’s field and long-term research experiences. There are differences between the follow-up questions asked by journalists, toddlers, students, and scientists such as yourselves, but the heart of the matter is the same: using new information to dig deeper.

Evaluate

The final section of the lesson can be done on a different day, if you need time to gather the students’ questions from today. If you have technology that lets them pool their questions instantaneously, you can continue the same day:

In small groups, ask students to:

Look at our pool of:

- New questions from today or the last field visit
- Unanswered questions from earlier this year

Which of these questions are great follow-up questions? Why do you think so?

If you had unlimited time and resources to actually follow up on any of these questions – whether or not you think they count as follow-up questions – what would you do?

If you can, promise your students to take their ideas into account when planning next year’s long-term research project.

Then lead a discussion in which students share their responses and respond to one another’s ideas.

Collect the 5 “best” questions on the board. To get the discussion going, feel free to play devil’s advocate, and argue for some unpopular choices.

As the final activity, the class can vote on the question they would most like to study in the future. You can post it in the room and even pass it on to their science teacher for the following year.

Standards

What were we thinking about?

Review the materials your teacher has prepared from your class's year of field work and original research. Let those things jog your memory.

Then, by yourself:

Choose one memento from the memorabilia that brings back the most vivid or interesting memories of your work this year in the field and/or on the long-term research project.

Why did you choose that particular memento?

What does that memento remind you of, specifically?

What are your thoughts and questions today, related to those memories?

At your seat you can continue writing, on your own:

What else do you especially remember noticing in the field or from the long-term research project earlier this year?

What kinds of things surprised you? Interested you most?

What were some of your questions from the field or the long-term research project, earlier this year?

What were some of the best questions that you or other students asked related to our long-term research project over the course of this year?

What questions do you still have now?

Then, in a small group, compare notes on what you remember. Based on this discussion, write down for your group:

What new things could you remember after talking with classmates?

What is one thing that everyone in the group recalls?

What are the things that only one or two students in your group recalls?

What questions came up this year -- including right now -- that you feel have not yet been answered?

What new questions do you have today, in your group?

Food Webs

BOP Curriculum
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Mar 21, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
NY Harbor Populations Investigation	6-8th	2	Classroom	Science

Summary

Students will each play the role of an estuary organism and together the class will create an estuarine food web with string connecting the organisms to each other.

Objectives

- Identify at least two organisms found in New York Harbor.
- Understand that organisms within an ecosystem are dependent on each other.
- Articulate the energy transfer from one organism to the next.

Materials and Resources

Supplies

- Food Web Cards
- String (Cooking twine works well. Depending on how many students you have you may need a few hundred yards and it's always good to have extra.)
- Clipboards (Ideally, one for every students plus one for every pair. If you have 30 students you need 45 clipboards.)
- Basic classroom supplies like markers, stickers, construction paper
- Scissors

Before you get started

Tips for Teachers

- You will have more success with this activity if you take the time to read through all the Food Web Cards, familiarize yourself with them and decide if you want to use them all.
- Consider printing more than one card for species that are abundant, such as diatoms, dinoflagellates, and amphipods.
- Each student should have ONE Food Web Card.
- Use the phrasing "x gets energy from y" instead of "x eats y" in order to emphasize that one important aspect of a food web is the fact that is depicts the energy flow in an ecosystem.

Teachers might want to consult these additional resources for more background:

- Documents within the Species ID folder on Digital Platform Dashboard
- Life in the Chesapeake Bay by Alice Jane Lippson
- The Hudson: An Illustrated Guide to the Living River by Stephen P. Stanne

Preparation

- Food Web Cards should be printed with the photograph on one side of the card and the information on the other side of the card.
- All cards should be laminated, hole punched and strung, so they hang around a student's neck. This allows the students to be hands-free during the activity.
- Decide beforehand how you will assign each student their card. Randomly? Based on students' prior questions or interest?

Background

The food chain begins with producers, organisms such as green plants, that can make their own food. Through photosynthesis, producers convert solar energy to chemical energy. Out of all the energy a plant receives from the sun, only about three percent is converted into chemical energy.

Plants are eaten by consumers, which are organisms that cannot make their own food. Herbivores are consumers that eat only producers. Consumers that prey on other consumers are called carnivores. If an animal can get its energy by ingesting both producers and consumers, it is an omnivore.

A food chain does not consist of a set amount of energy that is passed along like a baton from one organism to another. In reality, the 'baton' gets smaller and smaller with each transfer. When an herbivore eats a plant, it does not get all the energy that the plant captured from the sun. This decrease is only partly due to the fact that the herbivore may not eat all parts of the plant, or it may not be able to digest all of what it does eat. These undigested plant parts are excreted as waste.

The main reason that much of the energy obtained by one organism isn't passed on in the food chain is because it is no longer available. Some energy has already been used by the first organism. A plant uses some of the energy it receives to grow and function. A herbivore uses its energy to grow, but also to look for food and run away from predators. A predator uses large amounts of energy to chase after its food in addition to its regular life processes (e.g., breathing, digesting food, moving). The energy these organisms use leaves their bodies – and eventually the Earth – in the form of heat.

Instruction Plan

Engage

1. If you have taken your students on an expedition to your Oyster Restoration Station(ORS), begin with the following line of questions:
    - What organisms did you see at your ORS?
    - Where on the ORS did you observe them? Were they attached to something? Crawling on something?
    - What do you think this organism gets energy from?
    - What do you think gets energy from this organism?
2. Each student gets one Food Web Card. All students will have an organism on their cards, except for "detritus" and "the sun."
3. Give the students time to familiarize themselves with the information on their card.
4. Consider providing additional time and resources (found under Teacher Resources) for the students to read more detail about their organism, especially if you hear a lot of great questions.
5. Ask the students to present their card to a partner or small group, in order to reinforce what they have learned about their organism.

Explore

1. Once the students are familiar with their card, it is time to get in a circle.
2. You will need enough space to get your whole class standing in a circle, with nothing in the middle of the circle. You could move desks out of the way in the classroom, go outdoors, or go into a gymnasium.
3. Make sure each student has the card around his/her neck.
4. Stand in the middle of the circle and explain: You are going to create your own food web. The string represents energy transfer between organisms.
5. Ask: In this food web, where does the energy originate? (Note: There are some food webs where the source of energy is hydrothermal vents on the seafloor.)
6. Give the Sun the end of the string.
7. Ask all the students to glance at their card to figure out who gets energy from the sun.
8. Based on the responses, connect the string to an organism.

9. Then ask who gets energy from that organism.
10. Continue until the string has gone all the way up the food chain to a top consumer.
11. Ask: Do you think any organisms get their energy by consuming this animal? Give students time to think about and discuss different aspects of the question.
12. Discuss decomposers (e.g. bacteria) in more detail. Allow students to ask questions.
13. Explain: sometimes decomposers don't act that quickly, and dead organic matter remains for a time in larger bits like detritus.
14. Explain: the difference between the cycling of matter and the flow of energy through an ecosystem. Bacteria and detritus die, and the matter that makes up their bodies does return to the ecosystem, through soil, air, and water. But the energy that was originally captured from the Sun by a primary producer is now in the process of being converted to heat. It will leave the Earth as radiation, the same way it arrived on Earth as radiation from the Sun.
15. The string represents energy transfer, so there should come a point where you cut the string and start again.
16. Use a new piece of string to start again at the Sun.
17. When the string comes to someone who is already holding a piece of string, use the second piece of string to tie a simple overhand knot to connect it to the first piece of string.

IMG_0071.JPG

1. Continue this process until at everyone in the class is holding at least one piece of string (it's okay if some students get reconnected to the web multiple times, and some are only connected once).

Explain

1. Remind the students that the food web shows the energy transfer through the ecosystem.
2. Consider asking the following types of questions:
    1. In this food web, where does the energy originate? (The sun)
    2. How do the other organisms in this food web obtain energy? (Consuming each other)
    3. Once an organism has energy where does it go and what is it used for? (used for growth and other life processes, and eventually converted to heat energy that leaves the Earth as radiation)
3. Consider introducing vocabulary such as primary producer, omnivore and consumer.
4. Hand out a clipboard and Food Web Questions to each student.
5. Ask students to secure their string in the clip of the clipboard.
6. While students are standing in the circle, they look at the strings and connections and complete the Food Web Questions.

Elaborate

1. The energy transfer in this food web is represented by the string. What could we add to our model that would show the energy loss from one organism to the next?
2. Show the class the basic classroom supplies like markers, construction paper and stickers to prompt some creative thinking.
3. The students put their clipboards down at their feet together, thereby putting the entire food web down on the ground in order to illustrate the energy loss in the food web.
4. Next, tell the students to take the string off their clipboards, pinch the string tightly between their fingers and leave their clipboards down at their feet.
5. Tug on a piece of the string at one point in the web and then another point. You can do this several times.
6. Ask: Which students can feel the tug in other parts of the web?
7. Ask: Why is it that if you tug on the string at one point, students can feel it at another point – even if they aren't directly connected to the string you are tugging?
8. Have all the students take one small step back, pulling on their string with a little pressure, without letting go.
9. Ask: What would happen if one of these organisms was eliminated from the ecosystem? What would happen to the web?

10. Choose an organism that has more than one string leading to it (e.g. an amphipod) and cut all the strings leading to it.

1. Discuss what happens to the food web and the difference in the way food web “feels” (since the students were pulling on the web with some pressure and when those strings were cut.)

Evaluate

1. Students secure their string to the clip of the clipboard at their feet.
2. Students take off their Food Web Card and put it on top of the clipboard.
3. Students get into pairs and get a new clipboard.
4. Pairs sketch out the food web on the back of their Food Web Questions handout.
5. As they sketch, pairs should discuss if they think any modifications need to be made to the food web. They can note these changes in their sketch.

Extend

1. The students look back at the food chain they chose in their Food Web Questions and decide if they would still like to focus on this food chain.
2. This food chain has already been represented with string.
3. Ask: How could we represent this food chain a different way. Possibilities include: an essay, cartoon, pie chart, powerpoint, etc.

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
  - Cause and effect relationships may be used to predict phenomena in natural systems.
  - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Energy and Matter
  - The transfer of energy can be tracked as energy flows through a designed or natural system
  - The transfer of energy can be tracked as energy flows through a natural system.
- Influence of Engineering, Technology, and Science on Society and the Natural World
  - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- Patterns
  - Graphs and charts can be used to identify patterns in data.
  - Graphs, charts, and images can be used to identify patterns in data.
- Stability and Change
  - Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems and System Models
  - Models can be used to represent systems and their interactions.
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

NGSS - Disciplinary Core Ideas

- LS1.A: Structure and Function
  - Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
- LS2.A: Interdependent Relationships in Ecosystems
  - Growth of organisms and population increases are limited by access to resources.
  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
  - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical

environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
  - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
  - Analyze and interpret data to provide evidence for phenomena.
- Constructing Explanations and Designing Solutions
  - Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.
- Engaging in Argument from Evidence
  - Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
  - Interdependence

Food Web Questions

1. Who are you in this food web? ________________________________
2. Choose one food chain of which you are part. List all the organisms in that chain.
3. What is one organism that you depend on? ____________________________
4. What is one organism that depends on you? ___________________________
5. How are you connected to the organisms above?
6. What would happen to the organism that depends on you if you were not here in the food web?
7. How is the sun important in this food web?
8. What is one important part of this food web that is not alive, other than the Sun?
9. What are some important parts of this food web's ecosystem that are not represented here?
10. What do you think is the most important organism in the food web? Why?

Food Web Sketch

Geography Vocab

BOP Curriculum
bop-curriculum@nyharbor.org
Jan 12, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	1	Classroom	ELA

Summary

This lesson allows students to start with a map and explore it. As they do, they will look up whichever water and map words appear in one definition and look up those. By the end, they should have a long list of words related to the harbor.

Objectives

Students will explore a map in order to learn the words needed to talk about the harbor.

Materials and Resources

Supplies

- Internet
- Map of Estuary

Before you get started

Tips for Teachers

- You must have reliable internet to do this lesson.

Instruction Plan

Engage

Look at the map in the folder (or another map of NY Harbor or a different harbor). Have students circle one word that they don't know the definition of (Bay, Inlet, etc.).

Explore

Give students internet access (phones, tablets, laptops, etc.). Have them look up their word. Then, have them make a list of all the other water words in that definition. Then, have them look up those words as well. They should keep a running list of the definitions of all the words that they have looked up using the worksheet in this folder. By the time they are done, they should have the definitions of at least 10 water words.

Elaborate

Give students a blank map. (There is one at : http://www.mapsofworld.com/usa/blank-map-of-new-york-city.html)

Have them label the following waterways by describing them without them using any of the real water words.

1. Hudson River
2. East River
3. Long Island Sound
4. Newark Bay
5. Upper New York Bay
6. Lower New York Bay
7. Jamaica Bay
8. Atlantic Ocean

Evaluate

Have a class discussion where you decide which three water words are most important in discussing NY Harbor. Justify your answer.

Standards

Fill out the table below with definitions of new water words.

Word	Definition	New Water Words
Bay	a broad inlet of the sea where the land curves inward.	Inlet, sea

Part II:

Label the following bodies of water on the map below WITHOUT using any water words:

1. Hudson River
2. East River
3. Long Island Sound
4. Newark Bay
5. Upper New York Bay
6. Lower New York Bay
7. Jamaica Bay
8. Atlantic Ocean

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Regional Plan Association

Habitat Web

BOP Curriculum
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Mar 21, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
NY Harbor Populations Investigation	6-8th	2	Classroom	Science

Summary

Students expand on their food web by making connections to habitats that the organisms live in.

Objectives

- Interpret and recreate a map of New York City.
- Make connections between habitats and the organisms that frequent them.
- Go beyond food webs in their consideration of the connections within an ecosystem, particularly considering habitat and abiotic factors.

Materials and Resources

Supplies

- Two kinds of string OR silly string OR shaving cream (or a combination)
- Documents within the Species ID folder on Digital Platform Dashboard

Before you get started

Tips for Teachers

Some ideas for this lesson came from the Welikia Project and what they call a Muir Web. Check out their lesson and info at https://welikia.org/download/curriculum/.

Preparation

All Cards should be printed and laminated.

Instruction Plan

Engage

1. Students get back into their pairs from the Food Webs lesson and review the food web they sketched.
2. Pairs get together in small groups and discuss: What could we add to this "web" to make an even more complete model of all the different ways that the organisms rely on each other and on their environment?
3. Each pair creates one new Food Web Card using guide books and Species ID resources and any other resources provided.
4. Ask the whole class: What could we add besides other types of organisms? Make a list.

Explore

Go outdoors. Bring extra paper and species ID information, in case a group has an idea to add a new element (that's not on one of the Cards) to their Habitat Web.

1. Create a Map of NYC
   - Each pair gets a Geography Card and a Map of New York City. (Make sure that every Geography Card gets used even if you have to give a pair more than one card.)
   - Explain: The whole class needs to work together to figure out how to place the Geography Cards on the ground so that they resemble the map. (See Geography Card Sample Layout for one example of how it can be done.)

- Once all the Geography Cards are laid out like a map on the ground, circle up the class up around it.

2. Overlay Habitats onto the Map of NYC
    - Each pair gets one Habitat Card. You may pass out more than one of the same Habitat Card, but each pair must have at least one card.
    - Ideally pairs discuss and decide where to place the Habitat Cards on the map based on their personal experiences and knowledge.
    - If students need help, use the Habitats and Shorelines document as a resource for guidance.
    - Students place Habitat Cards on the ground.
3. Connect Organisms to Habitats
    - Each student gets at least one Food Web Card.
    - Using the information on the back of each Food Web Card, students put the card on the ground near the Habitat Card they think fits it best.
    - Each pair gets string (or, if you think students can handle it, silly string or shaving cream)
    - Pairs use the string to connect their Food Web Cards to the best fit habitat and any other habitats that are relevant.
4. Connect Organisms to Each Other
    - Each pair gets a different type/color of string.
    - Pairs use string to draw some important connections between organisms. This is similar to the Food Webs lesson.

Elaborate

1. Circle up class around their Habitat Web.
2. Specifically revisit top carnivores, detritus, and bacteria. Discuss how these things are connected to the rest of the web in terms of both energy transfer and matter cycling (e.g. bacteria helps cycle matter of dead organisms back into the sediment.)
3. Explain: Matter doesn't easily arrive at or leave the Earth, whereas energy is constantly flowing into the Earth system from the Sun and, at the same time, out into space as heat.
4. Each student gets a Dissolved Oxygen and Salinity Requirements handout and looks it over.
5. Choose a dissolved oxygen or salinity level and ask students to remove the organisms from the food web that would be adversely affected by this level.
6. Discuss how this removal of organisms would affect other parts of the Habitat Web.
7. There are lots of connections to be made and questions to be asked here! Solicit questions and curiosities from the students and keep track of them for their small tanks work on populations study later in this Investigation.

Standards

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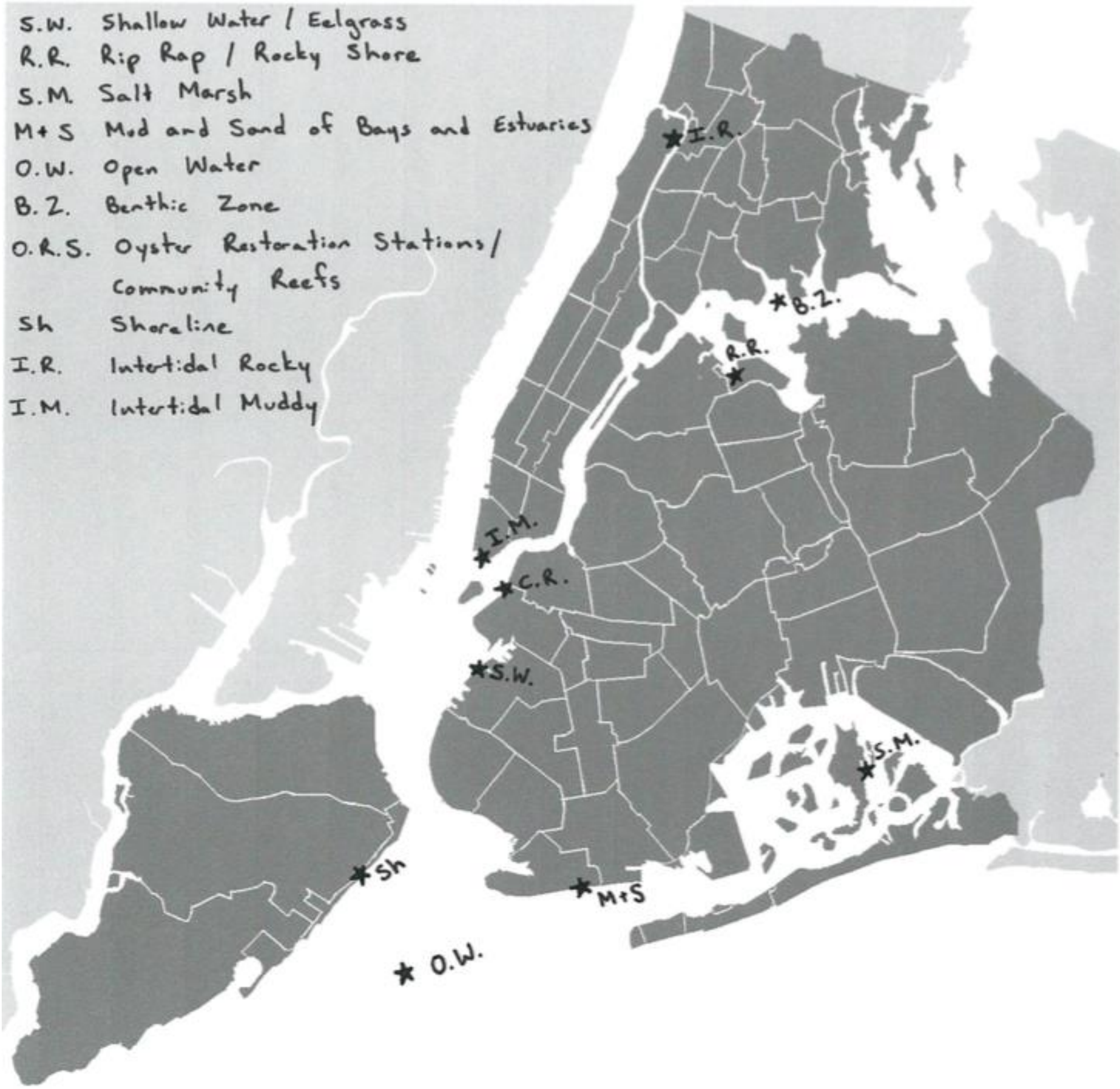
NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence

Organism Common name ***(genus and species)***	**Minimum dissolved oxygen** (ppm)	**Salinity range** (ppt)
Oyster (*Crassostrea virginica*)	3	5 to 42
Oyster drill (*Urosalpinx cinerea*)	Anecdotally, oyster drills are said to be very tolerant of poor conditions, so they may do okay in relatively low dissolved oxygen.	15 to 37 Usually, the greater the salinity content the more this species will thrive
Blue crab (*Callinectes sapidus*)	0.6	3 to 15
Lined sea horse (*Hippocampus erectus*)	Anecdotally, sea horses are said to be very sensitive to water quality, so they probably need plenty of dissolved oxygen.	Twelve professional aquaria keep their lined seahorses at 28-30 ppt, but we've seen them in our estuary...
Black fish (*Tautoga onitis*)	6	Eggs: 8 to 33 Juveniles: 18 to 31
Blue mussel (*Mytilus edulis*)	2	6 to 36
Oyster toadfish (*Opsanus tau*)	4.5	Oyster toadfish live in marine and brackish waters. It is difficult to find more specific information about their salinity tolerance. Perhaps no one has studied it, yet.
Northern rock barnacle (*Semibalanus balanoides*)	5.4	18 to 40
Gammarid amphipods (*Gammarus* spp.)	4.9	Different gammarid amphipods prefer different salinity levels.
Isopods	4	Different aquatic isopods prefer different salinity levels
Shore shrimp (*Palaemonetes* spp.)	4.7	2 to 36
Herring gull (*Laurus argentatus*)	n/a -- gulls get their oxygen directly from the atmosphere	Any -- gulls can even drink salt water!
Double crested cormorant (*Phalacrocorax auritus*)	n/a -- cormorants get their oxygen directly from the atmosphere	Any -- cormorants can even drink salt water!
Great egret (*Ardea alba*)	n/a -- great egrets get their oxygen directly from the atmosphere	Any -- great egrets can even drink salt water!
Mud crab (*Rhithropanopeus harrisii*)	4.8	0.2 to 40
Eelgrass (*Zostera marina*)	Anoxic conditions may kill the plants	5 to 45
Bladderwrack (*Fucus* spp.)	Below 2, reduced oxygen levels are likely to stop photosynthesis and respiration but may not directly kill the *Fucus*.	18 to 40
Sea lettuce (*Ulva* spp.)	Below 2, reduced oxygen levels are likely to stop photosynthesis and respiration but may not directly kill the *Ulva*	5 to 40

Examples of Habitat Locations



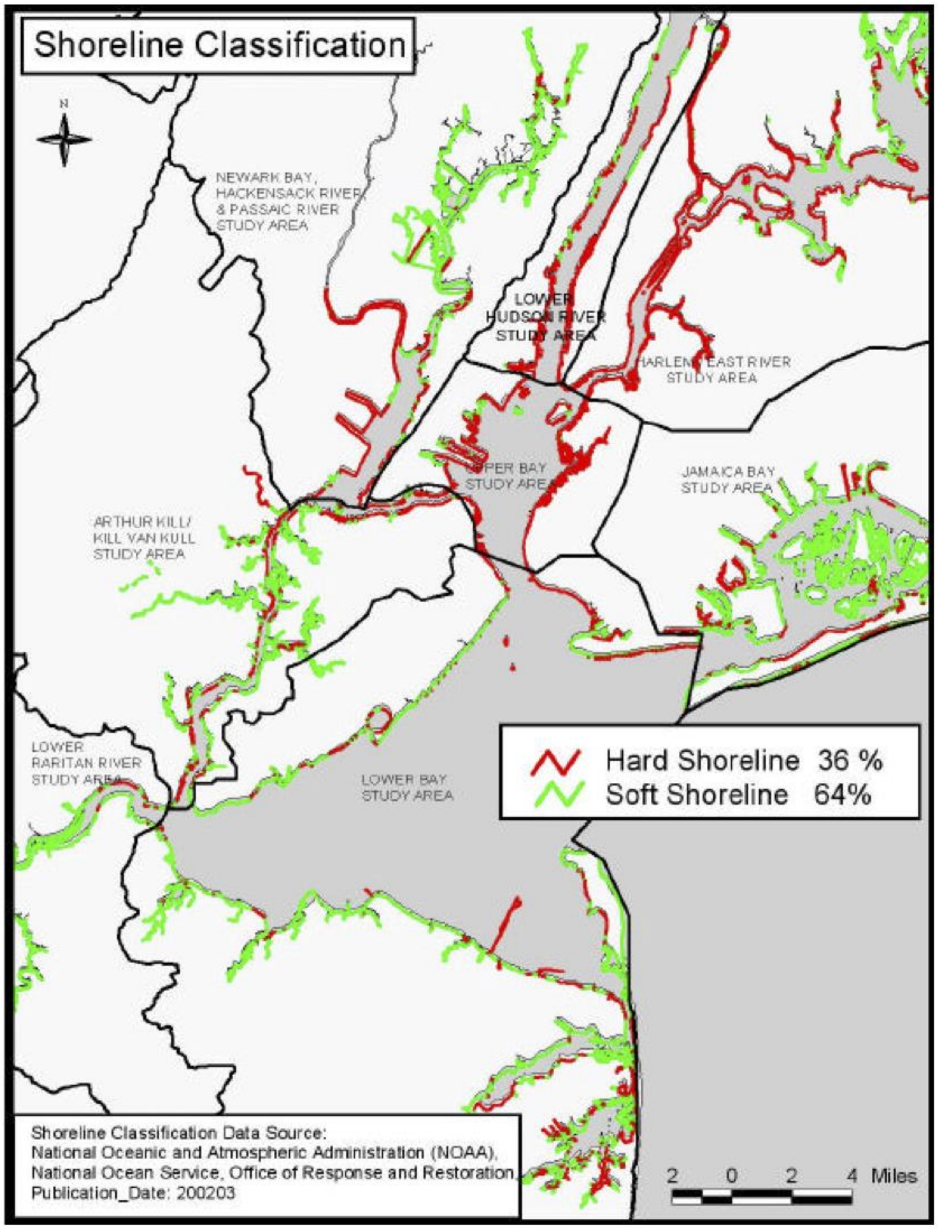


Figure 4-1. General distribution of shoreline conditions: hardened and built structures dominate the maroon and tan colored edges, and green edges vary from rock and gravel beaches to marshes and mudflats. Source: NOAA ESI Geospatial Data, 2003/03.


N
W
E
S
Harlem River
Bronx
Long Island Sound
Hudson River
Manhattan
East River
Queens
Upper NY Bay
Brooklyn
Jamaica Bay
Staten Island
Lower NY Bay
Atlantic Ocean

How do you make an oyster reef? Part 1

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 8, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	2	Classroom	

Summary

Students examine photographs of existing oyster reefs, looking for clues about how to make a reef. Then they propose reef designs and share ideas about those proposals.

Objectives

N/A

Materials and Resources

Supplies

You'll need a good way for the class to view photographs. Ideally, project the images onto a screen. Another option is distributing handouts, but you must have access to a color copier to make this worthwhile. Ideally, you can also use a document camera to facilitate the immediate sharing of students' sketches in the last part of the lesson. Alternatively, you can postpone that part of the lesson until the next day, and collect students' drawings for scanning and/or photocopying.

Before you get started

Tips for Teachers

N/A

Preparation

N/A

Background

N/A

Instruction Plan

Engage

Tell your students:

Look at this series of photos of oysters reefs. Note that many oysters reefs are completely underwater, in turbid (cloudy) waters, where it's hard to take a good picture. So use your imagination to create a mental image of what an oyster reef might look like when it's completely underwater!

Note that a few of these pictures show a different species of oyster, but the reef structures are quite similar.

As they look at the pictures, ask your students:

What do all or most of the pictures have in common? What are some differences that you notice?

Based on these pictures, what are some of the ingredients of a healthy reef? Create a list.

http://blog.wfsu.org/blog-coastal-health/wp-content/uploads/2013/02/Pic3.png

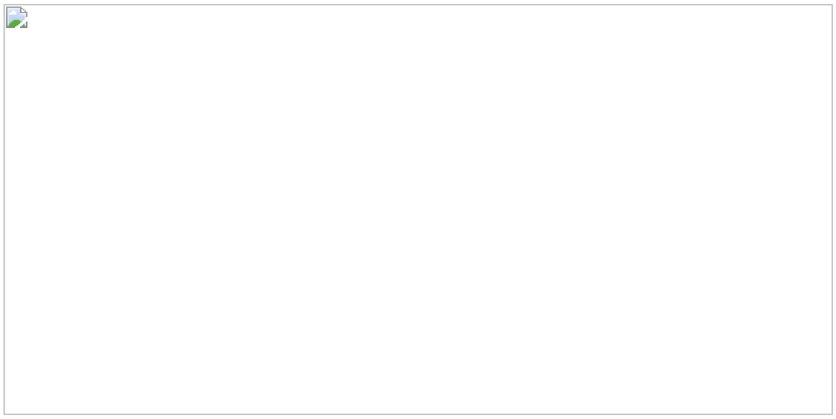
(Can you spot any evidence of monitoring or scientific experiments going on at this reef?)

http://lms.seos-project.eu/learning_modules/marinepollution/images/austernriff_juist.jpg

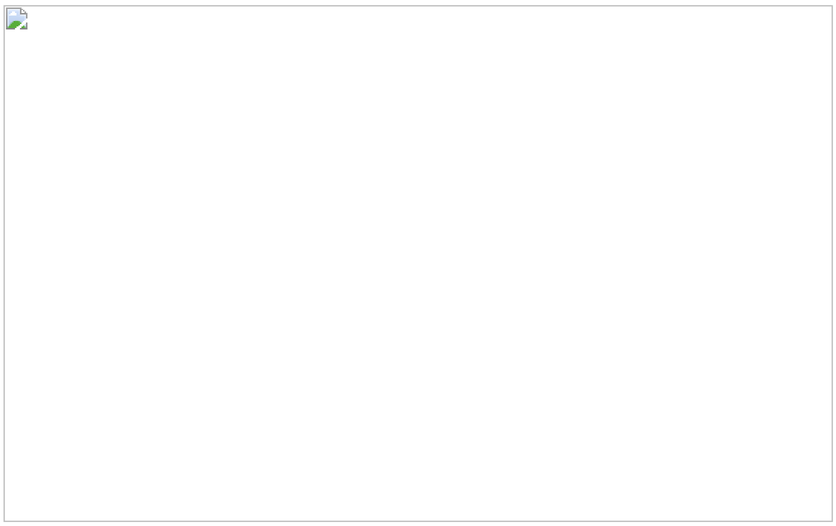
(I wonder what that is, in the distance…)

The next two pictures were taken underwater, but they don't show as much area.

(Do you think they were taken in tanks/aquaria, or in a different kind of body of water? Why?)



http://www.bayjournal.com/images/article_images/large/SMOCS_Oyster_Reefs1_%C2%A9_Jay_Fleming01.jpg



http://www.bayjournal.com/images/article_images/large/2010-October-3946-img-1.jpg

You could also use this lovely blog posting for both text and pictures: http://blog.wfsu.org/blog-coastal-health/?p=1032

Explore

Tell your students:

The first two reefs that we just observed are pretty large, and they are probably able to maintain their population or even grow in size. We don't have reefs like that right now in New York City, but we'd like to!

Review a definition of a self-sustaining reef.

Then assign your students to small groups and tell them:

In order to restore a self-sustaining reef, what questions would you need to answer? Get in groups of 3-4 to brainstorm.

Students will hopefully begin to come up with questions like:

1. Where in New York City's waters would the reef go?

2. What materials would we need to build the reef?
3. What age(s) of oysters would we need to begin with??
4. What kind of benthic surface (surface at the bottom of the water) would be best to start with? What should the first (lowest) layer of the reef be made out of?

If they are struggling, you might compare the activity to deciding where to put a garden. What factors would they need to take into account?

Explain

Staying in small groups, distribute the Handout, “How do you make an oyster reef?”

Evaluate

Have the different groups share their reef designs with the class.

If possible, use a document camera. If you don’t have access to one, you can postpone this part of the lesson, and collect students' drawings to scan them for sharing with the class the next day.

Encourage students to:

- Ask each other clarifying questions about their designs and their thought processes
- Point out the differences among the different groups’ designs
- Discuss the points of disagreement, asking students with different opinions to justify their thinking, challenge one another, and if they change their minds, to say so and explain what persuaded them to change their minds.

Standards

Propose an oyster reef design

One key fact to get you started:

> *A self-sustaining population of oysters is generally found in a large reef, where immature oysters settle on the shells of older oysters, who may be still living or already dead.*

Use that fact to help you discuss the following issues with your group. Then sketch your group's proposed reef design. Be sure to include and label:

- The benthic layer (what is sitting on the bottom surface underwater)

- Other materials that are part of your reef

These materials include:____

- Details about your oysters, such as
    - Just shells? Spat on shell? Mature oysters? Some combination?

My oysters will be:____

- How the oysters are held in position (or not), such as
    - Attached to each other somehow? In cages? Unattached, sitting in the harbor mud? Attached to a dock or other structure somehow?

My oysters are held together by:____

My reef is attached to:____

- Other features that have not been mentioned that you think would improve your oyster reef.

Sketch here:

How do you make an oyster reef? Part 2

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 8, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	2	Classroom	

Summary

Students revisit underwater oyster reef photographs, looking for clues that particular reefs are thriving. In small groups, they propose experiments that compare multiple oyster reefs.

Objectives

N/A

Materials and Resources

Supplies

You'll need a good way for the class to view the Oyster Reef Photographs. Ideally, project the images onto a large screen

Before you get started

Tips for Teachers

N/A

Preparation

N/A

Background

N/A

Instruction Plan

Engage

Revisit the underwater reef images from Day One, one of which shows other fish and organisms visibly inhabiting it and one that does not.

Ask your students:

Do you get the impression that one of these reefs is thriving more than the other? If so, why? If not, why not? Take a vote on which reef that is "healthiest."

Note: there is no right or wrong answer to the above questions! There are good cases to be made for all positions!

Just to get a few ideas out there, before they tackle this in small groups, ask your students:

What experiment do you think we could do on these reefs to collect evidence that would test whether one reef is thriving more than the other?

Explore

In small groups, give students the Handout, “Design an experiment comparing oyster reefs”

Students swap experiments with another group. They examine the other group’s questions and method. Then they come up with a list of questions they have for the other group.

Then you can lead a discussion in which students pose their questions to other groups, hear the answers, and are encouraged to ask follow-up questions.

Explain

It works best to teach the remainder of this lesson the following day.

Re-create the small groups, and distribute the Resource: description of ORRP Experimental Reefs. Also distribute the Handout: What was the ORRP experimental design comparing oyster reefs?

One option is to ask each group to read each section of the text and complete each section of the Handout. Another option is to “jigsaw” this text by assigning different parts to different groups, who then share their responses orally. Once you’ve heard groups’ summaries of their portion of the text, you can decide whether you want to jigsaw the Handout as well, or to ask each group to complete all parts of the Handout.

Elaborate

Still in their small groups, have students compare and discuss their groups’ experimental design and ORRP’s experimental design.

Meanwhile, move through the room, eavesdropping, and write notes for yourself about which issues the students are most interested in.

Evaluate

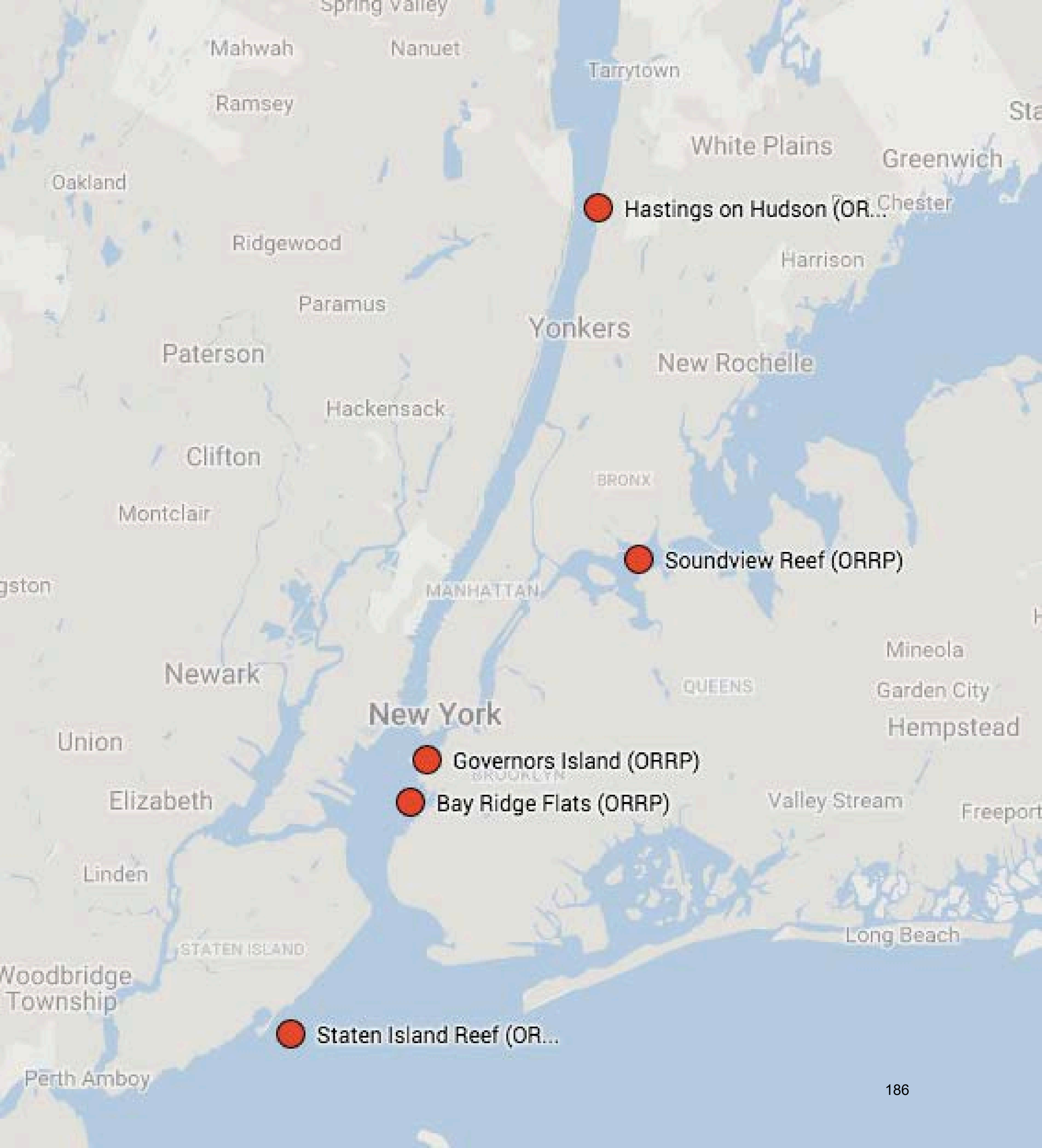
Lead a discussion in which you ask your students:

What are the pros and cons of particular choices that ORRP made?

What are the pros and cons of particular choices that our groups made?

Focus this discussion on the issues of interest to your students that you overheard in the small group conversations.

Standards


Spring Valley
Mahwah
Nanuet
Tarrytown
Ramsey
White Plains
Greenwich
Oakland
Hastings on Hudson (OR...
Chester
Ridgewood
Harrison
Paramus
Yonkers
Paterson
New Rochelle
Hackensack
Clifton
BRONX
Montclair
Soundview Reef (ORRP)
MANHATTAN
Mineola
Newark
QUEENS
Garden City
New York
Hempstead
Union
Governors Island (ORRP)
BROOKLYN
Elizabeth
Bay Ridge Flats (ORRP)
Valley Stream
Freeport
Linden
Long Beach
STATEN ISLAND
Woodbridge Township
Staten Island Reef (OR...
Perth Amboy

Description of ORRP Experimental Reefs -- Phase I

A few years ago, a group of people called the Oyster Restoration Research Project (ORRP), conducted studies to help them learn how to restore oyster reefs to New York City. Following is a summary of their first phase of experimental reefs.

ORRP's Study Design[1]

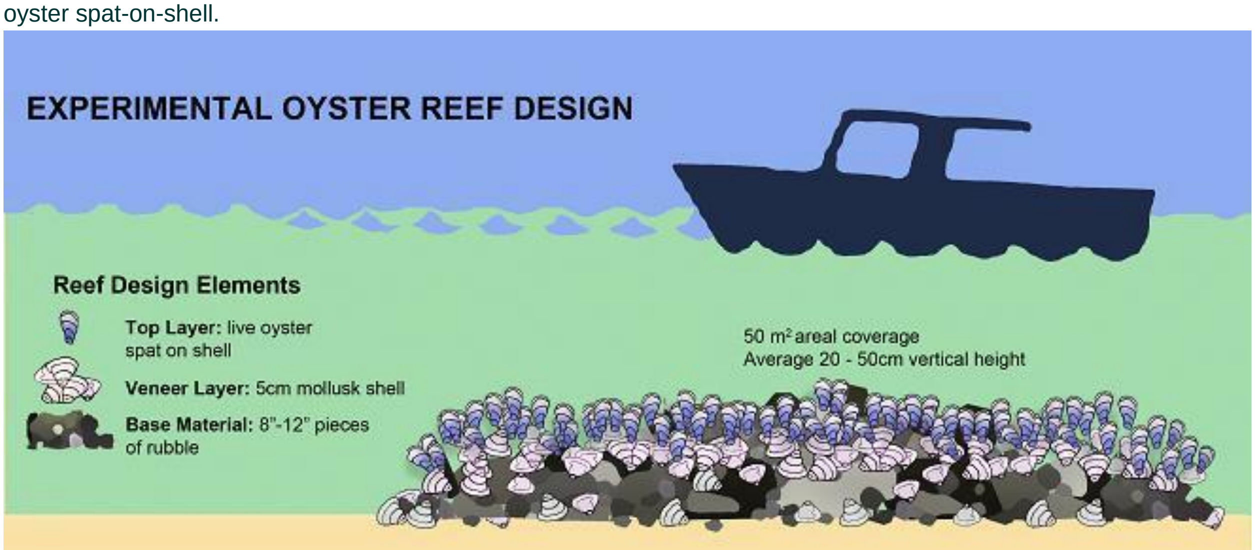
1. What did they want to know?

- How well their experimental reefs would survive and grow, in particular
  - The rate of growth of the oysters and the reef
  - When the oysters would reproduce
  - When they would see a lot of oysters die

- How the reefs would affect the environment and the other species living there
  - If they would see a lot of animals that eat oysters arriving in the area
  - If they would see more different kinds of animals able to live there
  - If the water quality would change
  - If there would be more fish

2. How did they design their experimental reefs?

- The reef structure was: 6 -18 inches of rock material, covered by a thin layer of clam shells, followed by oyster spat-on-shell.



http://www.hudsonriver.org/graphics/orrp_reef.jpg

- They put this kind of reef at all five sites in fall 2010. Then in June 2011, they put more spat-on-shell at Governors Island, Hastings and Soundview. Between July and November 2011, they put even more spat-on-shell onto their reef at Governors Island. *Why do you think they added more spat-on-shell to different sites at different times? Do you think that interfered with the validity of their experiments?*
- The first reefs were small. Later they planned to make larger experimental reefs.

[1] Adapted from Lodge and Mosher-Smith http://www.harborestuary.org/TEsummer10.htm#3 and http://www.oyster-restoration.org/wp-content/uploads/2012/06/ORRP-FINAL-REPORT_2013-02-20.pdf

- In this study they did not attach the shells to each other, so they were easy to move around.

Where?

- at 5 locations throughout the estuary -- check out the map on a separate handout.

3. What did they measure?

- Before putting down reefs:
    - They measured water quality.
    - They took samples of mud from the bottom, and they identified and counted all the macroscopic organisms they could find in that mud.
- After putting down reefs:
    - They counted live and dead oysters, and they measured live oysters -- periodically from Nov 2010–Oct 2012.
    - They put down trays with shells but no oysters in the middle and at the edges of their reefs. Then they identified and counted the macroscopic organisms they found in each tray. Then they put the organisms back in the trays and put the trays back into their places in the reefs. -- when they monitored their oysters, so periodically from Nov 2010–Oct 2012.
    - They measured water quality parameters, such as temperature, salinity and dissolved oxygen. Because water quality conditions can change very quickly, they used sensors that can record data all the time at many of the sites. The instrument they use to do that is called a sonde, and the data recorded by a sonde can be called “sonde data.”
    - They specifically measured chlorophyll -- a way of telling how much microscopic algae is suspended in the water -- upstream and downstream of each reef: at Hastings and Soundview in July 2011, and at Soundview in Aug 2012.

Design an experiment comparing oyster reefs

In your small groups, discuss the following questions, and then write down your group's shared opinions.

GOAL OF RESEARCH:

What's the most important goal of this research? Explain your thinking!
Things to consider:

a. Is it most important to figure out how to make oyster reefs that survive and reproduce?
b. Or to find evidence that the oysters are helping *other* species survive and reproduce?
c. Or something else altogether?

Write your thoughts below:

WHAT IS YOUR RESEARCH QUESTION?____

HOW DO YOU COLLECT DATA?

What data would you collect? Why? <u>Explain your thinking!</u>

1) *What will you count? (oysters, other organisms, etc) Why?*

2) *How often will you count it? Why?*

3) *What will be your method for counting (put them back, keep them out, etc)*

4) *What time of year will you start collecting and why?*

5) *Is there anything else you feel you should measure? Why or why not?*

What was the ORRP experimental design comparing oyster reefs?

In your small groups, discuss the following questions, and then write down your group's shared opinions.

GOAL OF RESEARCH:

1) Did ORRP think it was most important to figure out how to make oyster reefs that survive and reproduce?

2) Or to find evidence that the oysters are helping *other* species survive and reproduce?

3) What is your evidence?

4) *What's the most important goal of this research? Why did ORPP make the decisions it did?*

IN YOUR OPINION, WHAT IS ORRP's RESEARCH QUESTION?____

HOW DID ORRP COLLECT DATA?

What data did ORRP collect? Why do you think they did things this way? Explain what you think was ORRP's thinking!

1) *What did ORRP count? (oysters, other organisms, etc) Why?*

2) *How often did ORRP count it? Why?*

3) *What was ORRP's method for counting (put them back, keep them out, etc)*

4) *What time of year did ORRP start collecting data, and why do you think they did that?*

Improve Conditions in Your Small Tank

BOP Curriculum
bop-curriculum@nyharbor.org
Mar 21, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
NY Harbor Populations Investigation	6-8th	9	Classroom	Science

Summary

After collecting, analyzing, and discussing the data from the lesson Small Tanks for Small Arthropods, the class defines a consensus desired outcome (their definition of "best for the animals"). The class then develops a consensus set of conditions for what will become the class control tank. Finally, each group varies one parameter from the control tank, trying to do even better for the animals than the control tank, according to the consensus outcome.

Objectives

- Analyze their own group's and class-wide data from small arthropod tanks.
- Form persuasive arguments about the desired outcome for the class' small arthropods.
- Select one parameter to vary from a control condition.
- Set up a small tank in their chosen experimental condition.
- Develop a plan for collecting data that will assess their chosen experimental condition according to a consensus definition of the desired outcome.
- Collect data according to their plan.
- Analyze and present their data to classmates.
- Offer and receive questions and suggestions about their experiments.

Materials and Resources

Supplies

- Poster paper for each group to record baseline data
- 20 (or more) Petri dishes
- White paper to lay out under the Petri dishes, so it's easier to observe the animals on a white background
- Tweezers (one set for each table) – for transferring animals
- and/or Wide-tipped disposable pipets (which are quite reusable)– for transferring animals more gently, along with some water – one or two per table
  - You can buy 100 for $5 here: http://www.premiumvials.com/3ml-plastic-transfer-pipettes-gradulated-pack-of-100/?gclid=CIbKjufbz9ICFU9WDQodaqsGpQ
  - If the tip is too narrow, you can use scissors to cut the pipet where it's wider
- Sieves, screens, or pieces of loosely-woven fabric that can be used to separate animals from water (one for each table)
- Hand lenses (two or more for each table)
- 10 (or more) one-gallon tanks (e.g. Penn-Plax New World Habitat Tank, Small, 1 gal)
- At least 30 small arthropods collected from ORS mobile trap (the more the better!)

Refer to the BOP Oyster Tank Guide on the BOP Digital Platform for details on where to purchase and how to use the materials for your small tanks.

- Cold tap water – enough to fill all the 1-gallon tanks
    - Tap Water Conditioner (de-chlorination of tank water)
    - Instant Ocean Aquarium Salt (15 lbs bag)
- OR harbor water – enough to fill all the 1-gallon tanks
- 10 (or more) aerators with airstones and tubing (alternatively, you can use a manifold with extra tubing to divide the air from one aerator into several tanks)
- Shellfish Diet 1800 phytoplankton concentrate (1 quart) OR algae discs (optional for occasionally feeding the associated organisms)
- Optional: frozen brine shrimp for feeding crabs, if students don't want the crabs eating the harbor organisms
    - Purchase at your local aquarium store or Petco
- Optional: Stress Zyme (for adding more bacteria to your tank)
- Optional: Aquarium gravel (for DIY filters)
- Optional: Plastic bottles with wide mouth (for DIY filters that can fit inside the little 1-gallon tanks)
- Optional: Recycled oyster shells for substrate

Before you get started

Tips for Teachers

- Because students often ask fantastic questions without realizing it or writing them down, try to move around the room and write down the wonderings you overhear.
- Each time you move or handle your organisms, you stress them. In general, sieving or screening them is less stressful than using tweezers or pipets. But some of the amphipods will cling to the screens.
- You might first ask your students to practice using tweezers gently on other objects, such as soft-cooked rice or cut up cooked noodles. If they break the rice grains or noodle pieces, they're squeezing too hard.
- The hope is to allow students to explore and interact with these animals, and to do so gently, with awareness of how their actions affect the animals.
- During the data collection period, in the "Evaluate" section, you may want to split class time: each day students can have a certain amount of time to collect their data. If you like, you can use the remaining class time from each of those periods for students to present their experiments and data to date. Groups can present what they have so far, and that way you don't need to wait for everyone to collect all their data before getting started on presentations.

Preparation

- You need a fresh supply of amphipods and isopods from your Oyster Restoration Station (ORS).
- To give students the best opportunity to do interesting experiments that answer the questions they care about, you might want to visit the ORS on your own several times during this lesson, so you can collect even more animals for them to work with. You could also reach out to colleagues and BOP citizen scientists in your area to help you with the collection and delivery of small arthropods to your classroom.
- You need the running list of questions about small arthropods that you started to collect in the previous lesson, Small Tanks for Small Arthropods. Students will add to the list throughout this lesson.
- So that your students have some background knowledge about these animals and the local estuarine food web, teach the lessons Food Web and Habitat Web prior to this lesson.

Instruction Plan

Engage

1. Note: the next activity is a rich source of student questions about small arthropods. Be sure to record your students' questions and add them to your running list. You'll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

2. Groups describe to the class, “How are your animals doing?”

3. Ask the class: “Which group’s animals are doing best? What’s your evidence? Can you come up with an argument that a different group’s animals are doing best?”

4. Ask: “What questions come up as we try to figure out which group’s animals are doing best?” Add these questions to the running list of questions about small arthropods.

Explore

1. Note: the next activity is a rich source of student questions about small arthropods. Be sure to record your students’ questions and add them to your running list. You’ll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

2. Ask the class: “What are all the different ways we could define ‘best’? In other words, what do we really want for our animals, and why?”

   (One major distinction is: protect prey from predators vs. feed prey to predators. Many other distinctions are possible!)

3. Post the answers, and then present the task: “We need a consensus definition of ‘best’ or of our ‘desired outcome’ for our animals.”

4. Use polling, forced-choice, or other methods to stimulate discussion and debate. When you feel the time is right, articulate the consensus position, or articulate the lack of consensus and choose one position for the rest of this activity

This would be a good time to break until the next class.

Explain

1. Note: the next activity is a rich source of student questions about small arthropods. Be sure to record your students’ questions and add them to your running list. You’ll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

2. Students have the class definition of the desired outcome for the tanks

3. In groups, students design proposed tank conditions that they think will achieve that desired outcome.

This would be a good time to break until the next class.

1. Post those proposed conditions where everyone can see them, and arrive at a ‘class consensus condition’ for a tank that students predict will achieve the consensus desired outcome.

2. Again, solicit new questions for the running list of questions about small arthropods.

This would be a good time to break until the next class. Meanwhile you can get some students to help you set up one tank according to the class consensus conditions.

Elaborate

1. Tell students: “I have set up one tank according to our class’ consensus conditions. This will become the control condition in an experiment that each group will do. If this is our control condition, you can vary only one parameter to create an experimental condition. In your group, decide what parameter you want to vary.”

2. In small groups, students choose one parameter to vary from the class' control tank, using the handout Which parameter will you vary for your experiment on small arthropods?
    1. Note: the handout asks groups to end up with a list of their top three choices of independent variable, with pros and cons of each. At that point you might want to elimintate choices that are impractical or too destructive to the animals.

3. Depending on which parameters your students choose, consider providing groups with 2 or 3 or more small tanks. That way they can vary their parameters quantitatively. That said, for more tanks, you need more animals.
    1. For example, suppose a group chooses to vary aeration. It's not a great idea for them to get one experimental tank and provide no aeration. But it could be a great idea for them to get 2 or 3 tanks, and vary the amount of aeration in those tanks.

This would be a good time to break until the next class.

Evaluate

1. In their groups, students set up their experimental tank(s)

2. Students plan their data collection and predict their results by completing the handout How will you tell how your experimental tank is doing?

3. Solicit more questions for the running list of questions about small arthropods. You'll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

This would be a good time to break until the next class.

1. Students collect data according to their plans.

2. Students post and discuss their results.

3. Students present their experimental designs and offer questions and suggestions to other groups.

Note: it's often nice to split up the time so that for several class days, students have some time to collect data, and some time for presentations. That way both activities feel less repetitive.

Extend

Each group devises and conducts a follow-up experiment.

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
    - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
    - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
    - Cause and effect relationships may be used to predict phenomena in natural systems.
    - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Energy and Matter
    - The transfer of energy can be tracked as energy flows through a designed or natural system
    - The transfer of energy can be tracked as energy flows through a natural system.
- Influence of Engineering, Technology, and Science on Society and the Natural World

    - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- Patterns
    - Graphs and charts can be used to identify patterns in data.
    - Graphs, charts, and images can be used to identify patterns in data.
- Stability and Change
    - Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems and System Models
    - Models can be used to represent systems and their interactions.
    - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

NGSS - Disciplinary Core Ideas

- LS1.A: Structure and Function
    - Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
- LS2.A: Interdependent Relationships in Ecosystems
    - Growth of organisms and population increases are limited by access to resources.
    - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
    - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
    - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
    - Analyze and interpret data to provide evidence for phenomena.
- Constructing Explanations and Designing Solutions
    - Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.
- Engaging in Argument from Evidence
    - Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence

How will you tell how your experimental tank is doing?

1. Your class discussed and agreed on the conditions for a control tank. List those conditions below:

2. Your group will set up its own experimental tank. To make the experimental tank, you will do all the same things as the control tank except one. What is the one thing you will do differently in your group's experimental tank? Why?

3. Your class also discussed and agreed on a desired outcome for your small tanks. Write that

   desired outcome here:____

   ____

4. Now you need to figure out how you can tell if your group's tank is achieving that desired outcome.
   a. First, write down all the different kinds of data you think you could collect:

   b. Then, choose from that list. Which kinds of data are most important to collect, in order to show how well your group's tank is doing, according to that desired outcome? Why?

5. Now predict your results:

Type of data, and how we will collect it	Predicted result -- what we think the numbers will be, for that type of data	Reasoning -- why we make that prediction
Example: Water temperature, measure with thermometer, once a day	*The water temperature will stay constant, at 21 degrees C*	*Right now the water temperature is 21 degrees C. Because the classroom is always heated, we think the water temperature will stay the same.*

6. What new questions do you have about your animals, your tanks, your data, etc?

Which parameter will you vary for your experiment on small arthropods?

1. Describe the control condition by filling in the answers below. Our class' control tank is set up with the following parameters:
    - Size and shape of tank:
    - Water level:
    - Where the water comes from:
    - Salinity:
    - Water temperature:
    - Anything else you know about the water:

    What was added to the tank just once? List everything you can think of:

    - What is added to the tank on a regular basis? List everything you can think of:

    - Types of organisms included:

    - Types of organisms excluded:

2. Next your group will choose <u>one</u> parameter to vary from the control condition. (That one parameter that you vary is also known as your independent variable.)
    a. List all the ideas in your group:

    b. Discuss the pros and cons of each one. Then write down the pros and cons of the top three choices for your group's independent variable:

        i.

        ii.

        iii.

Introduction to Data Analysis

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 13, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	3	Classroom	ELA

Summary

Students will compare two graphs, one which includes only two pieces of information and one that includes four. The students will compare and discuss the difference. Then, students will examine a set of oyster data to determine which columns provide relevant data and why data is relevant or irrelevant. They will then create a graph showing the data over time.

Objectives

- Students will consider which data is important and why
- Students will graph data over time.

Materials and Resources

Supplies

- Graph Paper
- Rulers
- Projector/Document camera to display data

Before you get started

Tips for Teachers

This lesson can be done with any set of data from your Oyster Restoration Station (ORS). The data set I included has obvious examples of relevant and irrelevant data, but you should definitely use your own data or any other data that your students are excited about. The opening worksheet could take an entire class or could be completed quickly. It all depends on how deeply you want your students to investigate. If you take a period with it, then this lesson will take two class periods. There is a resource spreadsheet with more data Oyster Raw Data. Feel free to draw from that as well.

Background

This lesson provides a basic introduction to the idea that not all data is relevant. It encourages students to consider what data is useful for analysis and it is not. It is an introduction to teaching students to consider large quantities of data and choosing their focus.

Instruction Plan

Engage

Examine the two graphs on the handout "Tigers and Wolves." The handout asks students to compare a graph with only two pieces of data and one that is more complex and contains four pieces of data.

Explore

- Put the data from the *Graphing the Oysters!* (or any other set of data from your restoration station) on the board or on a projector.
- Ask the students to discuss in groups which columns of data show change over time and which do not.

As a class, once they have decided that, hand out the

Graphing the Oysters!

worksheet and have the students work on it.

Explain

Discuss with students that not all the data that you collect at your restoration station will be relevant. Have them give examples of data collected at the ORS that might not matter. Discuss what makes GOOD data and what data is not worth looking at.

Evaluate

Decide which data your group will focus on next time you go to the oyster site. Why have you chosen that data? Justify your answer.

Standards

Oyster Data

The data below was collected at Pier 6 in Brooklyn on a monthly basis.

Date	Time	Oyster Minimum Size (mm)	Oyster Maximum size (mm)	Total Dead	Total Living
6/10/14	3:50 PM	18	40	143	400
7/10/14	2:00 PM	12.5	49	15	300
8/11/14	10:30 AM	10	76	13	300
9/24/14	7:30 AM	39	90	5	300
10/23/14	7:30 AM	41	88	5	300

1) Look at every column except for the first two. Which columns show change over time?

2) Which columns do not show any change over time?

3) Which column shows change but does not really provide any information? Justify your answer.

4) Which columns could help you make predictions about the health of your oyster cage?

5) Which columns do you think do not provide any useful data? Why or why not?

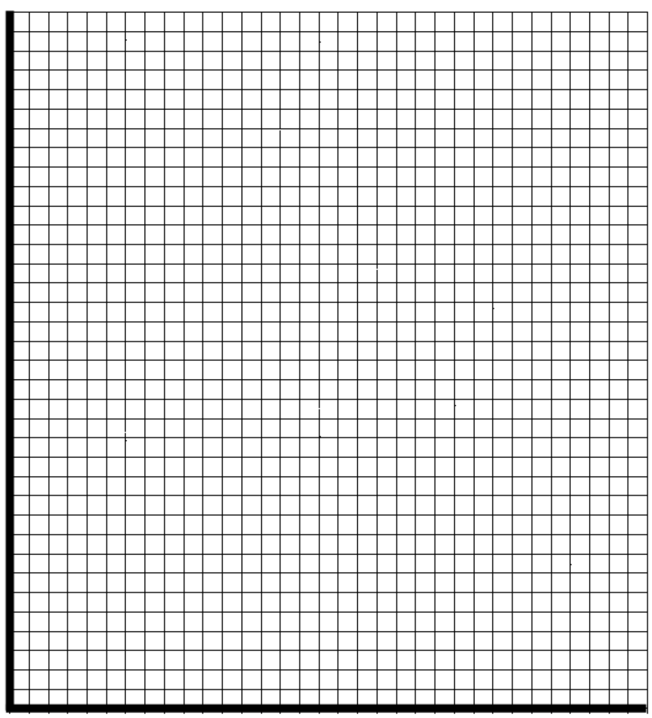
6) Your x axis will be months. Choose a column for your y axis that you think provides data that tells a story.

Graphing Instructions:

1) Title your graph______________________
2) Decide how to label each axis: x axis__month__________

   Y axis_________________
3) Decide how to SCALE your axes x axis__months_______

   Y axis_______________
4) Label your axes
5) Graph each point!

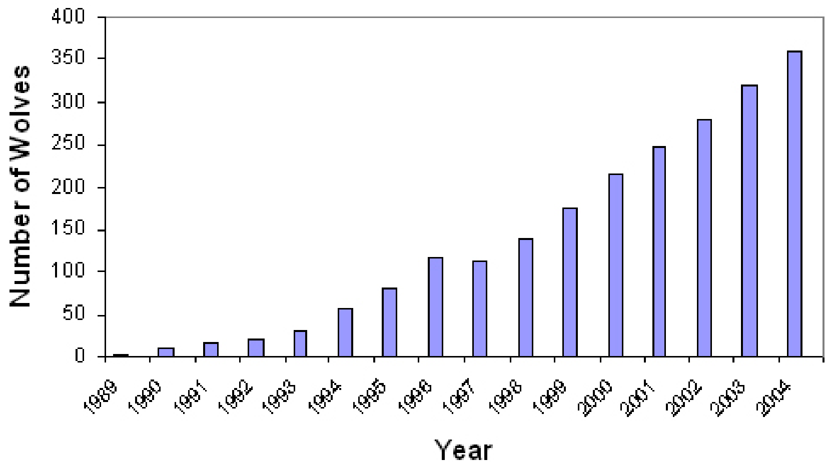


6) Can you draw any conclusions from your graph?

7) Do you think you chose the right column to graph? Why or why not?

Tigers and Wolves

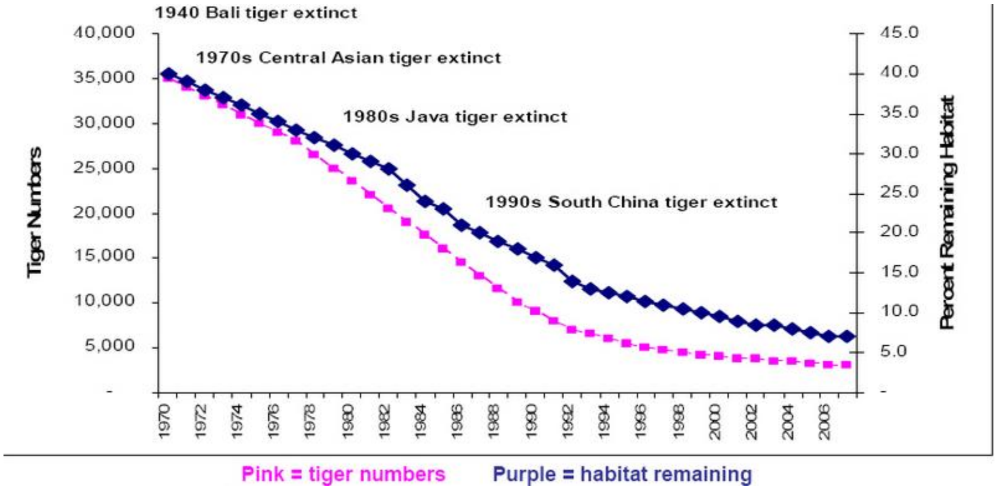
Look at the first graph:



1) How many different kinds of data are included in the graph? What are they?

2) In one sentence, describe what is happening to the population of wolves over time

Now, look at the second graph

3) 

How many different kinds of data are included in this graph? List them.

____

____

4) Write 2-3 sentences to describe what is happening to the population of tigers and WHY?

____

____

5) What information was included in the second graph but not in the first? How did that information help you to answer Question #4?

____

____

Journaling in the Field

BOP Admin
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May 10, 2018

Unit	Grade	Class Periods	Setting	Subject Areas
Introductory Lessons	6-8th	1	Field	Science Social Studies ELA

Summary

Students should always be engaged when in the field. Journaling is a useful tool when there is a gap in direct instruction or hands-on work and for groups that finish early. Journaling allows students time to reflect on their experiences, make observations about their surroundings and think meta-cognitively.

Materials and Resources

Before you get started

Tips for Teachers

Journal writing can include:

- Observation
- Inference
- Description
- Detail
- Site Metadata (e.g. location, time, weather conditions)
- Procedure (so someone else can do what you did)
- Personal experience
- Reflection (e.g. self to lesson, self to world, lesson to world)
- Opinions
- Feelings

Journal illustrations can include:

- Organisms
- Landscapes
- Structures
- Measurements
- Labels
- Additional written information
- Being “good at drawing” is not required!

Journal prompts can include:

- One of my goals is...
- Today I improved upon...
- One of my challenges is...
- This experience taught me...
- If I were to repeat this experience I would...

Journal assessment can be based on:

- Length of writing
- Touching on all points in the prompt
- Level and depth of detail
- Completeness/thoroughness of ideas

It is often helpful to:

- Have students write silently
- Have more than one prompt for students to choose from
- Include “Write anything else you want to write” at the end of each prompt
- Correct, but not penalize for incorrect spelling and grammar
- Give written, personal feedback when assessing journals

Instruction Plan

Standards

Measures of Central Tendency

BOP Curriculum
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Sep 6, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	2	Classroom	Math

Summary

Students start with a simulation of measuring spat-on-shell. They then find the central tendency measurements of their simulation. After that, students examine data from the Governor's Island oyster docks. Students compare a set of discrete data (number of spat-on-shell) with a set of data that is continuous (length of oysters). They discuss which measure of central tendency: mean, median, or mode, is useful in which situation and why.

Objectives

- Find mean, median, and mode.
- Decide which measure of central tendency is most useful in different situations

Materials and Resources

Supplies

- Oyster spat-on-shell simulation.
- Real oyster shells with a bunch of spat-on-shell on each one, or if you can't get those, drawings of oysters with a number indicating how many spat on shell are on them.
- Drawings of oysters with numbers on them.
- Calculators

Before you get started

Tips for Teachers

Try to make the simulation at the beginning as fun and engaging as possible. It would be best to pretend to pull a "cage" (box) out of the water and then count the oysters. You could even wear gloves! One option for the simulation is to set up your own classroom oyster tank and use the spat-on-shell from the tank. See the lesson entitled "Oyster Tank Setup (Part I What's in our tank?) Any data set can be used for the second activity. Just make sure that the data you use has a mean, median, and mode that can be calculated.

Background

On Governor's Island several years ago, oysters were grown in bays in the dock, known as FLUPSY buckets (FLoating UPweller SYstem). The oysters were grown in the harbor and were an experiment to see how oysters survived living in and eating out of harbor water. The data for this lesson looks at the oysters grown in that system and analyzes the data using measures of central tendency.

Instruction Plan

Engage

1. Teacher has a box of pretend oysters (or real shells with numbers written on them), each has a number on it to indicate the number of spat-on-shell on each one. 7 students volunteer to come to the front of the room. Each picks an "oyster" from the bag, then records the number of spat on shell on each one. Teacher puts all seven numbers on the board.
2. Example numbers: 4, 10, 5, 7, 7, 6, 0

3. Teacher introduces the mean, median, and mode and then the students find all three using the Data Warmup.
4. Teacher leads discussion around the following topics:

- Mean: Can you have a partial oyster spat? Does this number still have meaning? Why or why not? Are there any outliers that are dramatically throwing off your results?

- Mode: There are too few numbers for the mode to matter.Is there a discussion question here?

- Median: This is probably the most useful in this case. Why?

Explore

Students are given the data worksheet. They put the data in order, then they find the mean, median, and mode of both sets of data.

Explain

Students complete the analysis questions and discuss.

Evaluate

Students look at Protocol 2 -Oyster Measurements in the Oyster Restoration Station Field Manual and discuss which central tendency measurements they might use with Protocol 2.

Standards

CCLS - ELA Science & Technical Subjects

-
  - Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

CCLS - Mathematics

-
  - Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

NGSS - Cross-Cutting Concepts

- Patterns
  - Patterns in rates of change and other numerical relationships can provide information about natural systems.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
  - Analyze displays of data to identify linear and nonlinear relationships.

Data Warmup

Record the number of spat-on-shell on each of your "oysters"

1. Find the mean of the data:

2. Find the median of the data:

3. Find the mode of the data:

4. What did you get for the mean. Was it a whole number? Does this make sense? Why or why not?

5. Are there any numbers that are either way too high or way too low?

6. Do you think the mode is a useful measurement in this case? Why or why not?

Oyster Data Worksheet

This first set of data was taken from oysters grown off of the Governor's Island docks in specially designed bays.

Entry #	SITE	FIELD DATE	Live oysters per clump
1	FLUPSY Bucket #1	Jun 6, 2011	7
2	FLUPSY Bucket #1	Jun 6, 2011	6
3	FLUPSY Bucket #1	Jun 6, 2011	14
4	FLUPSY Bucket #1	Jun 6, 2011	10
5	FLUPSY Bucket #1	Jun 6, 2011	9
6	FLUPSY Bucket #1	Jun 6, 2011	5
7	FLUPSY Bucket #1	Jun 6, 2011	10
8	FLUPSY Bucket #1	Jun 6, 2011	8
9	FLUPSY Bucket #1	Jun 6, 2011	15
10	FLUPSY Bucket #1	Jun 6, 2011	8
11	FLUPSY Bucket #1	Jun 6, 2011	5
12	FLUPSY Bucket #1	Jun 6, 2011	8
13	FLUPSY Bucket #1	Jun 6, 2011	16
14	FLUPSY Bucket #1	Jun 6, 2011	13
15	FLUPSY Bucket #1	Jun 6, 2011	5
16	FLUPSY Bucket #1	Jun 6, 2011	3

LOOKING AT DATA PART I:

1) Put the oysters in clump data in order from least to greatest:

2) Find the median of the data:

3) Find the mode of the data:

4) a) How many data points are there?

b) Use this to find the mean of the data

ANALYSIS OF DATA SET 1

1) Are there any outliers in this set of data? Justify your answer.

____
____
____

2) Does your mean value make sense? Why or why not?

____
____
____

3) Is it possible for you to have a data point that equals your mean? Why or why not?

____
____
____

4) Do you think the mode is representative of the data? Why or why not?

____
____
____

5) Which measurement, mean, median, or mode best represents your data. Justify your answer.

____
____
____

LOOKING AT DATA PART II

The second set of data below was collected from a restoration station in a dock in Bayridge. Rather than measuring numbers of oysters, it looks at size of oysters.

1) Before you look at the data, think about this question:

How is data about size different from data about NUMBER of oysters?

____

____

____

Now, Look at the second data set

Site	Field Date	Oyster size (mm)
BR	10/22/2010	32
BR	10/22/2010	35
BR	10/22/2010	45
BR	10/22/2010	37
BR	10/22/2010	40
BR	10/22/2010	21
BR	10/22/2010	24
BR	10/22/2010	29
BR	10/22/2010	47
BR	10/22/2010	39
BR	10/22/2010	33
BR	10/22/2010	27
BR	10/22/2010	24
BR	10/22/2010	23

1) Put the size of oysters data in order from least to greatest:

2) Find the median of the data:

3) Find the mode of the data:

4) a) How many data points are there?

b) Use this to find the mean of the data

DATA ANALYSIS PART 2

1) Is it possible to have a non whole number value for this set of data?

2) Does the mean seem like it represents the data set?

3) Are there any outliers in this set of data?

4) Does this data have a mode? Explain.

5) Why is the mode not always a good measure?

6) Can you think of a set of oyster data where mode would be the best measure of central tendency?

7) What is the measure of central tendency that you think most accurately describes this set of data?

Monitor Your Oyster Tank

BOP Curriculum
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Mar 2, 2018

Unit	Grade	Class Periods	Setting	Subject Areas
Oyster Tank Investigation	6-8th	2	Classroom	Science Math

Summary

Students measure the size of the oyster spat and water quality data for the classroom tank.

Objectives

- Measure at least one component of the regular tank monitoring.
- Describe the significance of at least one component of monitoring the tank.
- Design a plan for the regular maintenance of their oyster tank.

Materials and Resources

Supplies

- 10 calipers
- 5 small containers (for water samples from tank to test)
- Thermometer
- Dissolved oxygen kit
- hydrometer
- pH kit
- ammonia test strips
- nitrate test strips
- phosphate test strips
- turbidity tube
- shallow pan (to catch water from turbidity tube)

Before you get started

Tips for Teachers

- Make sure you read the Oyster Tank Guide in preparation for this lesson.
- Ideally, the students who help set up the oyster tank will also help monitor it throughout the year. If this is not possible, consider ways to keep your students informed as to the progress of the tank and health of the oysters.

Preparation

Decide if you want to add “associated oyster reef organisms.” These are organisms found in your ORS that you are able to keep alive and transport back to your classroom. If you do not have time to add organisms during this lesson, we suggest you add them at a later date, as they can make for a very rich and dynamic oyster tank experience.

Instruction Plan

Explore

1. In this lesson, the students will measure oyster spat on each oyster clump and monitor the tank water. This will provide baseline data.
2. Ideally, students should be in 10 groups (5 groups measuring oysters and 5 groups doing water quality testing).
3. Each group gets the necessary monitoring equipment (see table below).

4. Each group gets a copy of the relevant protocol and data sheet sections from the BOP Field Science Manual (either the Oyster Measurements or Water Quality section).
5. Students complete their measurement task and fill out the relevant sections of their data sheets.
6. Students return to the Oyster Tank Analysis worksheet and complete the “Monitoring the Tank” section.
7. Facilitate the students’ sharing their monitoring results, discussing the significance and making some predictions.
8. Ask questions such as:
    - Will the parameters change? How much? On what time scale?
    - Will it matter if parameters change? Why?
9. Post the students’ baseline monitoring results in the classroom in a poster format where future monitoring could be recorded and compared.
    - See the included Oyster Tank Monitoring Poster for an example of a monthly monitoring chart.
10. Students return to the “Making Predictions” section of their Oyster Tank Analysis worksheet.
11. Consider handing out the Oyster Tank Topic Library for a deeper dive and to give students ideas to complete the worksheet.
12. Consider posting students’ predictions next to the tank.
    - Their own predictions tend to make students very invested in finding out what will happen over time!

Group	Task	Tool	Notes
1	Measure oysters	calipers	oyster clump 1 & 2
2	Measure oysters	calipers	oyster clump 3 & 4
3	Measure oysters	calipers	oyster clump 5 & 6
4	Measure oysters	calipers	oyster clump 7 & 8
5	Measure oysters	calipers	oyster clump 9 & 10
6	Temperature	thermometer	Test the temperature directly in the tank.
7	Dissolved oxygen	DO kit	Use a clean cup to remove water from the tank.
8	pH	pH meter	Use a clean cup to remove water from the tank.
9	Nitrate/ammonia/phosphate	Test strips	Use a clean cup to remove water from the tank.
10	Turbidity	Turbidity tube	Use a clean cup to fill up the tube. Use a shallow pan to catch water released from the bottom of the tube.

Standards

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence
- Grade 7, Unit 4
    - Dynamic Equilibrium: Other Organisms

Oyster Tank Analysis

Mixing the Salt Water

1. Describe the process your group went through to get the correct salinity in your gallon of tank water. What did you try? What went wrong? How did you resolve the problems that came up?

2. Write detailed directions for getting the correct salinity in a gallon of water. Write your directions so someone who has never done this before could easily do it.

Monitoring the Tank

3. What have you learned so far from your reading about what makes good water quality for an oyster to survive? Describe how this compares to your water quality results.

4. Describe the results of the oyster measurements. What was the range of oyster sizes?

Making Predictions

Choose a few of the most interesting questions below to answer:

1. Which parameter do you think will vary most at first? Which parameter do you think will vary the most over the year? The parameters your class tested are: temperature, dissolved oxygen, pH, salinity, ammonia, nitrate, phosphate and turbidity.
2. How many oyster spat do you think will die within the first month? Why?
3. Which parameter do you think will be most likely to create problems for our oysters?
4. How often do you think we should measure the size of the oysters? Explain why.
5. Based on everything you've seen and learned today, how often do you think we should maintain the tank? Check salinity levels? Monitor the water quality of the tank? Explain your thinking.
6. Is there anything else we should keep an eye on in our oyster tank? What? Why?

Nitrogen Part 1 - A New York City Water Cycle

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 10, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	2	Classroom	Science

Summary

Students will go outdoors to observe and document the water cycle in motion where they live. Students will also discover how they and their community impact not only the movement of water through the cycle, but also the water quality.

Objectives

- Describe the movement of water through the water cycle.
- Understand that water changes states when it gains energy from the sun or loses energy to the environment.
- Understand that gravity causes water to move downhill and to precipitate from the clouds.
- Create a model of the water cycle using the original pictures of water in the act of precipitating, infiltrating, condensing, running off, evaporating and transpiring.

Materials and Resources

Supplies

- sticky notes (one pad per group)
- colored markers
- projector cameras
- buckets of water (if weather is uncooperative)
  water sprayers (if weather is uncooperative)
- printed student photographs and poster board/paper OR presentation software (e.g. Prezi, PowerPoint)

Before you get started

Tips for Teachers

Students will take their own photographs and then construct a water cycle diagram. If you plan on printing out the pictures and having the students arrange them on posterboard, you could consider having groups of 4-5. If the students will be using digital photographs arranged on something like Powerpoint or Prezi you should consider having students work in pairs. Consider whether you want a standard water cycle diagram available for students to look at any point in this lesson.

Background

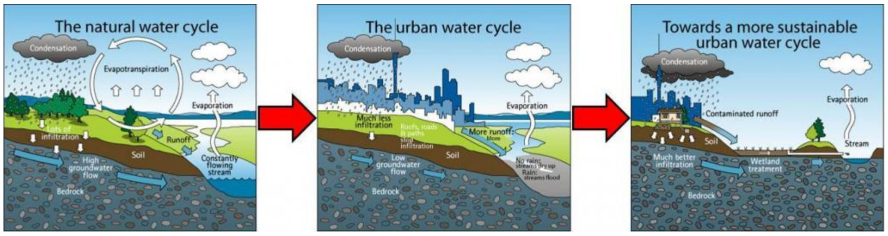
The water cycle has no starting point. But, we'll begin in the oceans, since that is where most of Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapor into the air. Ice and snow can sublimate directly into water vapor. Rising air currents take the vapor up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapor rises into the air where cooler temperatures cause it to condense into clouds.

Air currents move clouds around the globe, cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snowpacks in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt.

Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff and groundwater seepage accumulate and are stored as freshwater in lakes. Not all runoff flows into rivers [and lakes], though. Much of it soaks into the ground as infiltration. Some water infiltrates deep into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time.

Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge, and some groundwater finds openings in the land surface and emerges as freshwater springs. Over time, though, all of this water keeps moving, some to re-enter the ocean, where the water cycle "ends" ... oops - where it "begins."

Source: http://water.usgs.gov/edu/watercyclehi.html

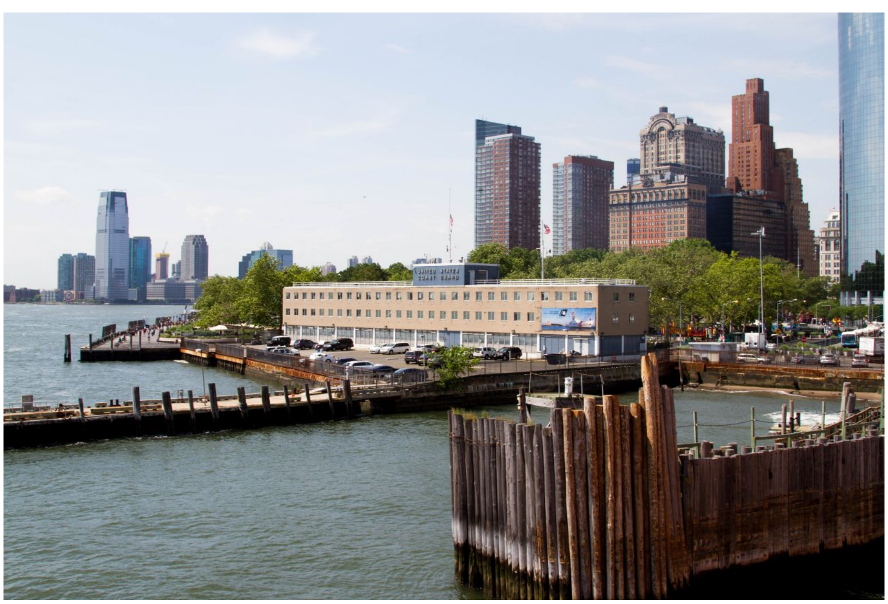


Source: http://www.sswm.info/category/implementation-tools/wastewater-collection/hardware/surface-runoff/stormwater-management

Instruction Plan

Engage

1. Ask students the following questions:
    -
    -
    - What types of precipitation do we experience living here in NYC?
    - Which state is water in for each type of precipitation you named?
2. Divide students into small groups. Give each group a stack of sticky notes and colored markers (each group gets a different color to write with).
3. Groups brainstorm what happens to the precipitation that falls here. Where does the water go? How does it get there?
4. Students write each idea on a separate sticky note.
5. Bring the class back together.
6. Project the below image (or a similar image that shows a NYC scene with road, water, buildings and park) in front of the class.
7. Facilitate groups/students coming up to the image and posting their sticky note on the photo. (e.g. "rain" could go in the sky, "runoff" could go by the edge of the dock, "infiltration" could go by the trees, etc.)
8. Recap the students' ideas. For example, "Rain falls onto the grass in the parks and infiltrates the soil. Rain falls onto the street and runsoff the edge of the dock into the harbor." Help the students understand that their sticky notes are all part of the water cycle.
9. Have a set of water cycle sticky notes pre-written before class. Fill in any gaps that the students missed (e.g. transpiration) and explain where it fits into the water cycle.



Explore

1. Students will go outdoors and become water cycle sleuths. Students use a camera to capture water moving through the water cycle. For example, they are to catch water in the act of precipitating, running downhill, infiltrating, etc.
2. Students will also photograph any human impacts on the water cycle. For example, students could photograph (or possibly stage) litter that could get caught up in runoff.
3. Ideally, students will have the opportunity to work outside on a day when it is raining, has just rained, or when snow is melting. If the weather is uncooperative, students can bring out water sprayers and buckets of water to simulate rain falling over different surfaces.
4. Divide students into small groups. Give each group a camera and a Photograph Record Worksheet.
5. Go outdoors! Define the students' work area.
6. Students work as a team to get the pictures they need and they fill out the Photograph Record Worksheet as they take each photograph. See examples below.
7. Bring students back together. Ask the groups which part(s) of the water cycle they have been unable to photograph.
8. Brainstorm as a class how to obtain the images they need. For example, students may suggest drawing a picture or using photoshop to depict evaporation or transpiration. (See Teacher Resources for links to simple transpiration activities.)

http://justrightplumbingla.com/yard-and-parking-lot-drains/yard-and-parking-lot-drains/

http://www.wallpapermania.eu/wallpaper/lost-of-water-drops-on-a-green-leaf-macro-hd-wallpaper

Explain

1. This lesson is an opportunity to introduce or reinforce the concept of Combined Sewer Overflows (CSOs).
2. Water that doesn't evaporate or infiltrate becomes surface water runoff. Surface water may flow over the ground surface or enter storm drains. Water captured by storm drains flows downhill through sewer pipes (downhill direction determined by the pipe orientation) into a wastewater treatment plant. Stormwater shares these pipes with raw sewage (also called the sanitary sewer). The stormwater is treated and then discharged into the nearest body of water. However, when the sewer system becomes overwhelmed with storm water, both the raw sewage and storm water flow directly into the nearest body of water through combined sewer overflow (CSO) outfalls. This means that almost every time it rains we have raw sewage flowing into our harbor.

Elaborate

1. Students can take additional photos or create additional drawings in order to fill any gaps in their water cycle.
2. Discuss the following with the class:
    - Did we leave any parts of the water cycle out?
    - When water isn't in the process of evaporating, condensing, etc., where is it?
    - Identify the places water "rests"/is stored (harbor, rivers, puddles, clouds, plants, etc.) within the cycle.
    - Where do freezing (snow/glaciers) and melting fit in the water cycle?
      Where do dew and fog fit in the water cycle?
    - Where does the water that the plants transpire come from?
    - Should we include capillary action as a force in the water cycle?

Evaluate

1. Students will create a New York City Water Cycle model utilizing their photographs. Students can use PowerPoint, Prezi, or printed photographs and poster board to create their models. Each group should have one complete set of photographs to work with.
2. To begin, students label each photograph with the part of the water cycle (or human impact) it represents. This activity can serve as an evaluation of students' comfort with water cycle vocabulary.

3. Ask students to think about what makes water move through the water cycle. Why doesn't the water just stay in the same state and in the same place forever? Give groups time to discuss amongst themselves.
4. If students have a difficult time figuring out gravity and sunlight are responsible for water's movement, show them a standard water cycle diagram and have them to look for clues.
5. Students' water cycle models should include all parts of the water cycle (processes and "resting" places); show the multiple paths water takes through the water cycle in New York City; and convey the idea that gravity and energy from the sun drives water's movement through the cycle.

Standards

CCLS - ELA Science & Technical Subjects

-
    - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
    - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
    -
    - Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
    - Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
    - Weather and Atmosphere

NYS Science Standards - Major Understandings

-
    - During a phase change, heat energy is absorbed or released. Energy is absorbed when a solid changes to a liquid and when a liquid changes to a gas. Energy is released when a gas changes to a liquid and when a liquid changes to a solid.

Nitrogen Part 2- How Does Water Get In and Out?

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 14, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	1	Classroom	Science

Summary

Students explore the water cycle within their classroom tank. Then they compare their tank to the estuary.

Objectives

- Describe how water can get into and out of their classroom tank.
- Compare the water cycle in their tank to the water cycle in the estuary.

Materials and Resources

Supplies

- Student models from the previous lesson, A New York City Water Cycle
- 10 wide-mouthed, clear bowls/jars
- 10 small jars
- Plastic wrap
- 10 Rubber bands
- Ice cubes (optional)

Before you get started

Preparation

- Be sure that you have the students' models of the water cycle from the previous lesson, A New York City Water Cycle.
- A couple of hours before class, you may want to prepare a bowl of water for an evaporation demonstration. Fill a glass bowl (or wide-mouthed jar) with hot water. Place plastic wrap over the top of the bowl and secure with a rubber band. Set in the direct sun, if possible. If you want to speed up the evaporation and condensation, place the ice cubes on top of the plastic wrap.
- To make the demonstration more complex and more similar to the classroom tank, you may also prepare a second bowl in a similar way, but cover it only partly. Most classroom tanks are not completely covered, or are not covered all the time, so preparing a partly-covered bowl could raise interesting issues for discussion.

Instruction Plan

Engage

1. In small groups, students review their water cycle models from the lesson, A New York City Water Cycle.
2. Students look around the classroom: What parts of the water cycle can you see in the classroom and out the window?
3. Discuss together and make a list of their ideas.
    - Are there any water cycle components that exist in the classroom that are not on your water cycle model?
    - Which parts of this water cycle could have an impact on your oyster tank?
4. Students get Our Tank's Water Cycle handout.
5. As a group, the students decide upon the appropriate arrows, labels and other additions in order to complete the diagram.
6. As a class discuss the following:

- How does water get into and out of tank?
- Is there a complete cycle in the tank? Or only part of a complete cycle? Or is there a complete cycle sometimes, depending on how we set up our tank?

Explore

1. In this activity student groups will create their own evaporation / condensation / precipitation water cycle.
2. Each group gets a wide-mouthed, clear bowl/jar, a small jar, water, a piece a plastic wrap and a rubber band.
3. Place the small jar in the large bowl/jar. Fill the large bowl with water about 2/3rds of the way up the small jar. Place plastic wrap on top of the bowl. Secure plastic wrap with the rubber band. Write student names on the side of the plastic wrap with a marker.
   - Note: particularly if your classroom tank is only partly covered, you might suggest that some groups could choose to only partly cover their bowls. There could be an interesting comparison with groups that choose to cover their bowls completely.
4. Place the bowl in a sunny location.
5. Check back next class to see how much evaporation and condensation took place (on the plastic wrap) and how much precipitation took place (in the small jar).
6. Extension: Students mathematically determine how much water evaporated out of the bowl and precipitated into the cup and how much could evaporate out of the classroom oyster tank.
7. Extension: Design a system for the top of the tank that captures the most amount of water (evaporation and condensation) and replaces it (precipitation).

Explain

1. In this activity students (as individuals or in small groups) look again at their water cycle models from, A New York City Water Cycle and consider how their models compare to a water cycle in the estuary.
2. What is missing from their models that need to be part of the estuary water cycle? What is in their models that does not belong in the estuary's water cycle?
3. What are the inputs and outputs of water in the estuary?
4. Is there a complete water cycle within the estuary? Or only part of a complete cycle? Or is there a complete cycle sometimes or in some places, depending on local conditions?
5. Students sketch an estuary water cycle on a blank piece of paper with arrows and labels.

Elaborate

1. What else goes into and out of the tank? The estuary?
2. If we think of the tank as a model for the estuary's water cycle, what are the strengths of this model? What are the weaknesses of our tank as a model for the estuary's water cycle?
3. What other kinds of things cycle through the water, air, earth and living things?
4. Is there anything, any substance, any type of matter on Earth that does not cycle through water, air, earth, and/or living things?
   - If everything must eventually cycle, why must that be the case?
   - If you can think of something that doesn't cycle, how is that possible?
   - That means it has to arrive on Earth from somewhere else, or leave Earth at some time. (How?) OR
   - That means it never moves or changes form at all. (Why not?)
5. Explain: In Nitrogen Cycle Investigation we will be looking at the nitrogen cycle in depth, as it has a major impact on the functioning of organisms and ecosystems in the tank, in the estuary, and around the world.

Standards

NGSS - Cross-Cutting Concepts

- Energy and Matter
  - Matter is conserved because atoms are conserved in physical and chemical processes.

NGSS - Disciplinary Core Ideas

- ESS2.A: Earth's Materials and Systems
  - All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
  - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

NYC Science Scope & Sequence - Units

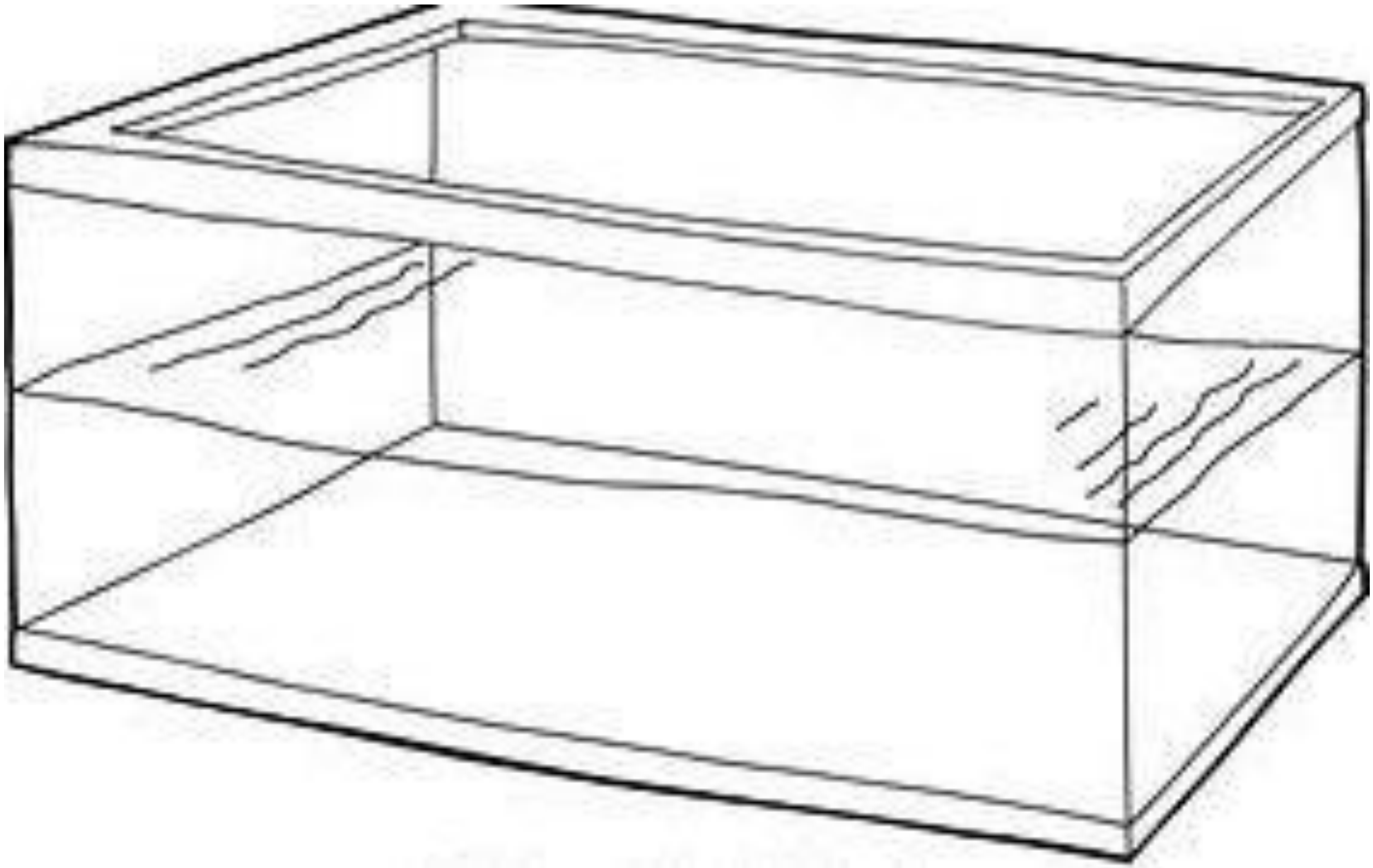
- Grade 6, Unit 4
  - Interdependence

NYS Science Standards - Major Understandings

-
  - Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.

Our Tank's Water Cycle

Directions: Using labeled arrows, draw the water inputs to and outputs from your tank.



Nitrogen Cycle Part 3- Nitrogen Test Strips

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 14, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	1	Classroom	Science

Summary

Students examine nitrogen test strip packaging, and practice measuring the ammonia, nitrite, and nitrate in various water samples. This lesson should be followed by regular monitoring of the ammonia, nitrite, and nitrate level in the classroom tank.

Objectives

- Use and interpret water quality test strips.

Materials and Resources

Supplies

- Test strips for ammonia, nitrites, and nitrates (see BOP Supply List)
- Samples of different waters to test for ammonia, nitrites, and nitrates, such as:
    1. Harbor water
    2. Fish tank water
    3. Tap water
    4. Tap water in which you have dissolved varying amounts of plant fertilizer
    5. Toilet water
    6. Aged urine diluted in tap water
    7. Pond water
    8. Puddle water
    9. Rain water
    10. Tap water with a small amount of an ammonia-containing household cleaning product dissolved in it
    11. Tap water with a small amount of ammonium chloride salt dissolved in it

Before you get started

Preparation

- Decide in advance how you want to challenge your students while they practice testing water for ammonia, nitrates, and nitrites. Prepare your samples and instructions accordingly. Some options include:
    - You can label your water samples, and require students to predict which ones will have the most and least ammonia, nitrite, and nitrate before they start measuring. This works best if they have some background in the subject, so they can make predictions that make sense to them.
    - You can not label your water samples, but give students a list of the possibilities. (You can throw in some possibilities that aren't actually there, too). Then students can use their data to try to figure out which sample is what.
    - Students can create their own water samples to test, based on a prompt such as, "Prepare ten samples that show a range of levels of ammonia. Let me know what materials you'd like to use, and I'll see what I can find for you."
- Also decide in advance if you want to make your own version of the Handout Test Strips for Ammonia, Nitrites, and Nitrates – using text from the actual test strip bottles that you have.

Instruction Plan

Engage

1. Project the resource Tilapia in Tanks.
2. Students describe, respond to, interpret, and raise questions about the slides (see below).
3. Explain: All tank animals – including oysters! – can be poisoned by their own waste turning into toxic ammonia and nitrites. Both ammonia and nitrites are compounds of nitrogen. Our goal is to figure out how to avoid this problem! One thing we need is a way to monitor the nitrogen changes in our tanks.

   Compared with other fish, tilapia are pretty tolerant to changes in ammonia and nitrites. So people often choose tilapia for aquaculture or aquaponics.

   From: http://blogqpot.com/images/minneapolis%20aquaponics

   But this can be the result of a nitrite spike during startup:

   FarmersShadow1-700px

   From: https://www.friendlyaquaponics.com/2015/08/10/1833/

Explore

1. Students explore the labels on the nitrogen test strips: it works best if you can take a good pictures of your own test strip container, and/or retype the text from it for all the students to read.
   - Alternatively, you can use the Handout Test Strips for Ammonia, Nitrites, and Nitrates, but it may not be identical to the kit you have.
   - Even better, recruit a local aquarium hobbyist or professional to visit your class and bring a bunch of test strip bottles to explore together!
   - Better still, take the class to visit the aquarium hobbyist or professional and their aquaria!
2. If your students are already aware of water conditioning drops and/or a live bacterial culture additive such as StressZyme, you may decide to introduce the Handout Aquarium Additives- Water Conditioner and StressZyme at the same time.

Explain

As a whole class, students debrief their study of the packaging on their nitrogen test strips by sharing their questions, confusion, and insights. As they talk, post points of disagreement, shared understandings, and persistent questions.

Elaborate

In groups, students practice testing water for ammonia, nitrites, and nitrates. Remember, as described in the “Preparation” section above, there are several ways to make this interesting, such as:

- You can label your water samples,
- You can not label your water samples,
- Students can create their own water samples to test, based on a prompt

Evaluate

Students debrief in a full-class discussion. As they talk, add to your posting of points of disagreement, shared understandings, and persistent questions.

Standards

NGSS - Cross-Cutting Concepts

- Energy and Matter
    - Matter is conserved because atoms are conserved in physical and chemical processes.

NGSS - Disciplinary Core Ideas

- ESS2.A: Earth's Materials and Systems
    - All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
    - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

NYC Science Scope & Sequence - Units

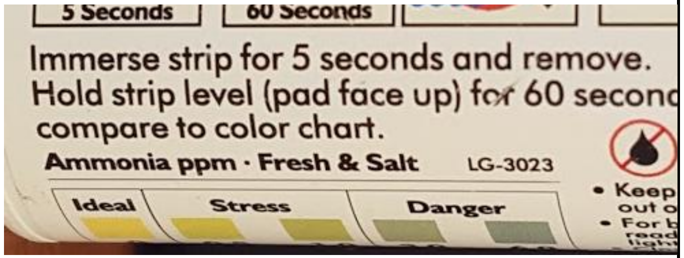
- Grade 6, Unit 4
    - Interdependence

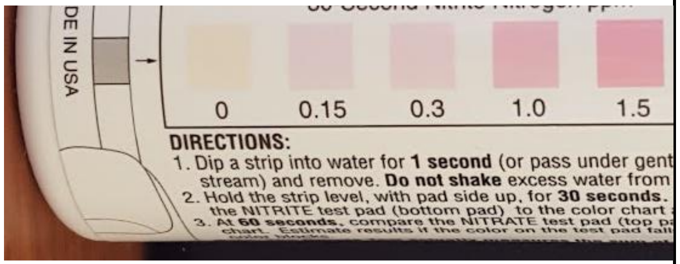
NYS Science Standards - Major Understandings

-
    - Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.

Aquarium Additives Underline things that surprise/interest/confuse you in this column.	**Your Notes** Write your observations and questions in this column.
Aqueon Water Conditioner Product Description: “Makes tap water safe by instantly neutralizing choline and chloramines. Aids in restoring a fish's natural slime coat to skin and gills, which can be worn away from netting and transporting fish. For use with fresh or saltwater aquariums. ● Safe for use with fresh or saltwater aquariums ● Made in the USA ● Instantly neutralizes choline and chloramines typically found in tap water, making it safe for fish Aids in restoring a fish's natural slime coat to skin and gills, which can be worn away from netting and transporting fish ● Helps reduce stress in fish as they become familiar with their new environment ● Detoxifies heavy metals, ammonia and other elements released from fish waste” Directions: “Not for human consumption. Keep out of the reach of children. Directions: Use attached dosage cap and add 5 ml (1 tsp) per 10 gallons of water.” Ingredients: Sodium thiosulfate, disodium EDTA, sodium carbonate, polyvinylpyrollidones	
Aquarium Additives Underline things that surprise/interest/confuse you in this column.	**Your Notes** Write your observations and questions in this column.

Stress Zyme	
Product description: “Contains live bacteria to consume sludge and reduce aquarium maintenance Benefits: • Keeps aquariums clean • Improves biological filter Follow API Easy Care Guide and use STRESS ZYME: • Weekly as part of Regular Care to reduce aquarium maintenance and maintain a strong biological filter STRESS ZYME adds beneficial bacteria to break down and consume organic matter to help keep the aquarium clean. The bacteria in STRESS ZYME is uniquely suited to consume aquarium sludge, and keep the gravel clean. Contains over 300 million live bacteria per teaspoonful. Breaks down organic compounds that cause dangerous conditions such as ammonia and nitrite poisoning and low oxygen levels. These bacteria improve the development of the biological filter and help clean a dirty aquarium. Making STRESS ZYME a part of regular care assures an active biological filter, cleaner aquarium, healthier fish and good water quality. No refrigeration necessary. For use in fresh and saltwater.” Ingredients: non-pathogenic bacterial cultures	

Test Strips Underline things that surprise/interest/confuse you in this column.	**Your Notes** Write your observations and questions in this column.
 **Lifegard Aquatics Ammonia Test Strips** <u>Product Description:</u> "Ammonia is very harmful to fish and should be tested weekly (more often in new aquariums). The Lifegard Aquatics Ammonia Test Strips are the easiest way to test for ammonia. Just dip the strip in the aquarium water and and the resulting test strip color will show whether the ammonia is at a normal or at critical level. Can be used for saltwater, freshwater tanks and ponds. ● Dip & read one-step test ● No separate vial required ● Leak proof pop top lid ● Desiccant liner for maximum moisture protection ● 25 tests"	



AquaChek Water Quality Test Strips: Nitrite, Nitrate

Manufacturer's product description:

"Tests for: Nitrate/Nitrite

Check nitrate/nitrite levels if you are seeing excess chlorine demand. Positive nitrate test also indicates the potential for algae growth. Dip and read test strips give results for both in less than one minute.

For a clean and healthy pool, test the water at each end a minimum of twice a week!"

Another manufacturer's product description:

"Excessive amounts of nitrate or nitrite in water can cause infant death, adult illness, and can produce spontaneous abortion in cows. Some wells contain high levels of nitrate. When water contains high nitrate levels, nitrites are often present in low concentration. Contains 25 tests.

Easy to use, disposable, and inexpensive

A great way to obtain quick, quantitative answers in the field or in the lab"

Nitrogen Cycle Part 4- Get to Know a Few Nitrogen Molecules

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 14, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	1	Classroom	Science

Summary

Students examine multiple meanings of the word line. Students then build molecular models of an ammonia molecule, a nitrite ion, a nitrate ion, and a nitrogen gas molecule. They use their molecular models and their practice with multiple meanings to help them understand how the word nitrogen sometimes refers to one part of each of these molecules (nitrogen as a type of atom), and sometimes refers to a whole category of molecules (nitrogen as the category of all the different kinds of molecules that contain nitrogen atoms).

Objectives

- Identify molecular models of ammonia, nitrite, nitrate, and nitrogen gas.
- Distinguish between the multiple meanings of a single word.
- Evaluate the decision to use a more specific or a more general label (e.g. ammonia vs. nitrogen to refer to the same thing).

Materials and Resources

Supplies

- Molecular model kits or materials for DIY molecular models. You need enough for each group to use at least:
  - 5 blues (such as gumdrops) to represent nitrogen atoms
  - 3 or 4 whites (such as gumdrops) to represent hydrogen atoms
  - 5 reds (such as gumdrops) to represent oxygen atoms
  - 11 connectors (such as toothpicks)
  - Note: you also need your own set of molecular models. They can be the same as your students'.
- Paper and pencil for sketching
- Paper and markers for labeling the molecular models
- Optional: a much larger set of molecular models of ammonia, nitrite, nitrate, and nitrogen gas, large enough for everyone to see at the same time -- to refer to during discussions. This can also serve as the teacher's set of models.

Before you get started

Tips for Teachers

Be sure to use the recommended colors of gumdrops, because students will encounter them again in chemistry in high school. Blue is always nitrogen. Red is always oxygen. White is always hydrogen.

Preparation

Ideally, prepare a list of students' questions from the previous lesson, in which they examined and played with test strips for ammonia, nitrites, and nitrates. (See "Engage" section, below).

Instruction Plan

Engage

1. Ideally, use your students' own questions from the previous lesson to motivate this lesson. One great way to do that is to prepare a list of the questions that they asked while studying ammonia, nitrite, and nitrate test strips, and to ask them to identify any questions that contain the words:

Nitrite

- Nitrate
- Nitrogen

Nitrogen gas

2. Students see four different ways that people use the word line:
    - “The line of students moved quickly down the hall.”
    - “My fishing line got tangled.”
    - “Write your name on the first line of the page.”
    - “Would you please hold? My mother is calling me on the other line.”
3. Individually, students sketch what they think the word line means in each sentence.
4. In small groups, students compare and contrast the four different uses of the word line. Do they think some are more alike than others? Do they think some are exactly the same? Encourage differing interpretations.
5. A few groups to report to the full class on the most interesting issues and disagreements from their discussions.

Explore

1. Each group of students gets a set of blue, white, and red balls from a molecular model kit or gumdrops, plus connectors.
2. Students get the information that in this model system:
    - Nitrogen atom = blue ball or gumdrop
    - Hydrogen atom = white ball or gumdrop
    - Oxygen atom = red ball or gumdrop
    - Note: If they’re using a molecular model kit, they should probably ignore any extra holes in any of the colored balls
3. Explain: In this model system, when you connect two or more model atoms, you are making a model molecule.
4. Explain: Even if they are made up of the same atoms, different molecules have different properties. A good example is nitrites and nitrates. The tilapia in the previous lesson were killed by nitrites, but they would still be alive if they were exposed to the same level of nitrates instead.
5. Each group accesses the images in the powerpoint: Ammonia, Nitrite, Nitrate, and Nitrogen Gas powerpoint. See images below.
6. Each group builds its own set of molecular models of:
        - Ammonia or ammonium
        - Nitrite
        - Nitrate
        - Nitrogen gas

An ammonia molecule and/or ammonium ion:

- All ‘forms of nitrogen’ (which in our model system are any sets of connected balls/gumdrops, as long as at least one of them is blue)
- Just the nitrogen atoms (which in our model system are the blue balls/gumdrops)
- Nitrogen gas (which in our model system is the pair of blue balls/gumdrops, linked to each other three times)
- Maybe a few other things as well!

Elaborate

Ask your students discussion questions like:

1. Why do you think people use the same word to mean different things?
    - How are the different meanings related to each other?
    - Do you think they have to be related to each other?
2. Can you think of other words that have different meanings?
    - Are some of the different meanings completely unrelated?

Evaluate

1. Students label their molecular models.
2. Maybe some groups will label all of their models “nitrogen.” Maybe some groups will label each model distinctly.
        - If that happens, point out that both are correct, according to today’s lesson, and ask your students: “what are the pros and cons of labeling all of the models nitrogen? What are the pros and cons of labeling each model distinctly?
        - If all groups name their models distinctly, label all of your models nitrogen, and ask your students: “Is this also correct? How does it change the way people will think about my models?”

Standards

NGSS - Cross-Cutting Concepts

- Energy and Matter
    - Matter is conserved because atoms are conserved in physical and chemical processes.

NGSS - Disciplinary Core Ideas

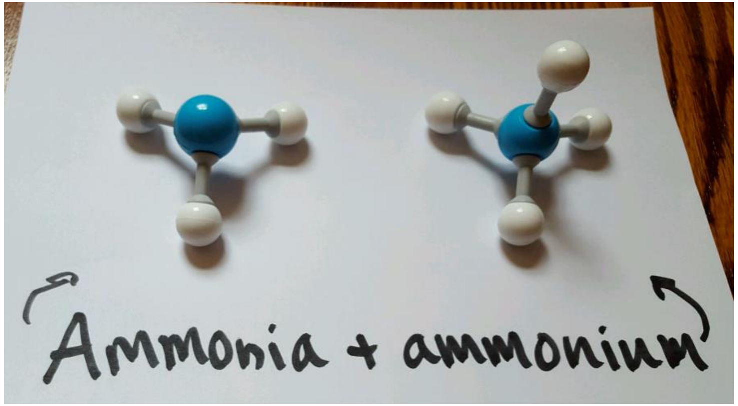
- ESS2.A: Earth’s Materials and Systems
    - All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
    - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

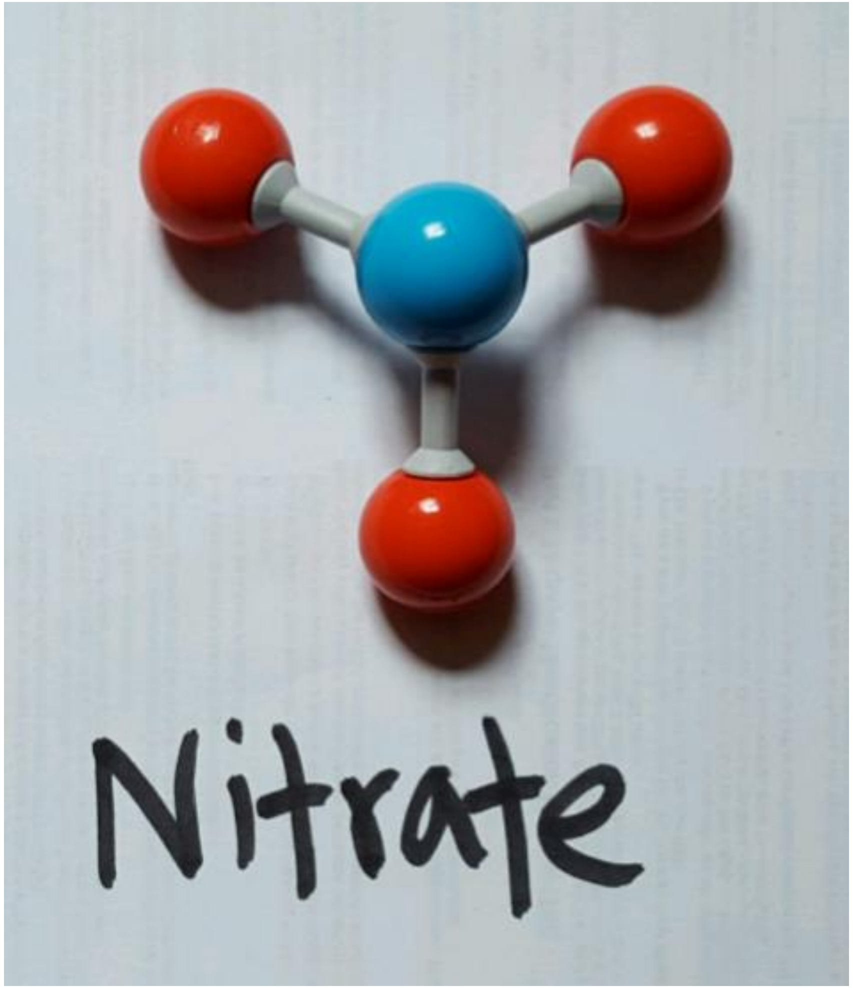
NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence

- Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.

Get to know a few nitrogen molecules!




Nitrate

Nitrogen Cycle Part 5- How Not to Kill your Animals with Ammonia and Nitrites

BOP Curriculum
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Feb 14, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	1	Classroom	Science

Summary

Students compare and evaluate the advice of several sources on how to protect their tank animals from ammonia or nitrite poisoning. Based on that analysis, students collectively decide how they want to 'cycle' the classroom tank, and make predictions about the tank's nitrogen and animal welfare in the weeks and months to come.

As an extension, students can aim to create the best possible conditions for developing a community of nitrifying bacteria in smaller containers such as spice jars. Later, if they can persuade their classmates that they have succeeded, the class may decide to incorporate some jars + contents into the classroom tank.

This lesson should be followed by daily monitoring of the ammonia, nitrite, and nitrate level in the classroom tank.

Objectives

- Evaluate different approaches to 'cycling' an aquarium.
- Predict ammonia, nitrite, and nitrate levels in the classroom tank in the coming weeks.

Materials and Resources

Supplies

-
- Test strips for ammonia, nitrites, and nitrates (see BOP Supply List)
- Optional: a couple of 'hardy' animals to produce ammonia in your tank, such as mud crabs, mud snails, or possibly oysters
- Molecular models of ammonia/ammonium, nitrite, nitrate, nitrogen gas – one set for each group. Note: students build their own models in a previous lesson, Get to Know a Few Nitrogen Molecules.
- Optional, for "Extend" section of lesson: enough spice jars with lids (or similar container) for every group (or every student) to have at least one, plus enough extra tank supplies for students to mess around with creating optimal conditions for the growth of communities of nitrifying bacteria in their jar. They'll also need extra test strips to see if their plan is working.

Before you get started

Tips for Teachers

This lesson should be followed by daily monitoring of the ammonia, nitrite, and nitrate level in the classroom tank. All the students need to be able to see the results of this monitoring daily.

Preparation

Optional: Be ready to distribute and update students' predictions from a previous lesson – Oyster Tank Questions Part 3 - Will Our Oysters Do Better in the ORS or in the Classroom Tank? – about whether their oysters will do better in the Oyster Restoration Station (ORS) or in the classroom tank.

Instruction Plan

Engage

1. Students get their molecular models of ammonia/ammonium, nitrite, nitrate, and nitrogen gas, since they will need them later.

2. Ask your students: “So far we know we can kill our tank animals with too much ammonia or nitrite. What other questions do we need to try to answer, in order to do a good job of protecting our animals from ammonia or nitrite toxicity?

3. Post students’ questions.

Explore

1. Students get How to Regulate Nitrogen in Your Tank,

2. With access to their nitrogen models, students skim the text looking for the names of the molecules.

3. If they like, they can place the appropriate model on the paper where the molecule is mentioned.

Explain

1. In pairs, students choose one text from How to Regulate Nitrogen in Your Tank and complete Different Approaches to Regulating Nitrogen in Your Tank.
   Note: this handout helps students organize advice from their selected text into a table, with columns for “Questions (about how to regulate nitrogen in your tank),” “Advice,” “Pros of the Advice,” and “Cons of the Advice.” The “Questions” column contains eight questions that at least one of the texts offers advice on. Teachers should feel free to edit the handout to reduce, add to, or rearrange the questions as they see fit.

2. Fast-working pairs choose another text and get another copy of the worksheet. This gives you a lot of flexibility to allow slow-working pairs enough time to digest at least one text thoroughly, to push fast-working pairs to go deeper, and to introduce more information to the class discussion later.

Elaborate

In pairs, or perhaps in pairs of pairs, students complete Your Recommendations for Regulating Nitrogen in Your Tank.

Evaluate

1. In an extended class discussion, based on the information they have pulled together from their readings, students make the collective decisions:

   - Should we initiate a ‘fishless’ or animal-less nitrogen cycle in our tank? Why or why not?

   - If we do add animals right away, how many and what kind? Assuming we go to the ORS and find some animals, how shall we decide which ones to bring back? What else will we need to know about our animals?

   - What should we plan to do if our tank ends up with more ammonia or nitrite than is healthy for our animals?

     Optional: If we don’t add animals right away, should we feed our ammonia-eating bacteria with ammonium chloride, a commercial cleaning product, a piece of fish or shrimp meat, a bit of fish food, nothing, or something else?

2. Students predict how the ammonia, nitrite, and nitrate levels will change in the tank by tomorrow, in one week, and in one month.

1. Class agrees to a regular monitoring and data-sharing protocol for ammonia, nitrites, nitrates, and pH.

   (Students may not yet understand why it’s important to monitor the pH. If you prefer, you could monitor the pH for them, at lest until they learn more about it.)

2. Ask the students:

   - Based on what you’ve learned so far about nitrogen, do you think your oysters will do better in the tank or in the ORS?

     Post (changes to) their predictions.

   - What new questions do you have?

     Post their new questions.

Note: Based on students’ decisions and predictions, schedule the appropriate timing for Is Our Tank Ready for (More) Animals?, an upcoming lesson in which the class examines the accumulated daily ammonia, nitrite, and nitrate data from the tank, and decides collectively whether the tank seems to be ready for animals.

Extend

1. Each student or each group gets their own small containers (e.g. spice jars).
    - Their task: to create the best possible conditions for encouraging the growth of a community of nitrifying bacteria (the ones that transform ammonia into nitrites and nitrites into nitrates.
    - Their constraint: they need to do so in a way that will not stress or kill animals with excessive ammonia or nitrites.
    - They also have to figure out how to check if their approach is working.
    - One issue to consider in advance: this requires some extra materials, and especially a lot of extra test strips.

1. Later, their jars and/or the contents can be added to the classroom tank, if the students can make a good case to their classmates that they will be contributing a productive community of nitrifying bacteria.

Standards

NGSS - Cross-Cutting Concepts

-
    - Matter is conserved because atoms are conserved in physical and chemical processes.

NGSS - Disciplinary Core Ideas

- ESS2.A: Earth’s Materials and Systems
    - All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
    - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence

NYS Science Standards - Major Understandings

-
    - Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.

Different Approaches to Regulating Nitrogen in Your Tank

Source name: ____

Questions ...about how to regulate nitrogen in your tank	**Advice from the source** Underline quotes in the source that give advice about each question. Then summarize the advice in the column below (or write "N/A" if there's no advice in this source).	**Pros of the advice** In your opinion, what are the pros of this advice?	**Cons of the advice** In your opinion, what are the cons of this advice?
Should you add animals to your tank right away? If so, which?			
What objects, equipment, and aquarium additives should you add to the tank? How much? How often?			

	Advice	**Pros**	**Cons**
What kind of water should you put in your tank?			
What water quality parameters should you test? How often?			
What should the temperature of your tank be?			
What should the pH of your tank be?			
Should you change the water? If so, how often? How much water should you remove?			

Should you clean the tank? If so, how often?			

How to Regulate Nitrogen in Your Tank

Text #1: Aquarium nitrogen cycle

from http://www.fishlore.com/NitrogenCycle.htm

Test your aquarium water every other day and write down your readings. You will first see ammonia levels rising.

A few weeks or so later you should see the nitrite levels rising and the ammonia levels dropping.

When you no longer detect ammonia or nitrites but you can detect nitrates you can assume that it is safe to add your animals.

Text #2: Estuarine Aquarium Keeping for Beginners

http://www.vims.edu/cbnerr/_docs/education_docs/EstAquKeepwriteup.pdf

The key concepts include:

- Stock your aquarium with smaller animals. •
- Don’t overfeed. •

Marsh Animals
...In order to live in the marsh during the summer time, marsh animals are able to handle very warm water temperatures and low dissolved oxygen. These animals include the mummichog, striped killifish, ...grass shrimp, mud snails, and blue crabs. These species are easy to keep.

Oyster Reef Animals (not including oysters)
Many species use oyster shell habitat. These include blenny, goby, skilletfish, mud crabs and blue crab. These species are also very hardy and easy to keep.

Estuarine Animals

Species	Care	Notes
Blue Crab	Easy	Eat other animals. Cannibals. Need lots of food
Gobies	Easy	Oyster reef species, very easy to keep
Grass Shrimp	Easy	Get eaten as they shed, but great in a tank while they last
Mud Crabs	Easy	Very hardy
Mud Snails	Easy	Very hardy
Mummichog	Easy	Marsh species, very hardy and adaptable
Oyster Toadfish	Easy	Will eat frozen fish and shrimp.
Skilletfish	Easy	Oyster reef species, very easy to keep
Black Drum	Moderate	May not enjoy warmer water
Black Seabass	Moderate	Cooler water species and eats live food
Pipefish	Hard	Need live brine shrimp
Seahorse	Hard	Need live brine shrimp for food
Searobin	Hard	Need right food and cooler water
Scup	?	Never tried, cooler water species
Tautog	?	Bottom fish, likely need cooler water.

Aging The Aquarium or Cycling the Biological Filter
One of the most critical steps in starting up an aquarium is giving the aquarium enough time for the bacteria population to build up or ‘cycle’....

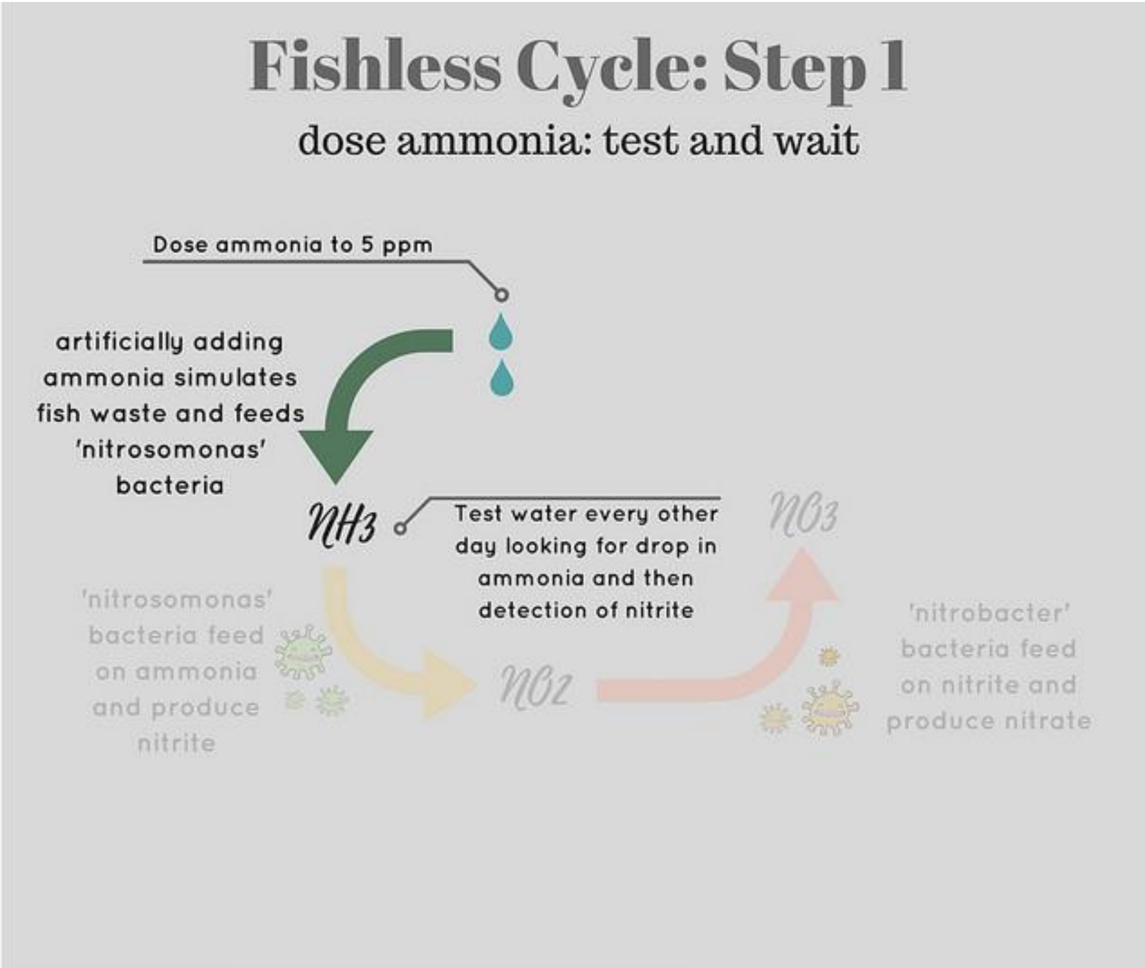
Aging your aquarium can take 20-40 days or longer.... I like to introduce two or three hardy animals after a week or so to help speed up the bacteria growth, and then add more animals after 1 or 2 more weeks.

Adding too many animals before your bacteria communities are up to speed can result in animal death from high levels of ammonia, so it is best to go slow off the start.... It is always better to have fewer animals rather than too many animals, so take your time when adding organisms and add just a few organisms at a time….

High levels of ammonia… mean you should replace some water, reduce the number of animals in your tank and most likely feed less. Non-detectable levels mean that you are doing a good job and you may be able to add more animals.

Text #3: How to do a ‘fishless’ cycle http://spec-tanks.com/how-to-fishless-cycle-a-new-aquarium/

Step 1 – Ammonia Dosing:



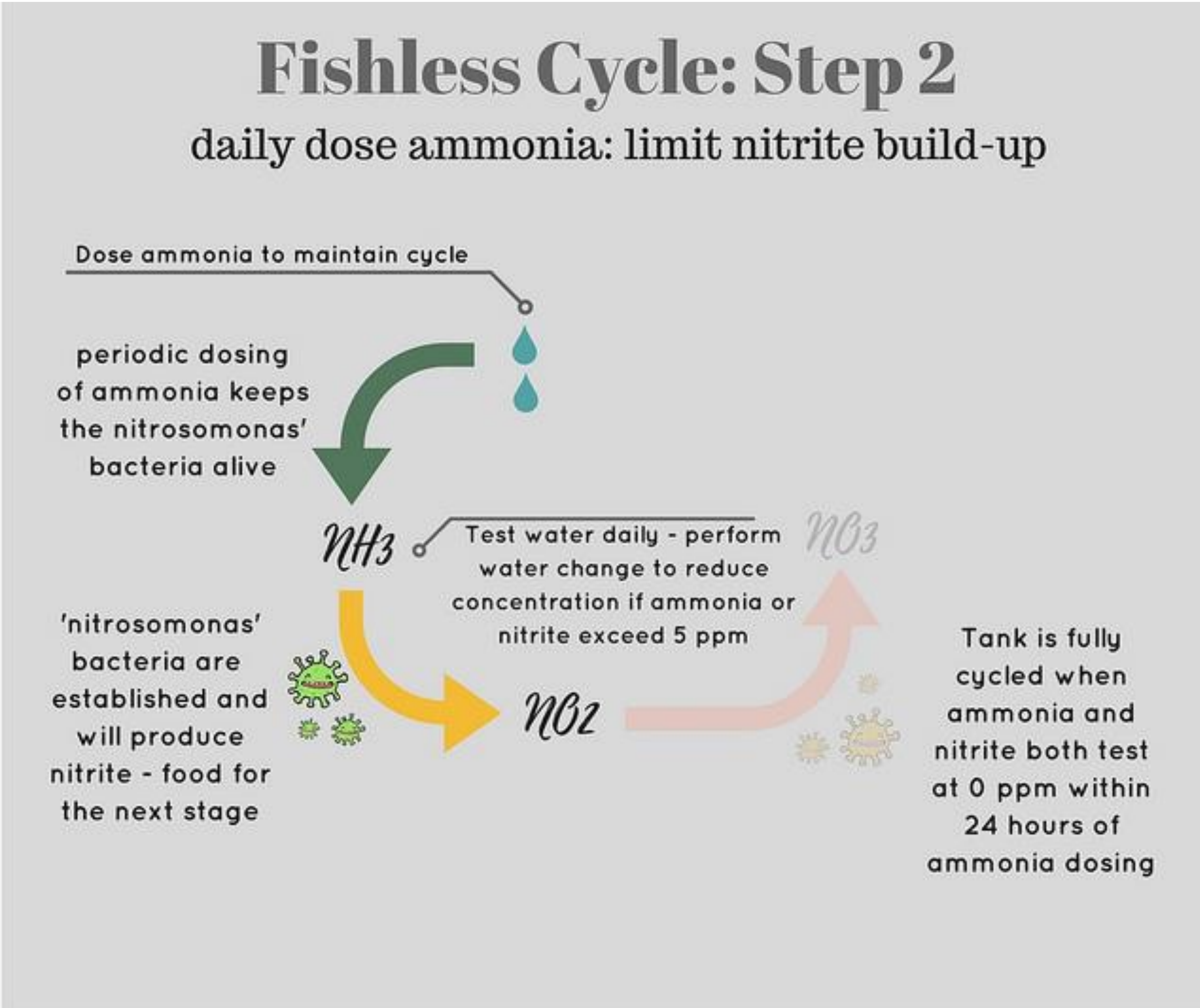
The process starts with giving the stage one “nitrosomonas” bacteria something to eat. We simulate fish waste by adding ammonia. Add 5 ppm of your ammonia to your aquarium.

After you add the ammonia, then you need to start regular testing of ammonia and Nitrite.

Your tank is a closed system, so when you add the ammonia at 5 ppm, it will stay at 5 ppm until the “nitrosomonas” bacteria develop in great enough numbers to reduce the ammonia. Any drop in ammonia ppm will shortly result in detectable Nitrite.

It will generally take 7 to 14 days to complete Step 1 (detect Nitrite).

Step 2 – Maintain Ammonia and Watch Nitrite Levels:

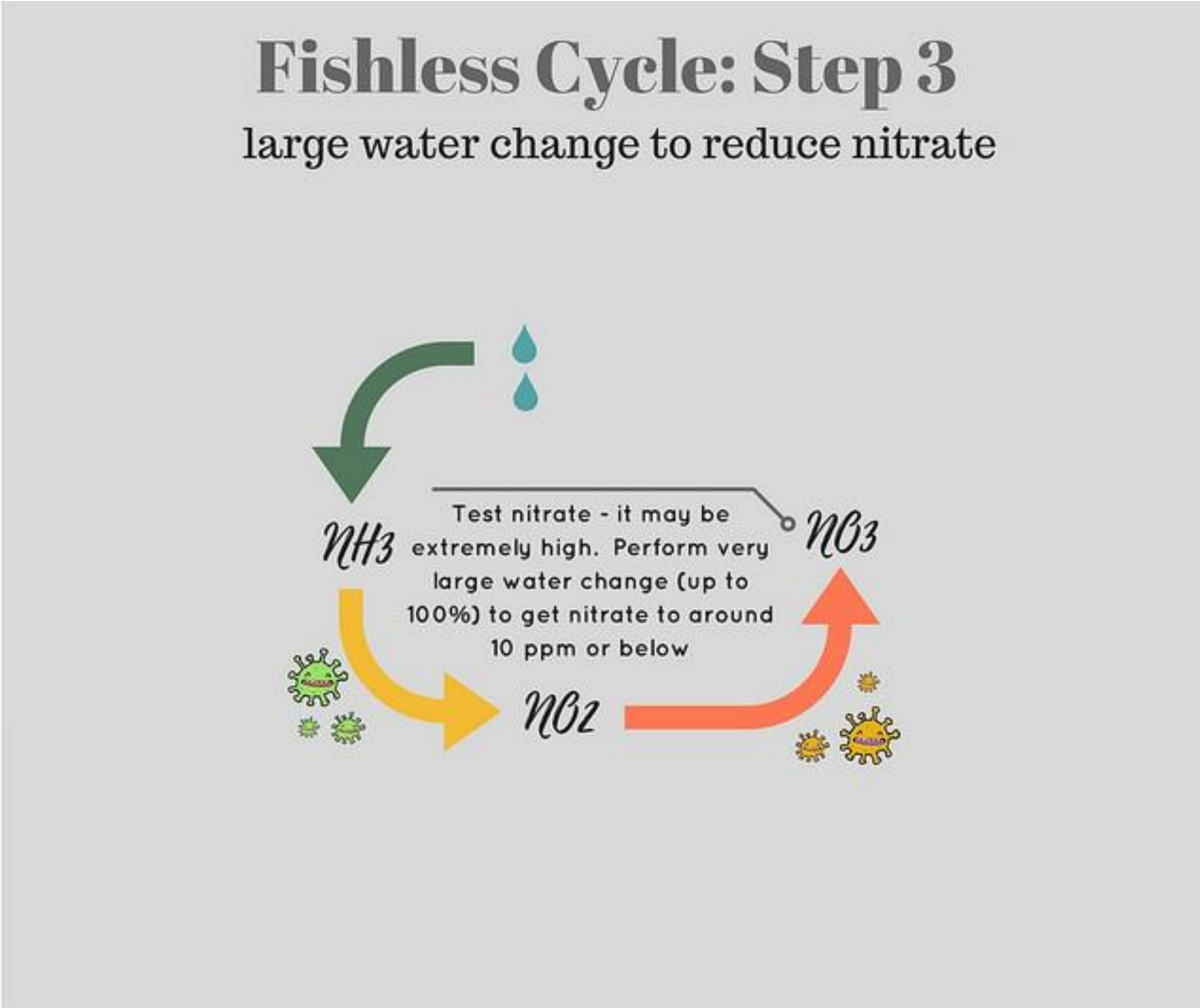


At this point, the first crew of "nitrosomonas" bacteria are in place and are making Nitrite as waste, which will be food for the next crew of "nitrobacter" bacteria. The "nitrosomonas" need food to stay alive, so start dosing ammonia as needed. You might not need to dose every day; just test and add as needed, when ammonia reads 0 or 1 ppm, add to around 2 ppm….

When you get a reading of Nitrite above 5 ppm, go ahead and perform a water change, then test Nitrite again the next day…. Keep doing this until you get it below 5 ppm. After a water change, dose ammonia in the necessary quantity to maintain around 2 ppm.

Here is the official test to pass in order to be fully cycled: Dose 3-5 ppm of ammonia, test 24 hours later, and the result is no ammonia and no nitrite! It generally takes 3 to 4 weeks (from start to finish) to complete your fishless cycle.

Step 3 – Large Water Change to Clean Out Nitrate:



Perform a very large water change (as close to 100% as you can) to get Nitrate levels close to zero.

Step 4 – Add your Fish and Other Critters:
You made it! Your time and perseverance has paid off and you now have optimized your tank to receive new fish, shrimp, and whatever other animals you are planning. The beneficial bacteria are strong enough, so you can add all of your animals at once if you wish.
If you are delayed in adding fish, you can keep dosing ammonia daily until you are ready (to keep feeding all the beneficial bacteria). Once you are ready, just perform your large water change to flush out Nitrate.

Tips for Performing a Fishless Cycle:

- **Beneficial Bacteria Live on Surfaces**: The beneficial bacteria do not live and grow in the water column; they live on surfaces. Glass, gravel, and plants can serve as a home to beneficial bacteria.

- **Use 'Seeding' Material to Speed the Cycle**: Take something from an established aquarium and put it into your tank when it is cycling. Since beneficial bacteria live on surfaces, that object will carry beneficial bacteria on it, and the whole process will move along much quicker. You can use some used decorations, rocks, wood, or gravel. Any good fish store will be happy to give you a

- **Use Water Conditioner:** Chlorine will stunt or kill the beneficial bacteria, so make sure to always dechlorinate the water that you put in the aquarium.

- **pH Level:** The pH of your water is not all that critical. If it gets into the low 6's then the cycle will probably stall. High 6's or anywhere in the 7's is fine.

- **Temperature:** Temperature isn't critical, but the process may move quicker if you keep the tank temperature slightly elevated.

Text #4: excerpts from Billion Oyster Project Oyster Tank Guide

Bacteria - —You need a healthy community of nitrifying bacteria in the tank to deal with the ammonia that builds up from keeping animals in the enclosed space. —This bacterial community can take weeks to develop. —Using harbor water to start adds a wide variety of bacteria. You can also add nitrifying bacteria with a product such as "Stress Zyme."

DIY Filter - Your plastic bottle full of gravel, with air running through it, and pushing water through it as well, is a 'biological filter'. That means that this setup encourages nitrifying bacteria to grow there, and they can covert your oysters' waste into less toxic substances. The 'filter' is really just a good habitat inside your tank for a community of nitrifying bacteria. Biological filtration occurs as the tank water passes over any surface (like the gravel) -- in the presence of oxygen -- so that the nitrifying bacteria can convert ammonia to nitrites, and nitrites to nitrates. Nitrifying bacteria tend to colonize hard surfaces, such as gravel, and you'll get more of them to grow if you have a lot of surface area, such as in a bottle full of gravel.

<u>Directions for Cycling a Tank Without Animals*</u>
Setup Day 1

- Harbor water
    - Advantage is that you will probably have a population of nitrifying bacteria already in the water
    - Disadvantage is carrying 10 gallons of water from the harbor to your school

- Tap water
    - Add water conditioning drops
    - Add Instant Ocean Aquarium Salt and follow the product guidelines to obtain an optimal salinity of 15ppt
    - Add nitrifying bacteria in a product such as Stresszyme (optional)

- Mixture of tap and harbor water
    - Dechlorinate your tap water by letting it sit for 24 hours (because the chlorine in the tap water will kill the bacteria in your harbor water)
    - Add harbor water
    - Add salt if necessary (What do you want the final salinity to be?)

2. Set up aerator and air stone. You may want to create more surface area for nitrifying bacteria to colonize. Options include:
    - Using the DIY filter (see above)

    - Other commercially available filters

3. Let water sit for at least 24 hours.

Setup Day 2

1. Monitor pH for baseline data
2. Monitor ammonia, nitrites and nitrates for baseline data

Setup Day 3

1. Monitor pH to make sure that it is stable. If the pH is not stable, wait another 24 hours and try again. (Nitrifying bacteria are sensitive to sudden changes in pH.)

2. Monitor ammonia, nitrites and nitrates in order to continue to collect data

3. Manipulate the tank's nitrogen cycle by dissolving ammonium chloride salt in tank water. You want to have an initial ammonia concentration of 2 to 3 mg/L (ppm). Do not go above 5 mg/L. The bottom row of this page helps with the calculation of the amount of ammonia: http://www.fishforums.net/aquarium-calculator.htm

***Monitor your tank for at least two weeks before adding animals. When ammonia and nitrites are at 0, and nitrates are present, you can start adding animals.**

Directions for Adding Animals

Add your animals, one species and a few individuals at a time. Add a new species every 3-5 days. Continue to monitor your tank daily and make sure water quality is stable before adding more animals.

1. Add mud snails (be sure they are mud snails and not oyster drills).
2. A couple days later add shrimp (grass shrimp, shore shrimp, sand shrimp, etc.)
3. A few days later add crabs (mud crabs are easier to deal with than blue crabs, because the blue crabs can swim, eat everything else, and fight -- although that might make them especially interesting to watch)
4. Finally, add 10 spat-on-shell substrate oysters, at which point you'll need to start feeding your oysters with plankton!

*Note: it's also possible to cycle your tank with animals. In that case, you start with just one or two small animals that are very hardy, and that you don't mind stressing or killing. Mud snails work. Those animals produce plenty of ammonia which, if things go well, can get the bacterial community going. **If you have animals in your tank, do not add ammonia!**

Associated Oyster Reef Organisms - Don't overfeed the other species. Doing so will create toxic levels of ammonia and a smelly tank. —You also want the crabs and other scavengers to eat as much detritus as they can from around the tank, which they will only do when they are hungry….

Your Recommendations for Regulating Nitrogen in Your Tank

Would you add animals right away? If so, which? Why?

In the table below, list all of the objects, equipment, and aquarium additives you think we should use. Then note the amount and the frequency.

Thing you're adding to the tank	Amount	Frequency

What kind of water would you use? Why?

List all of the steps you would take to regulate nitrogen in your tank.

Nitrogen Cycle Part 6- Nitrogen Transformations in Your Tank

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 14, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	1	Classroom	Science

Summary

Students compare and contrast multiple diagrams that describe nitrogen transformations in tanks. They evaluate the pros and cons of different diagrams, and use them to uncover information about how nitrogen enters a tank, gets transformed by the organisms in the tank, and ultimately leaves the tank. Students consider whether there is a complete 'cycle' of nitrogen within a tank.

Objectives

- Identify similarities and differences between multiple diagrams on the same topic.
- Identify strengths and weaknesses of multiple diagrams on the same topic.
- Evaluate whether a complete nitrogen cycle is likely to occur in the classroom tank.

Materials and Resources

Supplies

Molecular models of ammonia/ammonium, nitrite, nitrate, nitrogen gas -- one set for each group. Note: students build their own models in the previous lesson, Get to Know a Few Nitrogen Molecules.

Before you get started

Instruction Plan

Engage

1. Students get their molecular models of ammonia/ammonium, nitrite, nitrate, and nitrogen gas, since they will need them later.
2. Revisit the powerpoint Tilapia in Tanks.
3. Ask students to brainstorm: "If a nitrite spike can kill all those animals, what are some different ideas about how it's possible to keep a lot of animals, alive and healthy, in a tank?"
4. And: "What questions do you have now about about how it's possible to keep a lot of animals, alive and healthy, in a tank?"

Explain

1. In small groups, students examine Diagrams that Describe Nitrogen Changes in Tanks
2. They go through each diagram and place their models of ammonia/ammonium, nitrite, nitrate, and/or nitrogen gas on the diagram in the appropriate location.
3. Students identify the sequence of nitrogen transformations in a tank:
    - First is (ammonia/ammonium)
    - Then that gets transformed into (nitrites)
    - Finally, that gets transformed into (nitrates)

Elaborate

1. In pairs, students choose two sources' diagrams to study in depth, and complete Compare and Contrast Diagrams that Describe How to Regulate Nitrogen in Your Tank.

2. Ask fast-working pairs to create their own version of these diagrams, which should be, in their opinion, an improvement on all of the ones that they studied.

Evaluate

Students debrief in a full-class discussion.

- Insist that students refer to specific elements from specific diagrams.
- Insist that the rest of the class turn to those diagrams and examine those elements afresh.
- Ask the group if they understand those elements to mean exactly the same thing. Often they don't, and in those cases, ask everyone to search for other evidence within the diagram to support or contradict one of the interpretations that a student has suggested.

  Post of points of disagreement, shared understandings, and persistent questions.

Standards

NGSS - Cross-Cutting Concepts

- Energy and Matter
  - Matter is conserved because atoms are conserved in physical and chemical processes.

NGSS - Disciplinary Core Ideas

- ESS2.A: Earth's Materials and Systems
  - All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
  - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
  - Interdependence

NYS Science Standards - Major Understandings

-
  - Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.

Compare and Contrast Diagrams that Describe How to Regulate Nitrogen in Your Tank

With a partner:

1. Look through the resource *How to regulate nitrogen in your tank* - diagrams only.
2. Choose two of the diagrams to study in depth (Note: if you choose Source #4, you'll see that it has a set of three diagrams that go together.)
3. Fill in the blank: We choose to study the diagrams from Sources # _______ and __________.
4. Make some notes: Why did you choose those diagrams?

5. Compare and contrast your diagrams.
    a. Make a list of similarities between the diagrams:

    b. Make a list of differences between the diagrams:

6. In your opinion, what are the strengths and weaknesses of each diagram?

	Diagram(s) from Source #_____	Diagram(s) from Source #_____
Weaknesses of the diagram		

7. In your opinion, which is the better diagram, and why?

8. According to your diagrams, how does nitrogen first enter the tank? How can you tell? Do the different diagrams tell you the same exact thing about how nitrogen first enters the tank?

9. According to your diagrams, how does nitrogen eventually get out of the tank? How can you tell? Do the different diagrams tell you the same exact thing about how nitrogen eventually gets out of the tank?

10. According to your diagrams, is there a complete nitrogen cycle inside the tank? In other words, could there be some nitrogen that stays in the tank forever? How can you tell? Do the different diagrams tell you the same exact thing about whether there is a complete nitrogen cycle inside the tank?

Diagrams that Describe Nitrogen Changes in Tanks

Diagram from Source #1

https://matrixaquatics.com/fishless-cycle/

http://www.myaquariumclub.com/the-nitrogen-cycle-for-everyone-358.html

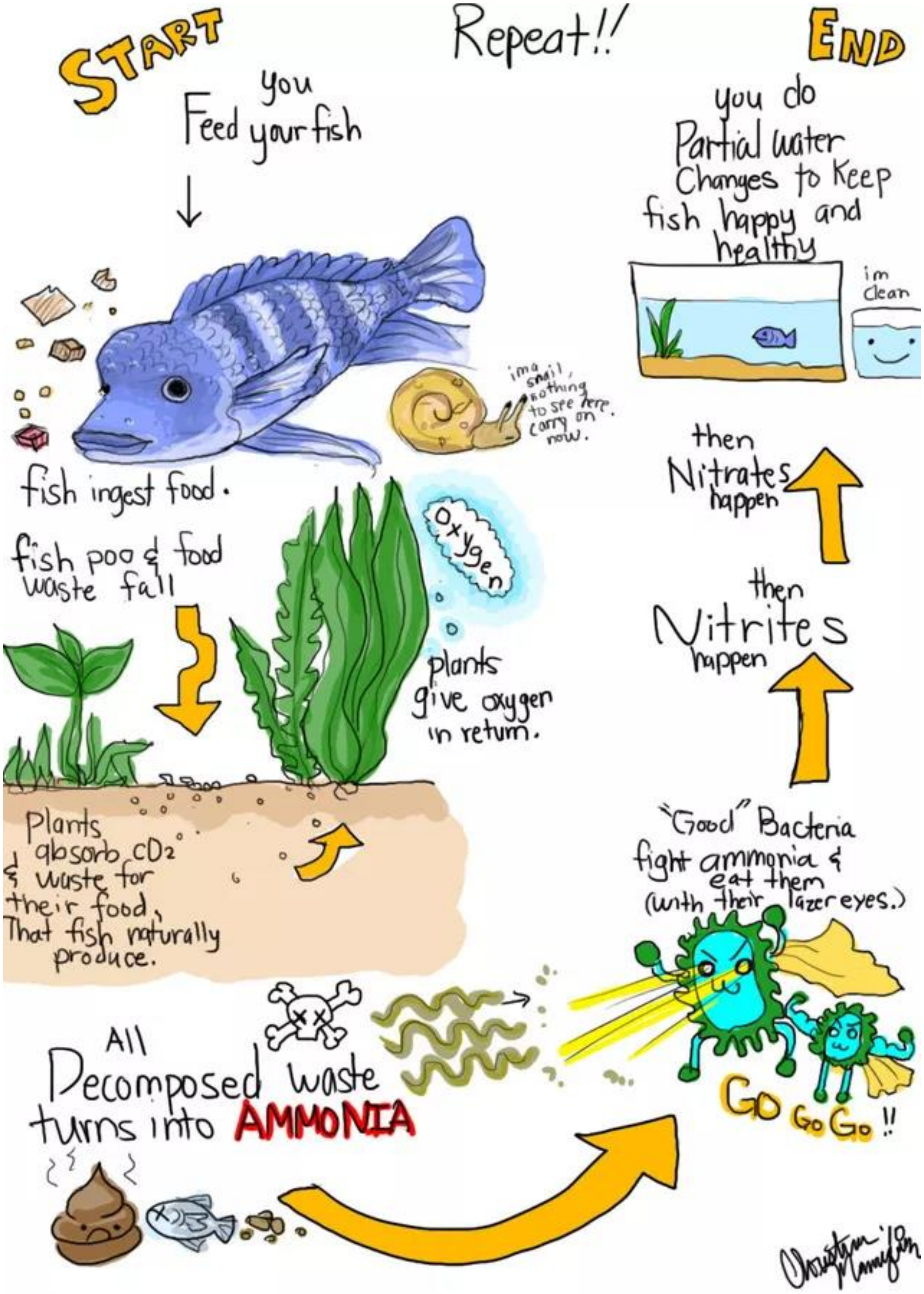
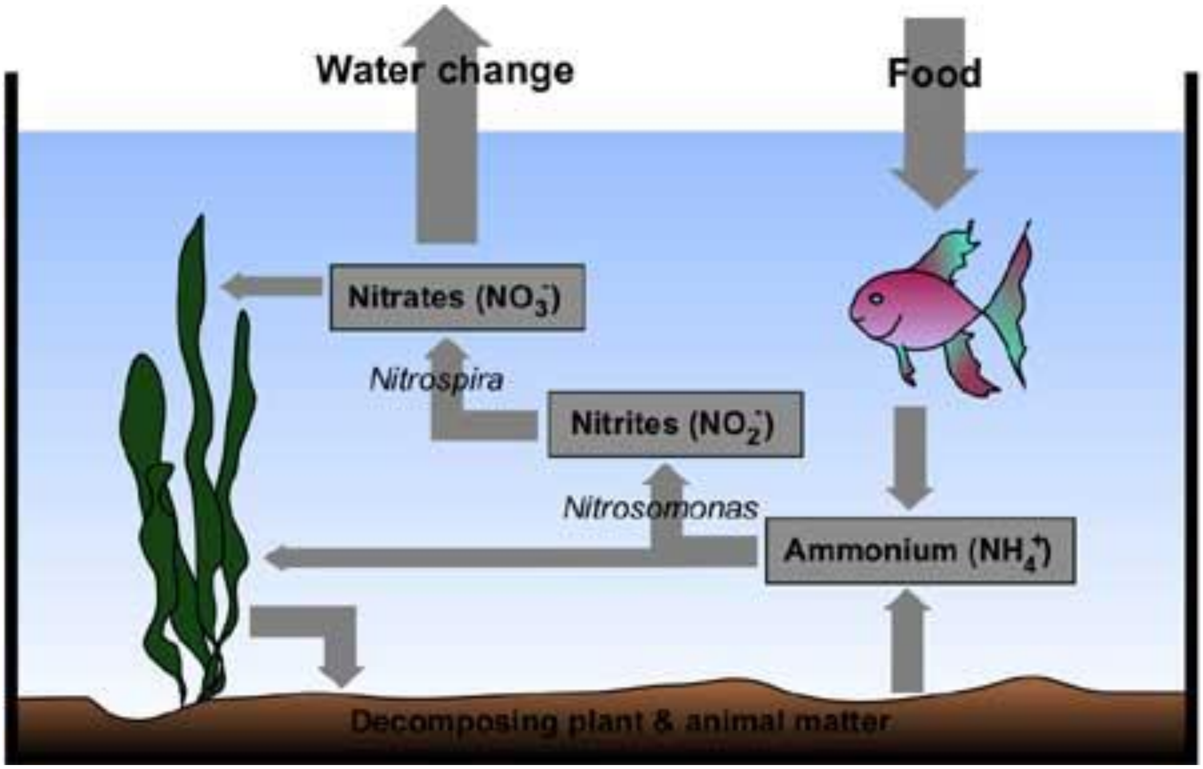
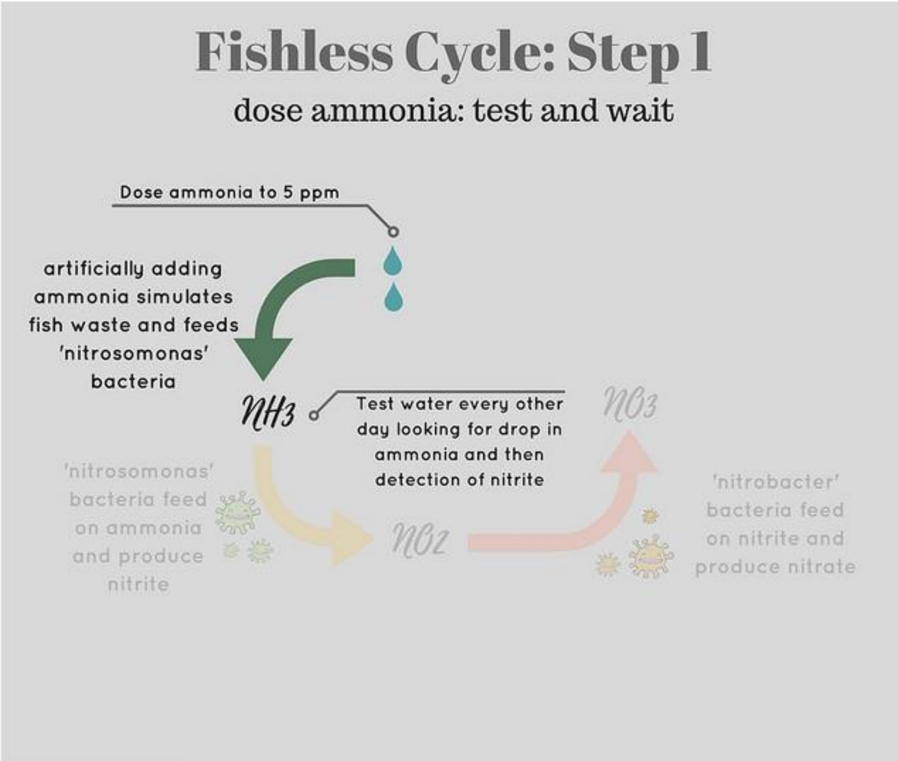


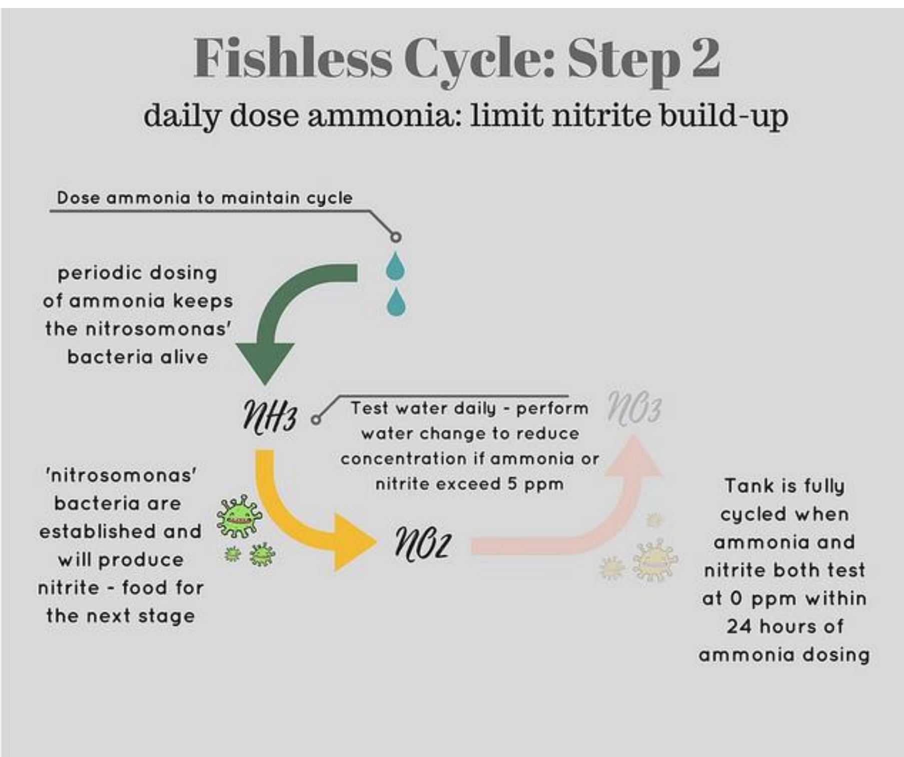
Diagram from Source #3

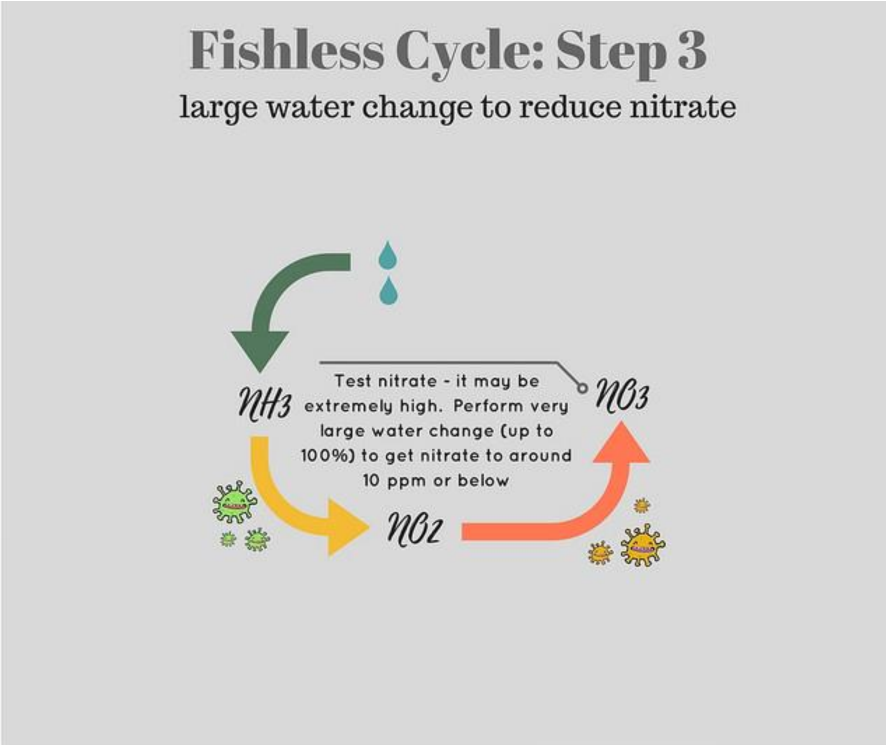
http://www.fishlore.com/NitrogenCycle.htm



Set of three diagrams from Source #4







http://spec-tanks.com/how-to-fishless-cycle-a-new-aquarium/

Compared with other fish, tilapia are pretty tolerant to changes in ammonia and nitrites. So people often choose tilapia for aquaculture or aquaponics.

But this can be the result of a nitrite spike during startup.

Nitrogen Cycle Part 7- Neighborhood Nitrogen Mapping

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 14, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	2	Field	Science

Summary

Students use a library of resources in the classroom to determine what are some of the neighborhood's sources of nitrogen that eventually ends up in the estuary. Then they go outside to actually find and map these sources of nitrogen.

Objectives

- Connect nitrogen source information in text and diagrams to what can be observed outside the school.
- Design a map of nitrogen sources based on observations.

Materials and Resources

Supplies

- Projector
- Blank paper
- Cameras
- Printed student photographs and posterboard OR presentation software (e.g. Prezi, PowerPoint)

Before you get started

Tips for Teachers

- Students will take their own photographs and then construct a Neighborhood Nitrogen Map. If you plan on printing out the pictures and having the students arrange them on posterboard, you could consider having groups of 4-5. If the students will be using digital photographs arranged on something like Powerpoint or Prezi you should consider having students work in pairs.

Preparation

- If students use hard copy of their photos to make their Neighborhood Nitrogen Map, you will need to do this lesson over two class periods and print the photos in between.

Instruction Plan

Engage

1. Students get into small groups and get the handout, Nitrogen Sources in New York City Neighborhoods.
2. Students read through the information in the handout and write a list sources of nitrogen they find.
3. Discuss as a class what students found.
    - What nitrogen sources on your list do you think we'll see in this neighborhood? (e.g. cars, other things that burn fossil fuels, storm water that can runoff)
    - What sources of nitrogen might be in stormwater runnoff? Landscaping? CSOs? wastewater treatment plants?
    - What's getting fertilized in this neighborhood? By whom?
    - What do you think are the largest nitrogen sources in our neighborhood? Why? Which nitrogen sources do you think are less significant in our neighborhood? Why?

Explore

1. In this activity, students will go outdoors and look for nitrogen sources using a camera for documentation.
2. It would be great if students had the opportunity to work outside on a day when it is raining or has just rained, but it is not necessary. If the weather is uncooperative, don't delay in getting your class outdoors!
3. Students get into small groups.
4. Give each group a blank piece of paper, a camera and a Nitrogen Inputs Photograph Record.
5. Go outdoors! Define the students' work area.
6. Students work as a team to draw a sketch of the area they are working in. Include landmarks such as the school, streets, sidewalks, other buildings, parks, playgrounds, etc. Label the sketch!
7. (optional) Students come up with a method for ranking the different sources of nitrogen they find, according to how much nitrogen they think each source ultimately contributes to the estuary. The ranking can go from "most nitrogen ending up in the estuary" to "least nitrogen ending up in the estuary".
8. Next, students take photographs of nitrogen sources and fill out the Nitrogen Inputs Photograph Record as they take each photo.
9. Bring students back together. Ask the groups which nitrogen inputs they think are there, but have been unable to photograph.
10. Brainstorm as a class how to obtain the images they need. For example, students may suggest drawing a picture or using photoshop.

Explain

1. Back in the classroom, students connect the sources of nitrogen they observed outdoors with sewershed maps of where some of that nitrogen goes.
2. Show the class the Open Sewer Atlas NYC wet and dry weather sewershed. Zoom in on the neighborhood of the school.
3. Discuss the difference between the dry weather sewershed and the wet weather sewershed.
    - In dry weather everything that goes down the drain either in a building or in the street should end up at a wastewater treatment plant.
    - In wet weather some of what goes down indoor and outdoor drains will end up at a wastewater treatment plant and some will end up going out a CSO (combined sewer overflow) into the Harbor.

Elaborate

1. Students can take additional photos or create additional drawings in order to fill any gaps in their nitrogen inputs.
2. Discuss the following with the class:
    - Did we leave out any nitrogen inputs?
    - What do you think are the most significant sources of nitrogen in our neighborhood? How does that list compare with what our readings suggested about the most significant sources of nitrogen?
    - Where does the nitrogen go besides into the sewershed?

      Where does the estuary and the location of our Oyster Restoration Station (ORS) fit into our story of nitrogen?

Evaluate

1. In this activity, student groups create a Neighborhood Nitrogen Map using their photographs.
2. Students can use printed photographs and posterboard to create their maps OR presentation software.
3. Each group should have their neighborhood sketch, their Nitrogen Input Photograph Record and one complete set of photographs to work with.
4. To begin, students label each photograph.
5. Students either re-draw their neighborhood sketch on posterboard or re-create it on a computer.
6. Ask: What makes nitrogen move through the neighborhood and into other areas? Why doesn't nitrogen just stay in the same place forever?
7. Give groups time to discuss amongst themselves and then discuss as a class.

8. Ask: If people in our neighborhood could do just one thing to reduce nitrogen inputs to the estuary, what would you tell them to do, and why?
9. Ask: If you could do just one thing to reduce nitrogen inputs to the estuary, what would you do, and why?

Standards

NGSS - Cross-Cutting Concepts

- Energy and Matter
    - Matter is conserved because atoms are conserved in physical and chemical processes.

NGSS - Disciplinary Core Ideas

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    - All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
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NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    -
-
    - Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.

Nitrogen Sources Photograph Record

Date: _______________ **Time:** __________ **Weather:** ______________________________

Photograph #	Describe what's going on in the photograph

Base modified from U.S. Geological Survey, 1:100,000, Long Island West; 1984
Projection UTM Zone 18N, Datum NAD27

Figure 1. Location of Jamaica Bay, Long Island, N.Y., and selected point and nonpoint sources of nitrogen.

1. Nitrogen Loading in Jamaica Bay, Queens

2. Loads of Nitrogen to Jamaica Bay, Queens

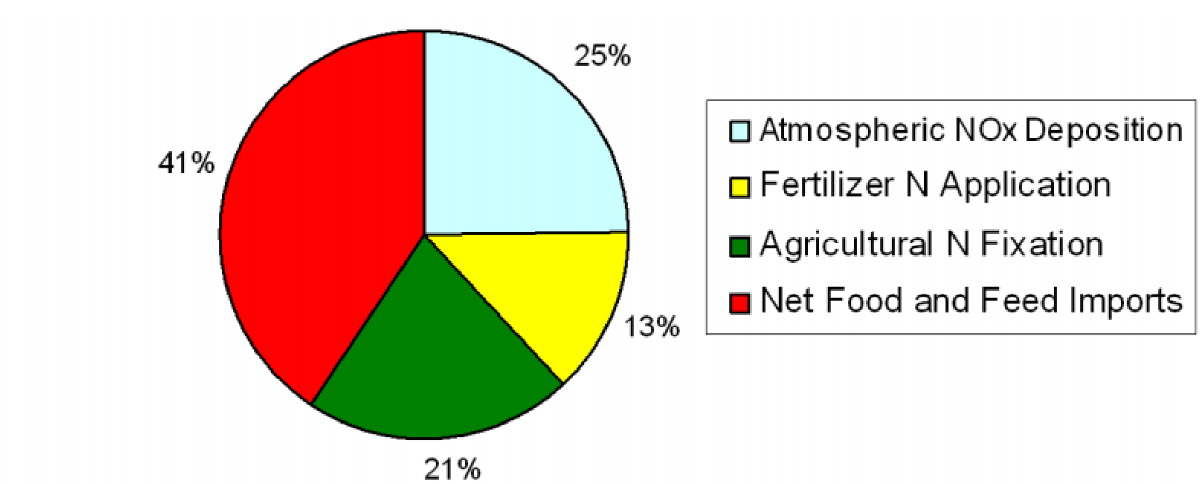
Table 7. Loads of nitrogen to Jamaica Bay under predevelopment and current conditions.

[kg/d, kilograms per day; na, not applicable; <, less than. Data from figs. 5 and 7, as well as tables 2, 3, 4 and 6]

Source	Predevelopment		Current conditions	
	Load (kg/d)	Percentage of total nitrogen load	Load (kg/d)	Percentage of total nitrogen load
Wastewater discharge				
Total nitrogen	na	0	13,995 ± 1218	89 ± 8
CSOs/storm-water discharge				
Nitrite plus nitrate	na	0	113.9	2
Ammonia			130.4	
Subway dewatering practices				
Nitrite plus nitrate	na	0	224 ± 17	1 ± <1
Ammonia	na		6.3 ± 1.6	
Landfill leachate				
Nitrite plus nitrate	na	0	4.6	2
Ammonia	na		256.6	
Ground-water discharge				
Nitrite plus nitrate	35.6	100	667 ± 49	4 ± <1
Ammonia	na		19 ± 4	
Atmospheric deposition (wet + dry)				
Nitrite plus nitrate plus nitric acid	0	0	368	2
Total	35.6		15,785	

https://pubs.usgs.gov/sir/2007/5051/SIR2007-5051.pdf

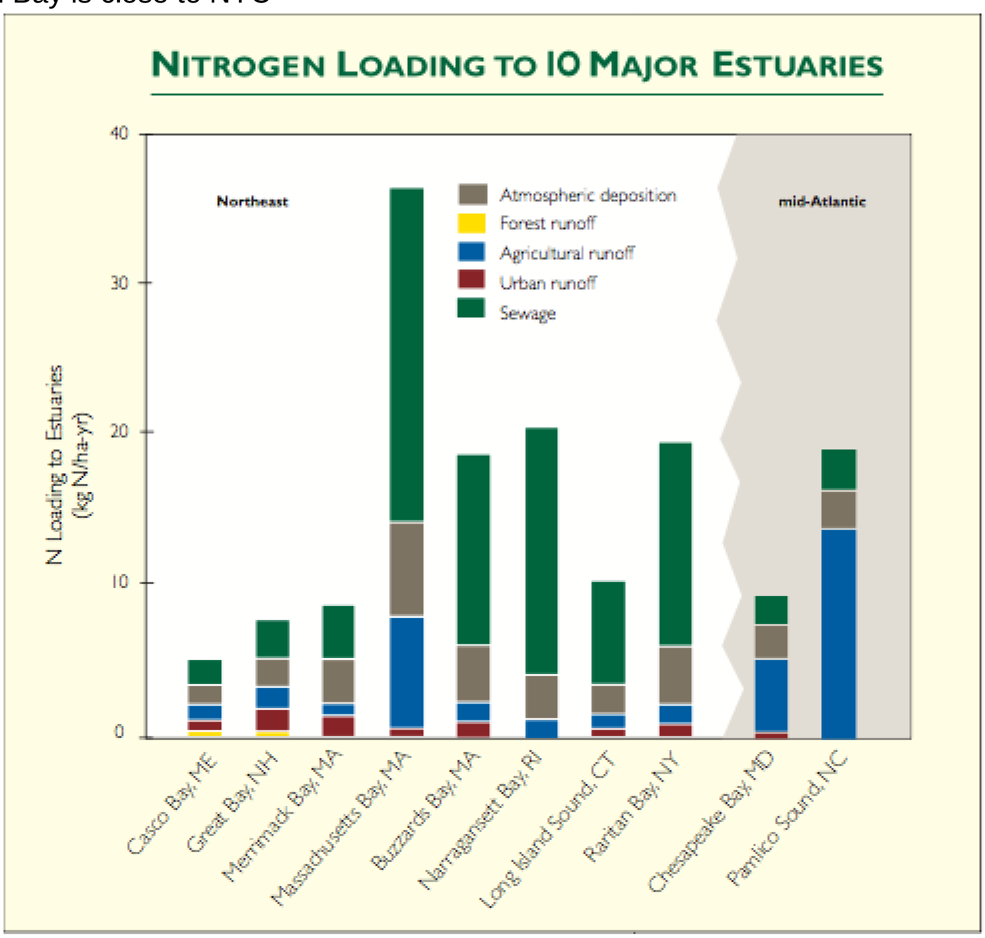
3. Sources of Nitrogen to the Hudson River Watershed, 2002



From presentation “The Hudson is the Most Heavily Nutrient-Loaded Estuary in the World: Should We Care?” by Robert Howarth at the Hudson River Foundation:
http://www.hudsonriver.org/download/seminars/Howarth_March11.pdf

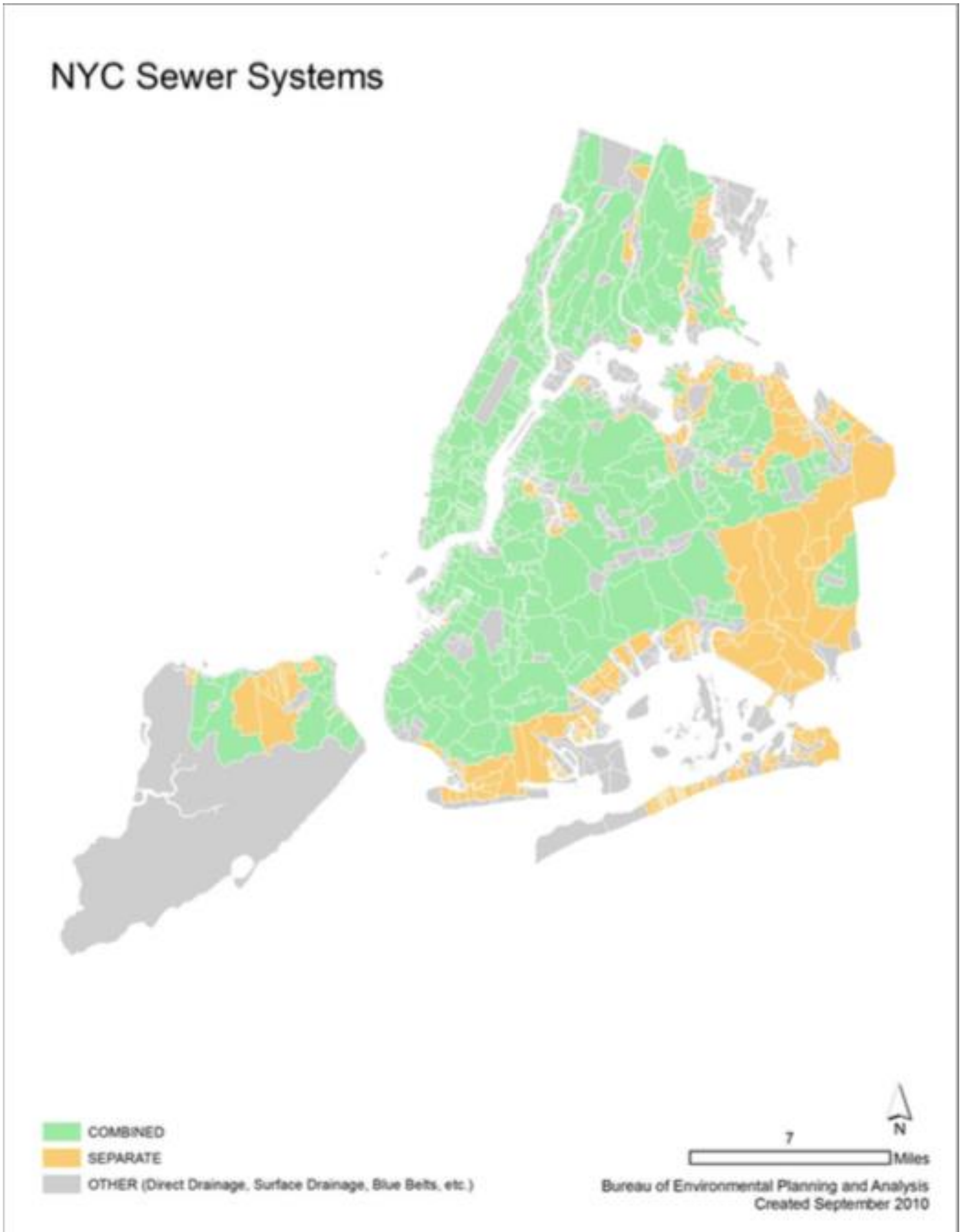
4. Nitrogen Loading to 10 Major Estuaries

Note: Raritan Bay is close to NYC



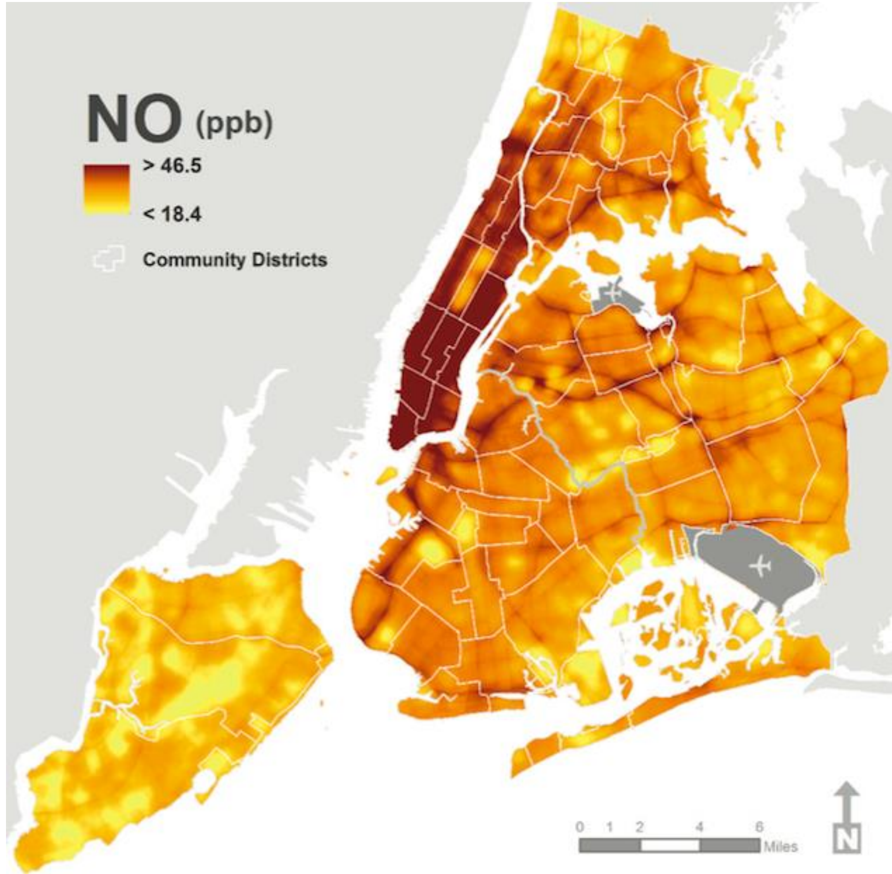
https://www.nyserda.**ny**.gov/-/media/Files/Publications/.../**nitrogen-pollution**.pdf

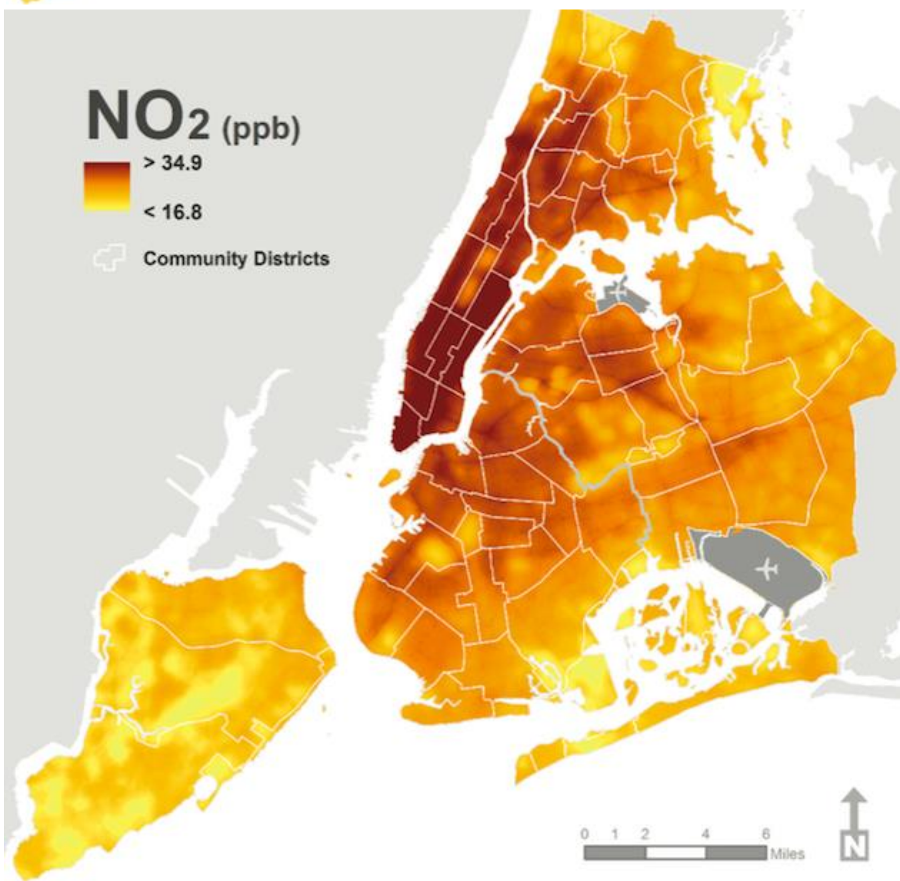
5. DEP New York City Sewer System



http://www.nyc.gov/html/dep/pdf/green_infrastructure/sewer_drainage_area_types_map.pdf

6. New York City Community Air Survey





http://untappedcities.com/2014/03/19/fun-maps-nyc-community-air-survey-indicates-we-have-clean-air-but-moving-to-staten-island-is-a-good-idea/

Nitrogen Cycle Part 8- Use the Digital Platform to Study Nitrogen Throughout Our Estuary

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 14, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	1	Classroom	Science

Summary

Students access NYC ammonia and nitrates data from platform.bop.nyc, in order to explore their questions about nitrogen beyond the classroom tank and beyond their own ORS. This lesson plan provides a simple example of how they might choose to do that.

Objectives

- Zero in on a subset of data that is of interest, when starting from a much larger set of available data.
- Organize and present that data in a way that highlights interesting patterns or raises interesting questions.

Materials and Resources

Supplies

- A way of projecting Google Map of the New York Harbor Estuary
- Access to platform.bop.nyc – See "Preparation" below

  Access to spreadsheet and graphing application such as Excel
- Hand-graphing supplies (optional)

Before you get started

Tips for Teachers

You may want to give students a handout describing, step-by-step, how to manipulate information from the Digital Platform. You could adapt the "Explore" section of this lesson for that purpose.

Preparation

1. Decide in advance which parts of the process you want your students to do for themselves, and which ones you will prepare for them, specifically:
    - Will they search within the data available at platform.bop.nyc, looking for things that interest them? If so, they'll need access to that website.
    - Will they download the data to Excel or a similar spreadsheet and graphing application, and 'clean it up' for themselves? If so, they'll need access to such an application.
2. Leave yourself time between classes to complete any steps that you plan to take on behalf of your students.

Instruction Plan

Engage

1. Students examine a map of the estuary (you can use Google Map street view and/or satellite view), and make predictions:
    - "Where do you imagine you would find higher and lower levels of ammonia and nitrates in our estuary? Why?"
    - "What questions come up as you think about this?"
2. Make note of students' questions and predictions.

Explore

- Zoom in!
- Look closely at nooks and crannies in the shape of the shoreline.

2. On a piece of paper, students write down the names of the ORSs in the places that interest them.
   - Example: I wanted to look at some nitrogen data in an area that doesn't flush as well as other parts of the estuary. So I located "IS 288 ORS", near the mouth of Coney Island Creek.

3. Students navigate to the Data page and select the Download tab.

4. Under "Filter the Expeditions" students search for the places and times that interest them.
   - Example: Under "Filter the Expeditions" I typed "IS 288 ORS" into the ORS Name field.

5. Under "Select Parameters to Display" students click on the the types of data that interest them.
   - Example: I clicked on the following boxes. I chose them because I thought that flushing might have something to do with currents, and I thought that nitrogen might have something to do with dissolved oxygen.
     - Tidal current

-
- Dissolved oxygen
- Ammonia
-

   -

   - I made the display look a little nicer by deleting rows I didn't need, bolding some things, etc. This is what is looks like:

Explain

Students present their findings to small groups or to the whole class, explaining:

-
- Why they looked at the parameters they selected?
- What they did to ‘clean up’ their data, and why?

Elaborate

The small groups or full class have a discussion focused on:

- What interested patterns do we notice in the data presented here?
- What questions do we have, look at the data presented here?

  How might we learn more by looking at the same data a different way?
- How might we learn more by looking at more or different data?

Evaluate

Students choose an issue from the class discussion to follow up on. They go back into the Digital Platform for more or different data, and/or they represent their data in a different way.

Standards

NGSS - Cross-Cutting Concepts

- Energy and Matter
  - Matter is conserved because atoms are conserved in physical and chemical processes.

NGSS - Disciplinary Core Ideas

- ESS2.A: Earth’s Materials and Systems
  - All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
  - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Grade 6, Unit 4

- Interdependence

NYS Science Standards - Major Understandings

- - Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.

Nitrogen Cycle Part 9- Nitrogen Pollution

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 14, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	1	Classroom	Science

Summary

Students read "Your Chicken Nuggets Are Killing Your Crab Cakes," an article about the connections between agriculture and nitrogen pollution in waterways. Students map the movement of nitrogen across the United States via the food system, and discuss how (or whether) the nitrogen map would change if people stopped eating chicken nuggets.

Objectives

- Identify major sources of nutrient pollution of estuaries.
- Translate textual information into map-based representations.
- Speculate about a hypothetical case.

Materials and Resources

Before you get started

Instruction Plan

Engage

1. Project Map of continental USA with Major Rivers and Mountains, No Labels (slide #1 of Maps to Explore Nitrogen Pollution- Teacher Powerpoint.)
2. Ask your students: "What can you identify on this map? Are you familiar with any of the mountains or rivers?"
3. Point to a few rivers and ask, "Which way does this river flow? How can you tell?"

Explore

1. Students read "Your Chicken Nuggets Are Killing Your Crab Cakes."
2. As they read, students identify locations from the article on "Continental United States with States, Capital Cities, and Rivers" (map #1 in Maps to Explore Nitrogen Pollution- Student PDF).

Explain

1. Students examine the maps in Maps to Explore Nitrogen Pollution- Student PDF.
2. In small groups, students use information from the article and maps to annotate the map "Continental United States with States, Capital Cities, and Rivers" with arrows to indicate the movement of nitrogen across the US.
    - Students decide where to draw arrows on the map to show the movement of nitrogen from one place to another. The direction of each arrow should show one route by which nitrogen moves around the country, according to the article.
    - Groups label each arrow in the article according to how the nutrients move along that route. Here's an example of one of these labeled arrows:

Elaborate

Students add the following arrows to their maps:

- Show the nutrients that are shipped to New York City in the form of chicken nuggets.
- Show what happens to those nutrients after New Yorkers eat the chicken nuggets.
    - At this stage, you could introduce a more zoomed-in map of New York City, such as one you can find on Google Maps.

Evaluate

Ask your students: “How does the nutrient map change if people stop eating chicken nuggets? Does it necessarily change at all?”

(This could potentially be a long and rich discussion!)

Extend

Ideally students will raise a lot of questions about nitrogen and estuaries! Depending on what kinds of questions they raise:

-

- This could be a perfect opportunity to make available the Nitrogen and Estuaries Topic Library. There students can do supported but independent research in search of answers to some of their questions.

- This would also be a great time to dig more into the maps from the powerpoint Maps to Explore Nitrogen Pollution- Teacher Powerpoint. Many of these maps come from Tom Philpott, the author of Your chicken nuggets are killing your crabcakes. The powerpoint includes maps and text he put together for a related article: http://www.motherjones.com/tom-philpott/2013/08/gulf-of-mexico-dead-zone-growth

Standards

NGSS - Cross-Cutting Concepts

- Energy and Matter
    -

- ESS2.A: Earth’s Materials and Systems

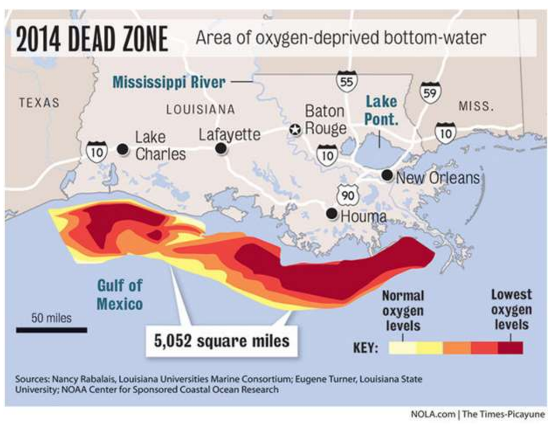
    - All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
    - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

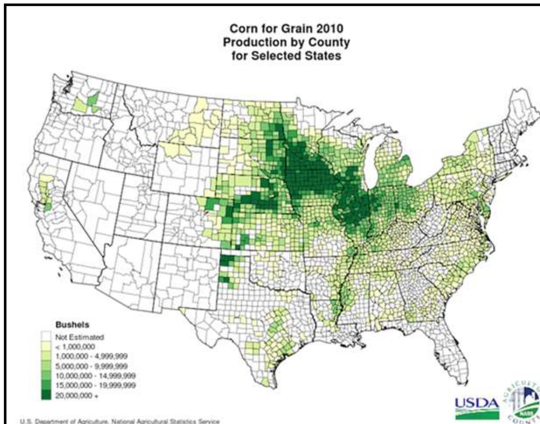
NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence

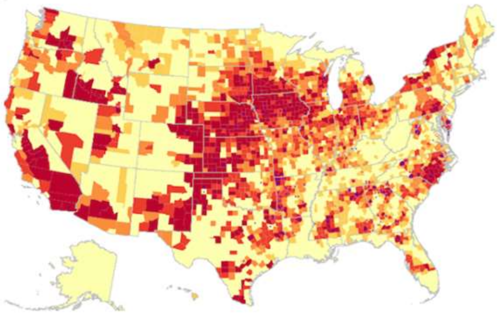
NYS Science Standards - Major Understandings

An enormous swath of the US landmass—41 percent of it—drains into the Mississippi River Basin.

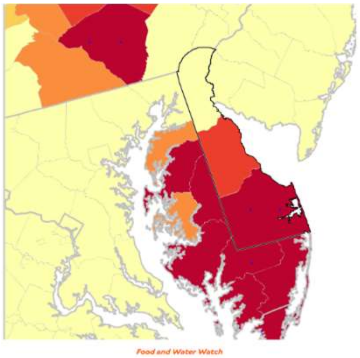




"The very same land mass that drains into the Gulf is also the site of an enormous amount of agriculture. The vast majority of US corn production—which uses titanic amounts of nitrogen and phosphorus, the two main nutrients behind the dead zone—occurs there."



This Food and Water Watch map depicts concentration of beef cow, dairy, hog, chicken, and egg farms—the redder, the more concentrated.

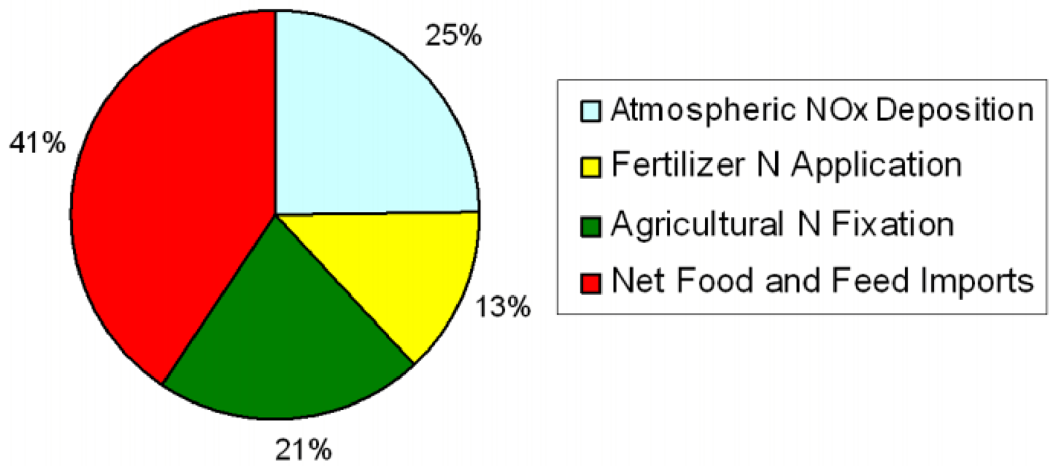


Then there's the Chesapeake Bay region, site of a stunning concentration of factory-scale chicken facilities.

Nitrogen and Estuaries Topic Library

Table of Contents:

1. Sources of Nitrogen to the Hudson River Watershed, 2002



From presentation "The Hudson is the Most Heavily Nutrient-Loaded Estuary in the World: Should We Care?" by Robert Howarth at the Hudson River Foundation:
http://www.hudsonriver.org/download/seminars/Howarth_March11.pdf

2. **Nitrogen load to Hudson River Estuary (in thousands of tons per year) as of 2006**

Sewage effluent[1]	23
CSOs and stormwater	2
Non-point sources	18
TOTAL	43

http://www.hudsonriver.org/download/seminars/HRF_Howarth.pdf

[1] Take a look at the word "effluent." The first part (the prefix) is "ef-," meaning "out." (You also see this prefix written as "ex-," "e-," and "ef-." Think of words like "eject"- "to throw out"- or "exterior"- "outside of.") The second part comes from the Latin word "fluere," which means "to flow."

So effluent is a substance that flows out of something- in this case, "sewage effluent" means the liquid that flows out of wastewater treatment plants. That's water that has already been treated!

Table 10.2. Loadings of total nitrogen and phosphorus to the saline Hudson River estuary

	Early 1970s	Mid 1990s
Total nitrogen (10^3 tons y^{-1})	49	43
Contribution from wastewater plants effluent	61%	53%
Contribution from upriver	37%	42%
tributaries	37%	42%
Contribution from CSOs and storm water	2%	5%
Phosphorus (10^3 tons y^{-1})	9.6	4.8
Contribution from wastewater plants effluent	88%	77%
Contribution from upriver tributaries	10%	19%
Contribution from CSOs and storm water	2%	4%

Note: the input from the ocean and downstream aquatic ecosystems are not included; see text for derivation of estimates.

4. Hudson River Estuary Nitrogen Loading through Time

Time Period	Total Nitrogen Load (grams of nitrogen per square meter, per year)
	23
Early 1970s	330
1990s	295
Potential future*	87

*Potential future assumes complete conversion to nutrient-reduction treatment for sewage treatment, elimination of CSO discharges, and a significant reduction in nitrogen loading from upriver tributaries.

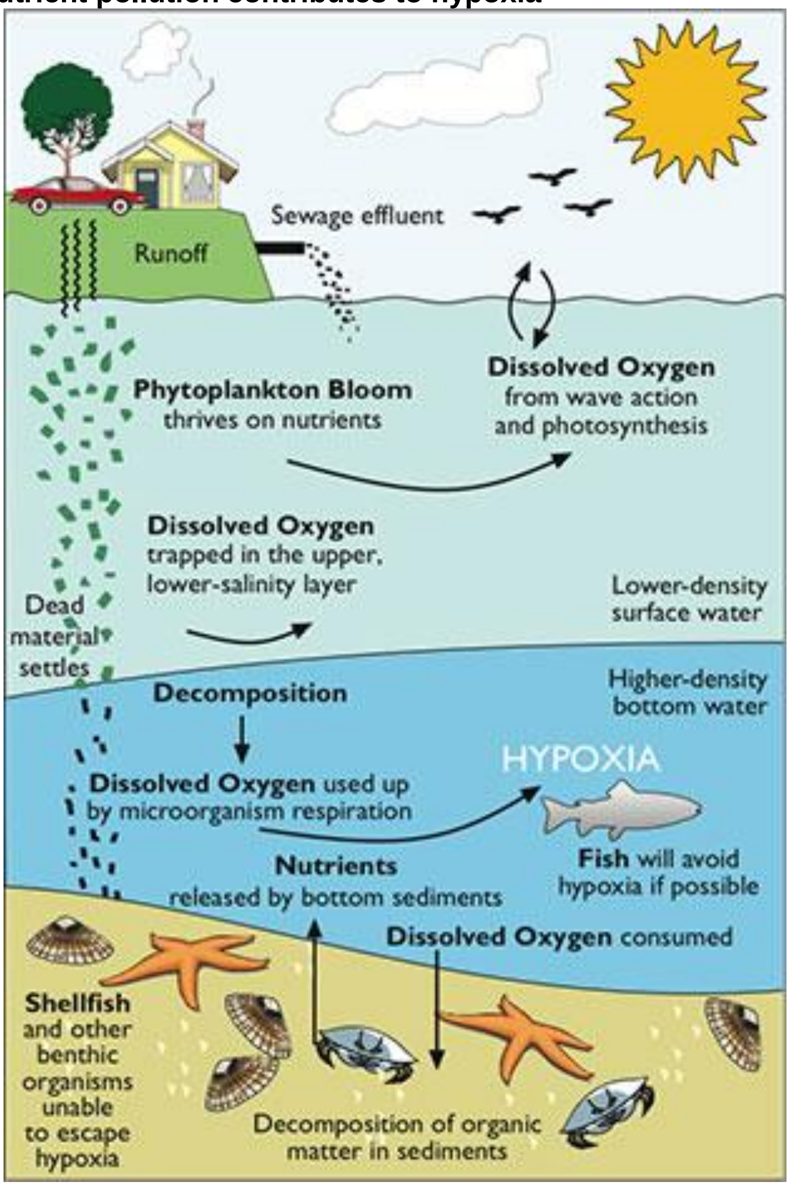
From “Wastewater and Watershed Influences on Primary Productivity and Oxygen Dynamics in the Lower Hudson River Estuary” by Howarth, Marino, Swaney, and Boyer from *The Hudson River Estuary*:

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.526.6736&rep=rep1&type=pdf

5. **A video describing the process of eutrophication in general**
   One misconception in this video is the suggestion that all nutrient pollution comes from fertilizers
   https://www.youtube.com/watch?v=6LAT1gLMPu4

6. **How the bottom of an estuary can become hypoxic**
   Watch "Hood Canal Animation #1: Creation of normal conditions" through 1:08
   http://www.nanoos.org/education/learning_tools/hypoxia/estuarine_hypoxia.php

7. **How nutrient pollution contributes to hypoxia**



From: http://www.riclimatechange.org/impacts_coastal.php

8. **What is Hypoxia?**
   Poster that describes how nutrient pollution contributes to hypoxia in the Long Island Sound:
   http://longislandsoundstudy.net/wp-content/uploads/2010/03/hypoxia-w_text2003-chart.pdf

9. **The State of The Estuary 2012**
pages 23-24, “Nutrients and dissolved oxygen”
http://www.harborestuary.org/pdf/StateOfTheEstuary2012/SOE_Rprt.pdf

10. **How sewage disposal has affected the Hudson River Estuary since the 1970s:**

For much of the twentieth century, untreated sewage entered the Hudson River Estuary (HRE), where bacteria decomposed the waste and, in the process, used up a lot of the dissolved oxygen. When sewage treatment improved, between the 1970s and the 1990s, the problem changed. Instead of raw sewage, there is treated sewage entering the HRE, and that contains a lot of plant nutrients such as nitrogen and phosphorus. These nutrients can promote the growth of phytoplankton, which eventually die and decompose. Bacteria decompose the phytoplankton and, in the process, use up a lot of the dissolved oxygen.

This problem is greatest when the water is not flushed quickly from the HRE. The water sticks around longer when the tidal action is smaller (about twice a month, at neap tides), and when the river flow is lesser (depends on the weather, but happens predictably in August).

Adapted from http://life.bio.sunysb.edu/marinebio/hrfhrbook/pdfs/10.pdf

11. **Nitrogen, Dead Zones, and New York Harbor**

The Hudson River Estuary is the most nitrogen-loaded estuary in the world. More than half of that nitrogen is from wastewater. “Wastewater” includes, among other things, everything you flush down the toilet and everything that goes down the drain from your sink and shower. It’s also called “sewage.”

Why does this matter?

Too much nitrogen can set off a chain of events that creates “dead zones” in the water- areas of low oxygen- that can kill aquatic life. Mobile animals, like fish, *might* be able to swim away. But sessile organisms that can’t move, like oysters, are stuck with too little oxygen to survive. It’s like a person not having any air to breathe!

Even though fish can swim, sometimes they still cannot escape a dead zone. Thousands of menhaden were killed in this Long Island dead zone caused by an algal bloom in 2015.
Image from the New York Times: https://www.nytimes.com/2015/06/06/nyregion/long-island-sees-a-crisis-as-it-floats-to-the-surface.html?_r=0

How does New York Harbor end up with too much nitrogen?

When you put millions of people in one place- like the New York City metro area- they produce a lot of waste in the form of...well...poop. And pee. And that waste is full of nitrogen. For a long time, when you flushed the toilet, everything in it went through the drain pipes, into the sewers, and straight into our waterways. Now, on most days, this wastewater goes to a wastewater treatment plant (WWTP).

The Newtown Creek Wastewater Treatment Plant in Greenpoint, Brooklyn.
Image from: https://www.youtube.com/watch?v=6nUAe7v-HLs

A wastewater treatment plant is massive factory-like building designed to remove solids, garbage, and chemical pollutants from sewage before draining the treated water back into waterways. (This treated water is called “effluent”- you may have noticed that word earlier in this topic library in the tables of nitrogen loads to the Hudson River Estuary.) Traditional WWTP remove some nitrogen, but not a lot. In the past ten years, six of NYC’s fourteen wastewater treatment plants have been re-designed to remove *more* nitrogen, but thousands of tons of nitrogen from WWTP still enter the Hudson River Estuary each year.

What exactly happens when there's too much nitrogen?

Nitrogen is a **nutrient** for plants and algae. A nutrient is something living things take in to survive. Humans get nutrients from eating food. Oysters get nutrients by consuming a type of algae- microscopic organisms called "phytoplankton" that they filter out of the water. Algae don't need to eat other organisms, because like plants, they can photosynthesize- a way to get energy from the sun. But they still need nutrients like carbon dioxide, iron, phosphorus, and nitrogen to carry out that photosynthesis.[2]

When there's lots of nitrogen in the harbor from sewage, that means there are a lot of nutrients available for the algae, and they reproduce rapidly, forming huge masses called **algal blooms**.

An algal bloom in Florida described as "vile-smelling and guacamole-thick."
Image above and below from: http://abcnews.go.com/US/toxic-algae-blooms-infesting-florida-beaches-putting-damper/story?id=40326610

One resident said, "I live on the water and I can't even go out my back door. It smells vile."

If oysters eat algae, then why are algal blooms a bad thing?

For oysters, an algal bloom is too much of a good thing. Algae produce oxygen, but they also consume oxygen. And when the nutrients run out and the phytoplankton die, bacteria use up

[2] That's why people put fertilizer on their plants- most fertilizers contain nitrogen, phosphorus, and potassium, among other things, as a way to make sure that plants get the nutrients they need, if the soil is not fertile enough to provide enough plant nutrients by itself.

oxygen to decompose them. This means that the oxygen gets used up. But oysters and other animals need that oxygen to live! That's why we call areas of low oxygen "dead zones"- because low oxygen can kill many organisms living in that area.

Is New York Harbor a dead zone?

The Hudson River Estuary is unusually resilient because the Atlantic Ocean helps "flush" some of the polluted water out more quickly than most other estuaries get flushed. So even though the Hudson River Estuary is the most nitrogen-loaded estuary in the world, it's not even the biggest dead zone in the United States (that title goes to the Gulf of Mexico). But many scientists argue there have still been significant consequences for New York Harbor, like soft shell clam die-offs and salt marsh destabilization. Others are concerned that climate change may reduce the flow of the Hudson River. If that happens, our harbor won't be flushed so quickly every day, and we could end up with a smelly city of water that cannot support life.

What are some terms you might see when reading about dead zones?

Too much nitrogen in the water is a form of "**nutrient pollution**"- because certain nutrients, in excess, can have harmful effects on the environment, just like other forms of pollution. Another word for nutrient pollution is "**eutrophication.**"[3]

Another word you might see is "**hypoxia**." Hypoxia is the state of having low oxygen.[4]

Vocab

- **Nutrient:** a component in foods that an organism uses to survive and grow.
- **Algal bloom:** a rapid growth of microscopic algae or cyanobacteria in water. Phytoplankton are a type of algae.
- **Dead zones = Hypoxic zones:** areas of low oxygen in water.
- **Hypoxia:** the condition of having low oxygen in an environment.
- **Anoxia**: the condition of having no oxygen in an environment.
- **Eutrophication = Nutrient pollution:** excess nutrients that can have harmful effects on the environment.

Adapted from: https://www.billionoysterproject.org/can-habitat-restoration-improve-water-quality-in-urban-estuaries-september-2016-bop-ccers-colloquium/

12. Oysters and Nitrogen Removal from the Water Column

In the past few decades, New York City has made efforts to reduce the amount of nitrogen in New York Harbor. But to fix our **nutrient pollution** problem we'd need to spend $200 million a year to continue to upgrade our wastewater treatment systems, and sometimes it's a challenge to convince people that it's important. (This is one reason why it's important for all of us to learn

[3] The word eutrophication has Greek origins, with "eu" meaning "well/good," and "troph" meaning "food/nutrition/nourishment." A Swedish scientist

[4] The word hypoxia also originates from Greek words. The prefix "hypo-" means "under/sub" and "ox" stands for "oxygen." A related word is "**anoxia**." The Greek prefix "an" or "a" means "without." So while "hypoxia" means "low or reduced oxygen," "anoxia" means "no oxygen." A dead zone might also be referred to as a hypoxic zone, or an anoxic zone. What do you think is the difference between a hypoxic zone and an anoxic zone?

about our local environmental issues- so we can help the city make informed decisions about how to spend our tax dollars.)

Since oyster reefs in other parts of the country have been shown to remove nitrogen from the water, researchers are now studying whether oysters could help reduce the amount of nitrogen in New York Harbor.

Different forms of nitrogen

To understand why researchers hypothesize that oysters might help remove nitrogen from the Harbor, it's useful to know a little bit about the different forms nitrogen takes. In the environment, nitrogen goes through a series of transformations that we call the "Nitrogen Cycle." In different stages of the cycle, nitrogen combines with other elements, like oxygen and hydrogen.

Some of these forms of nitrogen are harmful to aquatic life, while others are relatively harmless. Nitrogen gas (which makes up 79% of our air!) is harmless. But some nitrogen compounds, like ammonia (a compound of nitrogen and hydrogen) can kill fish and oysters if there is too much of it in the water.

Ammonia is not all bad- we use it to fertilize plants to make them grow. Plants then incorporate that nitrogen into plant proteins, which we and other animals eat. Some of that protein then becomes a part of our bodies. Your body is around 3% nitrogen! And you got that nitrogen from…

When animals digest protein, some of the nitrogen from that protein ends up in our poop and pee. Bacteria break the waste down, turning that nitrogen back into ammonia.

Could oysters help?

Sometimes there's so much nitrogen in a waterbody that it sets off a chain of events that uses up the oxygen in an area, creating what's called a "**dead zone**." (To learn more, look at the reading "Nitrogen, Dead Zones, and New York Harbor.") Since oysters need oxygen to survive, if they're caught in the dead zone, there's not too much they can do to help!

However, in places where there is a lot of nitrogen, but not so much that all the oxygen gets used up, there are several ways that scientists are studying, to find out if oysters might be able to help remove nitrogen from the water.

1. **Oysters incorporate nitrogen into their bodies and shells.**
   Remember how we said that ammonia is a fertilizer for plants on land, and that your body is 3% nitrogen? In the water, ammonia acts like a fertilizer for tiny microscopic organisms called phytoplankton. Like plants, phytoplankton turn ammonia into protein. When oysters eat the phytoplankton, that protein becomes a part of the oysters' bodies and shells. Oysters have nitrogen in their bodies, just like you! But oysters also excrete nitrogen waste, just like you. And when they die, the nitrogen in their bodies returns to the water as they decompose.

   Oyster reefs are also a habitat for lots of *other* organisms whose bodies contain nitrogen. So scientists have found that some nitrogen is removed from the water just by being incorporated into the oysters' and other organisms' bodies. But those animals also excrete nitrogen waste.

And when they die, the nitrogen in their bodies also returns to the water as they decompose.

Scientists are still trying to determine if oysters and their reef associates in New York Harbor could remove more nitrogen from the water (by incorporating it into their bodies) than they put back (through excretion and decomposition).

2. **Oyster poop and other "biodeposits" can settle on the bottom of a waterbody and get buried.**
   When oysters filter in little bits of rock or other materials that aren't food, they cover it in mucus (basically snot!) and spit it out. These are called "pseudofeces." ("Pseudo" is from a Greek word that means "fake," and the word "feces" means "poop"- see how scientists came up with that term?) Oyster feces and pseudofeces are called "biodeposits."

   Both real oyster poop and pseudofeces contain nitrogen, like human poop. But because oysters coat their feces and pseudo feces in mucus, oyster biodeposits settle on the bottom. Sometimes their biodeposits get buried under sediment instead of floating back into the water. Scientists aren't sure how much nitrogen can be removed from the water column this way, or how long the nitrogen can stay buried. But it might play a small part.

3. **Oyster reefs create a special habitat for specific bacteria that can turn ammonia back into nitrogen gas.**
   Bacteria can turn nitrogen from forms that are harmful to fish and other wildlife (like ammonia) back into a form that is harmless, nitrogen gas. Scientists are learning a lot right now about how oyster reefs can create good conditions for bacteria to carry out this process, and it has a lot of them excited about the possibilities.

Oysters alone won't solve the problem of nitrogen overloads in New York Harbor But they might help! That's one reason why your Oyster Restoration Station data is so important. Your work will help our scientists find the best spots to put oyster reefs in New York Harbor!

Adapted from: https://www.billionoysterproject.org/can-habitat-restoration-improve-water-quality-in-urban-estuaries-september-2016-bop-ccers-colloquium/

See also: "Setting Objectives for Oyster Habitat Restoration Using Ecosystem Services, Manager's Guide," pages 36-39 from The Nature Conservancy: https://www.conservationgateway.org/ConservationPractices/Marine/Area-basedManagement/mow/mow-library/Documents/OysterHabitatRestoration_ManagersGuide.pdf

By Stephanie Ogburn on Feb 5, 2010

Most people don't think too much about nitrogen. But with every bite we take — of an apple, a chicken leg, a leaf of spinach — we are consuming nitrogen. Plants, including food crops, can't thrive without a ready supply of usable nitrogen in the soil.

The breakthrough, by German chemists Fritz Haber and Carl Bosch (rhymes with posh), made it possible to grow many, many, many more crops per acre of farmland. For the last 50 years, farmers around the world have used synthetic nitrogen fertilizers to boost their crop yields…

But in their desire to increase yields, farmers often put more nitrogen into the soil than the plants can use. The excess is now causing serious air and water pollution, and threatening human health. Ironically, all that fertilizer may even be ruining the very soil it was meant to enrich.

Nitrogen, it seems, has a dark side, and it has created serious problems that we are only now beginning to reckon with…

Bombs away: Synthetic nitrogen comes of age

Nitrogen is everywhere. It makes up 78 percent of the earth's atmosphere. But atmospheric nitrogen is inert. It exists in a stable, gaseous form (N_2), which plants cannot use. Unless nitrogen is made available to plants, either by nitrogen-fixing bacteria in the soil or by adding fertilizer, crops won't grow as productively.

The German chemists Haber and Bosch found a way around this availability problem. Originally meant as a way to make explosives for war, their technique turned inert nitrogen gas into highly reactive ammonia (NH_3), a form of nitrogen that can be added to soil and used by plants. This discovery meant that nitrogen would not longer limit agriculture.

The widespread use of synthetic fertilizer took off after World War II .... In 1960, farmers in developed and developing countries added about 10 million metric tons of nitrogen fertilizer to their fields. In 2005, they added 100 million metric tons.

This huge increase in the use of nitrogen fertilizer is largely responsible for the phenomenal crop yield increases of the past 45 years. Without the additional food production fueled by nitrogen fertilizer, researchers estimate that two billion fewer people would be alive today.

Shifting shapes, getting around

Modern agriculture — and, consequently, present-day human society — depends on the widespread availability of cheap nitrogen fertilizer, the ingredient that makes our high-yielding food system possible. But the industrialization of this synthetic nitrogen fertilizer has come with costs.

It takes a huge amount of energy to produce the high temperatures and very high pressures needed to transform N_2 to NH_3. About one percent of the world's annual energy consumption is used to produce ammonia, most of which becomes nitrogen fertilizer. That's about 80 million metric tons (or roughly one percent) of annual global CO_2 emissions — a significant carbon footprint.

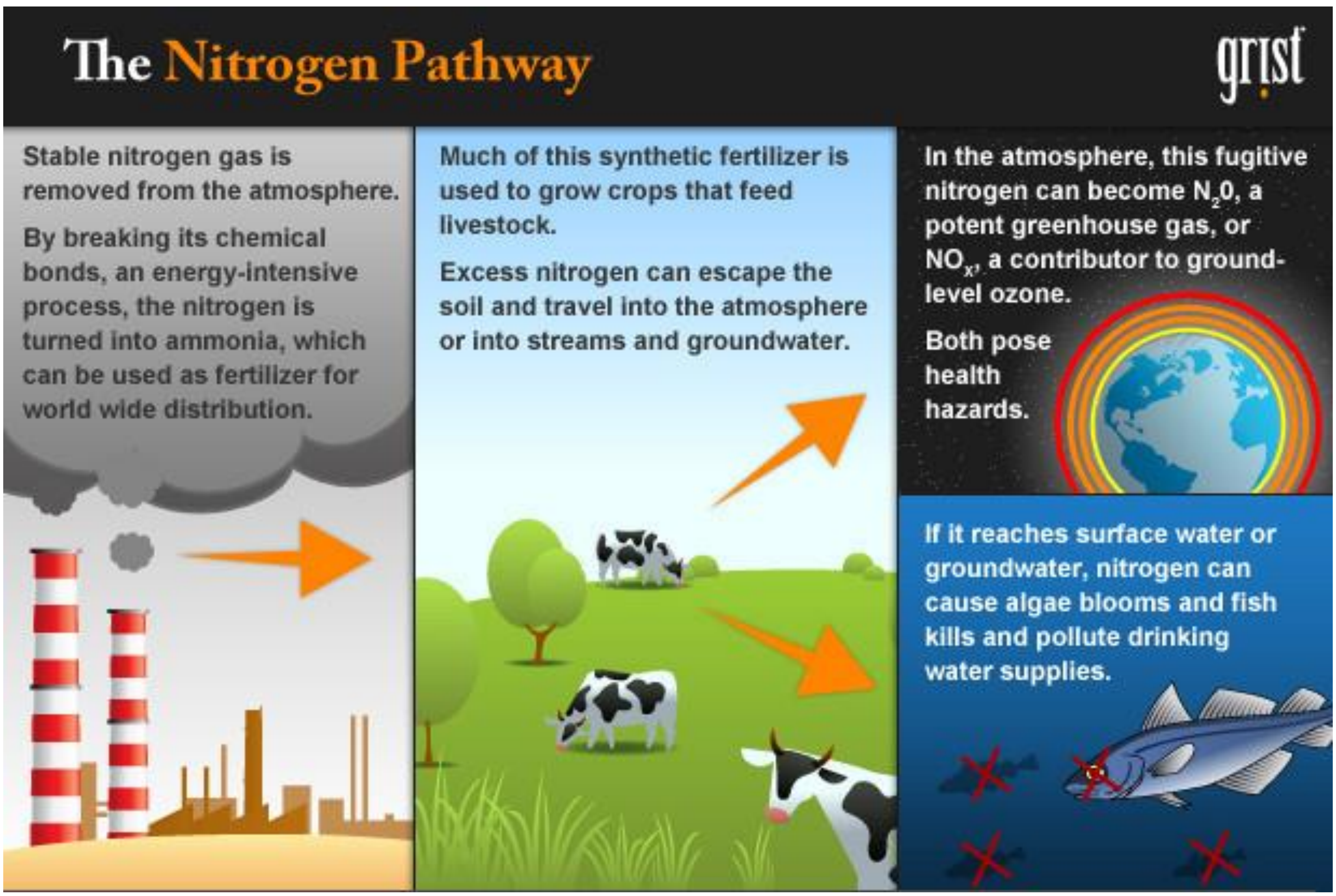
Nearly half that fertilizer is used to grow food for livestock. Animals pee and poop, and return the nitrogen to the landscape, where it is a form of pollution — the second cost of synthetic nitrogen.

Synthetic fertilizer is made with reactive nitrogen, which doesn't always stay where you put it. Farmers may apply this synthetic fertilizer to their cornfields, but the nitrogen in it will react with the soil carbon, oxygen, and water in its environment.... Estimates vary on how much nitrogen escapes from fields and remains reactive and potentially harmful, but it's reasonable to assume that plants absorb 30 to 50 percent of the nitrogen in the soil. So if a farmer applies 125 pounds of nitrogen fertilizer to an acre of corn, 30-50 percent of it will end up in the corn; as much as 70 percent — or 87 pounds per acre — could end up somewhere else.

‘N’ stands for ‘Needs to improve’

There is an obvious way around this nitrogen problem: use less fertilizer more efficiently. But there’s not much incentive to cut back.

Farmers get paid by the ton, so producing more crops is the driving force of modern agriculture. Most agronomists agree that farmers can get the same yields without applying as much fertilizer and manure as they now do. But few farmers are willing to take that chance. Many farmers use fertilizer as a form of insurance; better to apply a little too much and get high yields than apply too little and risk yield (and profit) declines.



....It’s tough to find mainstream farmers who are using nitrogen efficiently and safely. There simply aren’t incentives to do so. Fertilizer is cheap, and no one makes polluters pay for polluting....

Farmers don't over-apply nitrogen on purpose, and they don't *want* to contribute to estuary pollution and dead zones. But for 40 years, we've invested in a type of agriculture that rewards high yields above all.
....Under the Farm Bill, commodity farmers get subsidies based on how many bushels they churn out, not how efficiently they use nitrogen....

Organic farming practices provide many potential alternatives to current practices. But the incentive structure around farming must change.

Farmers should be rewarded for conserving nitrogen and building the organic matter in soil... not just for pumping out tons and tons of crops.

Nitrogen Cycle Part 10 - Is Our Tank Ready for Animals?

BOP Curriculum
bop-curriculum@nyharbor.org
Feb 14, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Nitrogen Cycle Investigation	6-8th	2	Classroom	Science

Summary

Students graph the ammonia/nitrite/nitrate data they have been collecting and compare their graphs to a professional aquarium graph. After investigating these graphs the class decides whether their tank is ready for animals.

Objectives

- Create a graph based on their data.
- Compare their graph to one from another source.
-

- Graphing supplies (either analog or digital)

Before you get started

Preparation

- Compile the ammonia/nitrite/nitrate data from the students' monitoring of the classroom tank over the past weeks. Prepare the data so there's a copy for each student.
- Be prepared either to take the next step with your tank set-up at the end of this lesson!
    - If the students agree that the tank is ready for animals be prepared to add oysters, and possibly other organisms.
    - If there are legitimate concerns among students about adding organisms, ideally be prepared to start a second tank with a fishless cycle so you can create a comparison tank.

Instruction Plan

Engage

1. Each student gets a copy of the ammonia/nitrite/nitrate data from the classroom tank.
2. Students graph each parameter over time on a single graph.
3. Students get into small groups, compare their graphs and make observations about their graphs.

Explore

1. Each student gets an Observation / Inference / Questions handout.
2. Students work in their small groups to write down things they notice about the graphs. They note patterns, connections, and questions that each observation raises for them.
3. Students get Is Our Tank Ready for Animals? (which includes the graph below) and complete it with their small groups.
4. Consider re-distributing Diagrams that Describe Nitrogen Changes in Tanks and or Nitrogen and Estuaries Topic Library (from previous lessons in this Investigation) in order for the students to cite additional evidence to support their claim.

nitrogen-cycle-graphic.jpg

From: https://www.pondexperts.ca/pond-advice-tips/ammonia-ponds-aquariums/

Elaborate

1. Discuss: Is our tank ready for animals?
2. Push for evidence, and a discussion in which students talk to each other.
3. Add your animals! Consider making this into a ceremony, as the students have done a lot of work in the past weeks to get to this point.
4. If there is legitimate controversy and the class cannot build consensus, consider starting a second tank to accommodate multiple conclusions.

Evaluate

1. Discuss: How does the nitrogen cycle in our tank compare to the nitrogen cycle in the estuary?
2. Will our oysters do better in our tank or in our Oyster Restoration Station (ORS)?

Standards

NGSS - Cross-Cutting Concepts

- Energy and Matter
    - Matter is conserved because atoms are conserved in physical and chemical processes.

NGSS - Disciplinary Core Ideas

- ESS2.A: Earth's Materials and Systems
    - All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
    - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

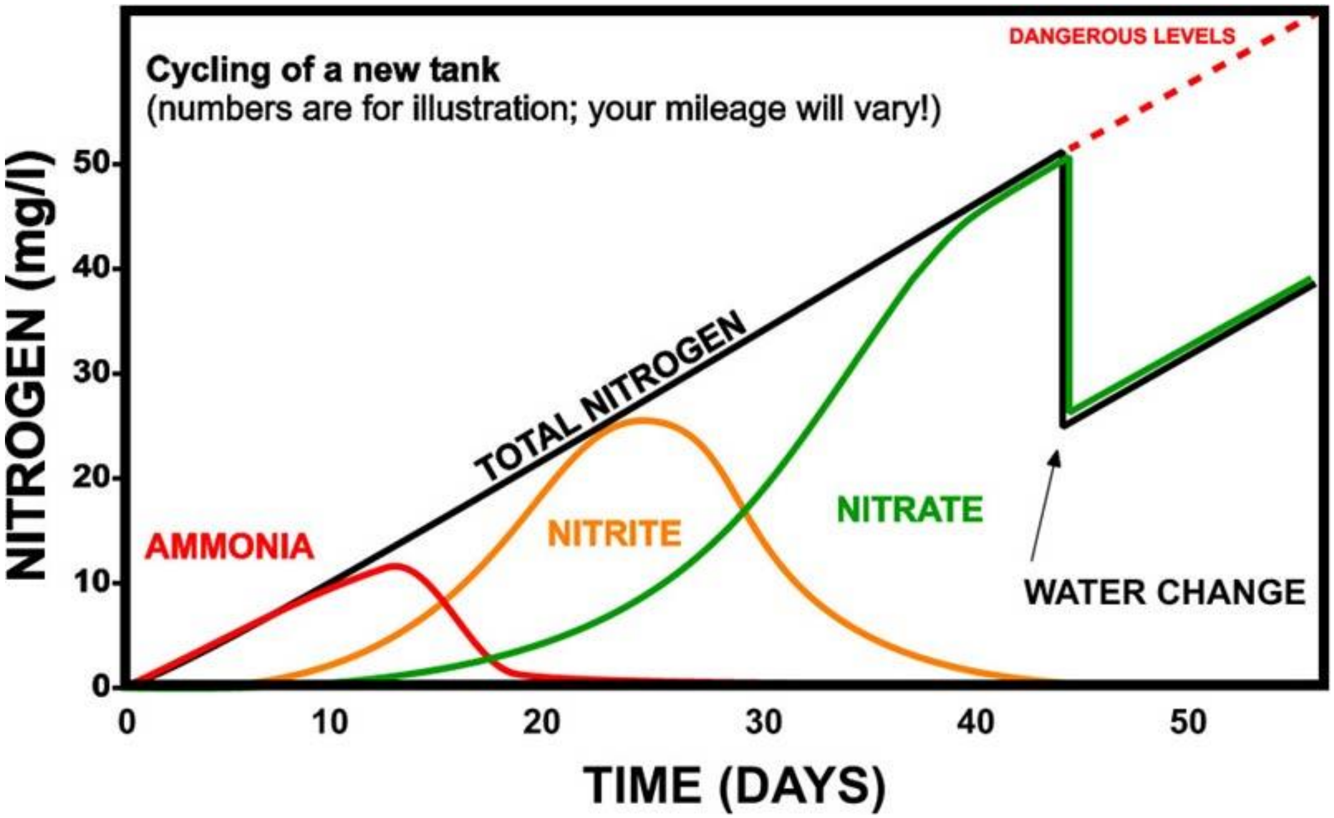
NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence

NYS Science Standards - Major Understandings

-
    - Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.

Is Our Tank Ready for Animals?



https://www.pondexperts.ca/pond-advice-tips/ammonia-ponds-aquariums/

1. Compare your graph to the graph above. What are some of the similarities? Differences?

2. Based on what you have learned so far: is it time to put animals in the tank? Why or why not?

Observation *Use your five senses. What do you see, hear, smell, taste, feel*	**Inference** *What do you think it means? Why do you think it is this way?*	**Questions** *What questions do you still have about this? What do you want to learn more about?*

Notes/Results/Sketch/Connections

NYC Water Map

Matt Steiniger
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Jun 20, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Teacher-Authored Lessons	6-8th	1	Classroom	ELA Science Social Studies

Summary

This lesson allows students to start with an outline map of the NYC Estuary and highlight all of the waterways. Students will generate observations and questions. They will then use a more detailed map to find "water words" they are unfamiliar with, look up the terms, right our definitions in notebook. Lastly, students will use the map to label the 8 major parts of the NYC Estuary.

Objectives

Students will generate observations and questions about NYC waterways and explore a map in order to learn the words needed to talk about the harbor.

Materials and Resources

Supplies

- Class set of blue highlighters
- Print outs of NYC outline map
- Analog Dictionaries
- Internet
- Map of Estuary

Before you get started

Tips for Teachers

- Reliable internet/computers would be useful to allow for additional online resources

Preparation

1. Decide whether you want to create charts to have students fill out or have them complete all notes in NB.

2. (Optional, but super useful) Create a large NYC Outline Water map to hang on a wall (http://www.blockposters.com/all-done/ or similar sites are useful)
3. Photocopy NYC outline maps for students
4. Have Blue highlighters/markers available for students
5. Decide if you will have students use/share computers for second map analysis and dictionaries (have analog dictionaries on hand if desired)

Background

This is an intro lesson for NYC Estuary studies

Instruction Plan

Engage

1. Guide students to highlight all of the waterways on their NYC outline maps (large color poster can also be a model)
2. As you demonstrate the highlighting (don't forget the little rivers and streams), demonstrate some observations and questions..."I notice that some water areas are bigger/smaller than others...or here the coastline looks more like a straight line, and here it looks more jagged. I wonder why..."

Precise attempts to characterize the size/shape/texture of things. Spikey, bumpy, straight, curvy, smooth, -- compare/contrast - how is this spot similar/different to that spot, enrich observations.

3. Prompt kids to complete their observations/questions T-chart as they complete the highlighting of their maps.
4. Students share out observations/questions (all students should have at least 5 of each recorded in notes.

Examples of Student Generated Questions:
Student generated questions:

How much of NYC is manmade

Whats difference between island/buro

How much of the island is clean?

What about the map of the past?

Why does the water jut into land/land jut into water?

Why is it sometimes smooth/jagged?

How big are these things?

Islands that humans have not built on?

Rivers? - do they have to flow into a sea?

Does a lake have to be moving/can it be stagnant

What is water/land, or are there things that are both?

How do they form, why are they the shapes that they are?

Does water turn from river to ocean?

Why some small/big rivers clear and salt water

Do bodies of water affect the land/;and affect the water?

What lives in the water

Why is there a difference between salt/fresh water

Direction of water?

Why are there different sizes of water

bk/queens one island?

Why is river connected to the sea

Why are there pockets of water?

Explore

Give students internet access (phones, tablets, laptops, etc.). Have them look up their word. Then, have them make a list of all the other water words in that definition. Then, have them look up those words as well. They should keep a running list of the definitions of all the words that they have looked up using the worksheet in this folder. By the time they are done, they should have the definitions of at least 10 water words.

5. After completion, direct students to the more detailed "NYC Estuary Map" (either digitally or printed out)
6. Direct students to explore the map and find water related terms that they are unfamiliar with ("bay," "channel," "creek," "estuary," etc)
7. Create a list of 10 terms and definitions in notes.

Elaborate

8. Students should locate the 8 major areas of the NYC Estuaries and label them on their maps using the NYC Estuary Map.

9. ...If/when students struggle to find all of the locations, guide them to using google maps (optional) to locate the rest.

Give students a blank map. (There is one at : http://www.mapsofworld.com/usa/blank-map-of-new-york-city.html)

Have them label the following waterways by describing them without them using any of the real water words.

1. Hudson River
2. East River
3. Long Island Sound
4. Newark Bay
5. Upper New York Bay
6. Lower New York Bay
7. Jamaica Bay
8. Atlantic Ocean

Evaluate

Have a class discussion where you decide which three water words are most important in discussing NY Harbor. Justify your answer. Student Observations/Questions can fuel subsequent lessons (what is an estuary!)

Standards

NATURE'S ESTUARY

THE HISTORIC TIDELANDS

of the

New York New Jersey Harbor Estuary

Cartographic Design by Jennifer Cox, Regional Plan Association
Cartographers George Colbert and Guenter Vollath

This composite map is largely based
on 19th century U.S. Geological Survey topographical maps,
U.S. Coast & Geodetic Survey harbor charts
and New Jersey Geological Survey topographical maps.

Conditions from Midtown Manhattan to Red Hook, Brooklyn
are based on the Ratzer Survey of 1776–1777.

FUNDING PROVIDED BY THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY
PRINTED JULY 2002

NJ NY CT
Regional Plan Association

NY Harbor Oyster Population Decline Part 2

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May 2, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Teacher-Authored Lessons	6-8th	1	Classroom	Science, Social Studies

Summary

This lesson is a continuation of the previous lesson "NY Harbor Oyster Population Decline Part 1." The room has been split into 6 groups- 2 groups for each photoset (oyster harvesting, industrial pollution, and sewage.) In this lesson, students will become teacher assistants and present their posters to the two groups that did not see their photo set. During their presentations, students are required to take notes.

Objectives

Students will present and discuss their groups historical photos, maps and other resources that point at some of the causes of oyster decline in New York.

Students will create a DSET about oyster population decline by using data from their classmates photo sets.

Materials and Resources

Supplies

1. Student generated posters.
2. DSET Scaffold (CESR generated by the MS88 Science Department)

Before you get started

Tips for Teachers

- For students who struggle to take notes on their own, give them the CESR graphic organizer to fill out the evidence and scientific concept sections during presentations
- While writing the CESR, have students peer review each others work.
- Have students practice writing a DSET/CESR by writing their conclusion in DSET form on their photo set handout.

Preparation

- Students have completed part 1 of this lesson.

Background

Students completed part 1 of the NY Harbor Oyster Population Decline. Students have made posters with their predictions, and their annotated photo set. Students have their posters made with all members photo set worksheets.

Instruction Plan

Engage

Engage sections in part 1 of this lesson.

Explore

Engage sections in part 1 of this lesson.

Explain

1. Students are given an opportunity to review their posters with their groups for five minutes.

- Instruct students that they must explain the title of their photo set, descriptions of the photos, and how these issues have negatively impacted the Harbor.

- Cause and Effect
    - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
    - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
    - Cause and effect relationships may be used to predict phenomena in natural systems.
    - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Energy and Matter
    - The transfer of energy can be tracked as energy flows through a designed or natural system
    - The transfer of energy can be tracked as energy flows through a natural system.
- Influence of Engineering, Technology, and Science on Society and the Natural World
    - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- Patterns
    - Graphs and charts can be used to identify patterns in data.
      Graphs, charts, and images can be used to identify patterns in data.
- Stability and Change
    - Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems and System Models
    - Models can be used to represent systems and their interactions.
    - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

NGSS - Disciplinary Core Ideas

- LS1.A: Structure and Function
    - Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
- LS2.A: Interdependent Relationships in Ecosystems
    - Growth of organisms and population increases are limited by access to resources.
    - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
    - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
    - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data

Analyze and interpret data to provide evidence for phenomena.

- Constructing Explanations and Designing Solutions
  - Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.
- Engaging in Argument from Evidence
  - Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
  - Interdependence

Project #_: [TITLE]

Directions: Read and study the information below to construct a scientific explanation (CESR) that addresses the testable question provided below.

[insert explanation of experimental design and data + any necessary background text]

[insert data set]

Testable Question: *How does [insert IV] affect [DV]?*

CLAIM: *Write a statement that addresses the testable question and describes the relationship between the I.V. and the D.V.*

EVIDENCE: *Write a sentence that uses the data to support your claim.*

SCIENTIFIC CONCEPTS: *Write a sentence that identifies the science concept that is relevant to your claim.*

REASONING: *Write 1-3 sentences that explain how this science concept links the evidence to your claim.*

Scientific Explanation Rubric

Component	Level 0: Not Evident	Level 1: Beginning	Level 2: Developing	Level 3: Advancing	Level 4: Proficient
Claim	Does not make a claim	Claim does not answer the question (i.e., describe the relationship between the 2 variables)	Claim does answer the question but it is inaccurate.	Claim answers the question, and is accurate, but is incomplete	Claim answers the question, is accurate, and is complete. Completely describes the trend in the relationship between the IV and DV where appropriate.
Evidence	Does not provide evidence	Only provides inappropriate evidence (evidence does not support the claim)	Provides appropriate, but insufficient evidence to support the claim. May include some inappropriate evidence	Provides appropriate and sufficient evidence to support the claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support the claim
Reasoning: Science Concepts	Does not include reasoning	Restates evidence and does not include explanation of science concepts	Includes explanation of science concepts but all are inappropriate concepts that do not link evidence to claim	Includes explanation of some science concepts that link evidence to the claim, but are insufficient (one or more concepts that should have been included are not included) or some are inappropriate	Includes explanation of science concepts that link evidence to the claim (concepts are appropriate), and they are sufficient (no omission of key science concepts) and are clearly stated and accurate.
Reasoning: Logic	Does not include reasoning	Restates evidence or claim and does not include a logic statement that links the evidence to the claim	Attempts to include a logic statement that links the evidence to the claim but does not adequately link the evidence to the claim.	Includes a logic statement that attempts to link the evidence with the claim but needs to be more clearly stated to demonstrate logical reasoning	Includes a logic statement that links the evidence to the claim (including words such as 'because…' 'therefore…') that clearly demonstrates logical reasoning

Cognitive Skill	**2**	**3**	**4**	**5**	**6**
Justifying / Constructing an Explanation	❏ Provides some description of phenomena. Explanation or justification is missing or very limited.	❏ Provides a description of phenomena and provides some explanation or justification for those phenomena.	❏ Provides a logical chain of reasoning to explain or justify phenomena. Develops explanation/justification with some detail/examples.	❏ Provides a logical chain of reasoning to explain or justify phenomena in support of an overall explanation of the phenomenon. Develops explanation/justification with relevant detail/examples.	❏ Applies a specific premise (such as a disciplinary principle, axiom, or theory) to explain or justify a solution, strategy, response, or phenomenon. Fully develops explanation/justification through relevant detail and examples. Acknowledges limitations, tradeoffs, and/or alternate explanations /approaches.

CE(S)R Graphic Organizer

Claim	Evidence	Scientific Concepts	Logical Reasoning
Statement describes the problem affecting oyster populations.	*From past experiments, observations, or experience*	*From readings, notes, or videos*	*Explain the reasons why your concepts and evidence support your claim*

Pocket Guide for Writing a Scientific Explanation

CE(S)R

CLAIM:

- ❑ I answered the testable question.
- ❑ I explained the relationship between the IV and DV.

EVIDENCE:

- ❑ I paraphrased my data to support my claim.
- ❑ I provided sufficient (enough) evidence to support my claim.
- ❑ My data proves my claim is true.

SCIENCE CONCEPTS:

- ❑ I identified appropriate scientific concepts (theory, law, or principle) that support my data.
- ❑ I defined key terms to help provide context and explain the scientific concepts.
- ❑ I introduced **quotes** with a transition phrase (*"For example,"* or *"According to….,"*).
- ❑ I cite the page # in parentheses.

REASONING:

- ❑ I explained my thinking in more than once sentence.
- ❑ I used sentence frames that help scientists follow my thinking (Usually/But/So, If/Then, Since, Even though, This shows, Also, etc).

Observation and Inference

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 6, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Introductory Lessons	6-8th	2	Classroom	Science ELA Social Studies

Summary

Students will look at various objects to practice the skills of observation and inference.

Objectives

1. Describe an object with clarity and detail.
2. Develop inferences that are connected directly to the observation.
3. Strengthen inferences with thoughtful questions.

Materials and Resources

Supplies

Unusual objects for making observation and inferences (things that a middle school student would probably not have seen before). For example:

- melon baller
- pear corer
- textile shuttle
- sailor's palm
- antique carpenter compass
- antique medical supplies (like an ear syringe)

Before you get started

Tips for Teachers

- The "Engage" section of the lesson includes a discussion of observations, inferences and questions all in a row. You can consider breaking up that discussion throughout the lesson as the students practice each skill.
- Consider whether you want to introduce the terms objective and subjective as they relate to the ideas of observation and inference.

Preparation

N/A

Background

Making thoughtful observations and inferences is an essential part of doing research and working in the field. Students often have a difficult time making detailed observations and quality inferences about something with which they are partially familiar because they want to jump to the conclusion about what it is, instead of slowing down and taking a close look. It is important for students to practice the skills of observation and inference in the controlled environment of the classroom before going out into the field. It is helpful to begin with objects with which the students are not at all familiar because then they can focus more on their observations. Afterwards, students can practice the same skill with objects that are more familiar.

Instruction Plan

Engage

1. In this activity the teacher leads the students through an observation, inference and question about a photo of an unusual animal called a blue dragon.

2. Show the class the image of the blue dragon in the Observation Inference Images powerpoint.

3. Give students one observation about the blue dragon.

- For example, “This organism has finger-like parts that are black on the tips and are on both sides of its body.”

4. Ask: Based on what I just said, how would you define “observation?”
5. Ask: What senses should we use to make observations? (Everything but tasting!)
6. Ask: How can we make our observations more accurate? (Spend time quietly looking at it, feeling it, etc. Instead of looking at the object as a whole, start by looking at individual parts of the object and study them carefully.)
7. Give students one inference about the blue dragon.
   - For example, “The organism uses these finger-like parts to dig into the sand and hide from predators. Maybe the tips are black because they are harder than the rest of the body, like fingernails, making easier to dig.”
8. Ask: Based on what I just said, how would you define “inference?”
9. Explain: We make observations and inferences all day long without thinking about it. This is an integral part of navigating our surroundings. But there are pitfalls of observations and inferences that we need to be careful about. Sometimes we think we know what something is as soon as we glance at it, so we don’t take the time to look at it more carefully.
10. Explain: Even after careful observation and thoughtful inferences, we likely will not know everything there is to know about an object.
11. Ask: How can we continue to probe deeper, even if we have exhausted our observations and inference. (Ask questions!)
12. Give the students one question about the blue dragon.
    - For example, “Exactly, how many finger-like parts does the animal have?”
13. Point out that a good question, followed up by research can lead to more observations and inferences. Maybe we could research other photos of this organism and find one that shows all the finger-like parts clearly, then we could count them (observation) and think more about how they might function (inference).

Explore

In this activity, the students receive three unusual objects one at a time. With each new object the students practice an additional skill: observation, inference and asking questions.

Making Detailed Observations - Object #1

1. Students get into small groups.
2. Each student gets an Observation Inference Practice worksheet.
3. Each group gets an unusual object. If anyone in the group knows what the object is or how it works, trade the object out for another. The object should not be known or understood by anyone in the group.
4. Use as many of your five senses as appropriate. How does it look? smell? feel? sound?
5. Circulate around the room and help the students make their observations more detailed.
6. For example, if a student says, “This object is small,” ask her, “How small? Describe the length. 1cm? 1 inch? The size of a button? What is the shape of the object?”

Initial Observation	More detailed observation
It’s small	This object is the size of a dime, and is flat, but is a square shape.

1. If a student says, “This object is made of wood,” ask him, “What color is the wood? Is the wood hard or soft? Does it feel heavy or light?”

Initial Observation	More detailed observation
It’s made of wood	This object is made of a very lightweight wood that is a tan color with lines running through it.

1. Try to get around to every group to help students deepen their observations.
2. Students choose one observation to read to their group. Group members help each other make each observation more detailed. Students record the improved observation on their Observation Inference Practice worksheet.

Making Observations AND Inferences - Object #2

1. Bring class together briefly and discuss: Sometimes our inferences are not based on the observations and only based on prior assumptions we have. How can we make sure our inferences are closely tied to our observations? (Repeat the observation at the beginning of the inference.)
2. Each group gets a new object.
3. Again, if anyone in the group knows what the object is or how it works, trade it out.
4. Students make observations and inferences about the object and write their ideas on the Observation Inference Practice worksheet.
5. Bring the class together and have each group share out one observation and inference about their object.
6. Take the time to discuss and critique each observation and inference.
7. Students improve upon their observations and inference in the Observation Inference Practice worksheet.

Making Observations and Inferences AND Asking Questions - Object #3

1. Bring class together and briefly revisit the importance of asking questions.
2. Each group gets a new object.
3. Again, if anyone in the group knows what the object is or how it works, trade it out.
4. Students make observations and inferences and ask questions about the object and write their ideas on the Observation Inference Practice worksheet.

Explain

1. In this activity, the use of each unusual object from the previous activity is revealed.
    - This portion of the lesson may need to be completed in a second class period.
2. The Observation Inference Practice worksheet intentionally does NOT include a place for students to guess what the objects are for, so that students focus on their individual observations and inferences.
3. However, guessing what the objects are and finding out what they are is fun!
4. Give students an opportunity to write down a guess for each object in the margin of their worksheet.
5. Reveal each object's true use.
6. Enhance this portion of the lesson with a slideshow that has images or videos of each item in use.

Elaborate

1. In this activity, the students make observations and inferences about a more familiar creature, the blue crab.
2. Bring the class back together and show them the image of the blue crab in the Observation Inference Images powerpoint.
3. Explain: We will be seeing organisms in our Oyster Restoration Station that look somewhat familiar: they might look like a shrimp or a crab or a worm. When observing these organisms, it is very important that we don't jump to conclusions about what the organism is. We first need to look at the different parts of the organism and describe them (observations) and then we can consider what their particular purpose might be (inference).
4. Have students offer observations.
5. Do not accept the observation, "It's a crab." Students must not jump to the big picture or "the answer," but look at the details of the organism.

6. Read down through the table below to see an example of a teacher helping a student deepen and strengthen his/her observation and inference and question.

Student Observation	**Student Inference**
It's shell is brown	For camouflage
Teacher Response	**Teacher Response**
Be more specific, what kind of brown? What other colors?	For camouflage with what?
Student Improvement	**Student Improvement**
The crab has a brownish/greenish shell with some red spikes around the edges	This color is so that the crab can camouflage with the mud and sand at the bottom of the harbor.
Teacher Probing Deeper	**Teacher Probing Deeper**
Give a detailed observation about the legs	If the shell is for camouflage, how do the legs fit into that inference?
Student Response	**Student response**
The crab has bright blue on all eight of its legs and its legs are lower down than its shell	The crab buries it's legs under the sand when it is at the bottom of the harbor, so predators don't see the blue color, but when it wants to catch some prey it jumps out of the sand and surprises it's prey with it's bright blue legs.
Teacher Probes about Remaining Questions	
After looking carefully at the shell and blue legs, what questions are you left with? Is there something that doesn't quite fit into your inference?	
Student Asks a Question	
What is the purpose of the red color at each join and on the spikes of the shell?	

Remember, inferences don't need to be 100% correct for students to be doing really good thinking!

Evaluate

1. For an evaluation, show the image of the gammarid amphipod in the Observation Inference Images powerpoint.
2. Each student gets an Observation Inference Evaluation worksheet.
3. Decide how much assistance you feel you need to give students for this final activity. You could repeat the process above or you could treat it more like a quiz and have students fill it out silently and then collect it.

Standards

Observation Inference Evaluation

Directions: *Look at the image of the organism and write three detailed observations and three corresponding inferences and questions.*

Observation (Objective) ● Use your five senses. What do you see, hear, smell, taste, feel?	**Inference** (Subjective) ● What do you think it means? Why do you think it is this way?	**Question** ● What are you left wondering?
1)	1)	1)
2)	2)	2)
3)	3)	3)

Observation Inference Practice

Observation (Objective) ● Use your senses. What do you see, hear, smell, taste, feel?	**Inference / Prediction** (Subjective) ● What do you think it means? Why do you think it is this way?

Notes/Results/Sketch/Questions/Connections

Observe Oyster Spat-on-Shell

BOP Curriculum
bop-curriculum@nyharbor.org
Jan 17, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Oyster Tank Investigation	6-8th	1	Classroom	Science Math

Summary

Students closely observe live spat-on-shell and record their observations.

Objectives

- Make close observations.
- Identify live versus dead oysters.

Materials and Resources

Supplies

- 10 oyster clumps with live spat-on-shell
- Paper towels
- Nail polish

Before you get started

Tips for Teachers

- This lesson is designed to be completed in preparation for setting up a classroom oyster tank. The spat-on-shell oyster clumps that the students observe in this lesson are the same oysters that are put into the classroom tank.
- Figure out when you will get your oyster clumps from Billion Oyster Project and how long it will be until your class is ready to set up the oyster tank. Be sure to have a plan in place to keep your oysters alive during that time. See the Oyster Tank Guide for more info.

Instruction Plan

Explore

1. In this activity, students get a close look at the spat-on-shell that will live in their classroom tank.

2. Explain: These oyster clumps are the same ones that will live in the classroom tank once we set it up.

3. Students get into small groups. Ideally, there should be 10 groups - one group for each oyster clump that will be placed in your classroom tank.
    - Each group gets an oyster clump and paper towels.
    - Each student gets a Spat-on-Shell Observations worksheet.

4. Students start by observing the oyster clump and making a list of detailed observations. Then they sketch both sides of the oyster clump.
    - Discuss: Similarities and differences groups noticed about their oyster clumps?
    - Discuss: Observation of any organisms other than oysters? Invertebrates? Vertebrates? Can we identify any of them? Students can refer to the these Species ID Resources.
    - Discuss: Did you have both live and dead oysters? How could you tell?

5. Describe: The methods to determine whether an oyster is dead. Reminder: Small oysters (<2cm) are very fragile.
    - Gently try to pry the oyster shell open with your fingernail. A dead oyster will generally open very easily. A dead oyster can be filled with mud, so don't mistake that for being a live oyster.
    - Shell is visibly open.
    - Softness in the shell.
    - Bubbles discharged when the shell is lightly pressed.

- Hollow sound when tapped.

6. Students return to their oyster clump, identify live and dead oysters and record findings on the Spat-on-Shell Observations worksheet.

7. Students need to get to know their oyster clump very well. We hope students also begin to form an interest in and attachment to their oysters. After all, the students should be responsible for maintaining the tank and caring for the oysters throughout the school year.
    - Discuss: How will students be able to identify their oyster clump once it's mixed in with the other clumps in the tank? Are there any oyster clumps that have distinguishing features?
    - Each group gives their oyster clump a name.
    - Hand out the nail polish.
    - Students dry off the oyster clump and using the nail polish, paint a number (1 through 10) on it, so each clump has a unique number.

8. Consider hanging up a poster that includes the number of each oyster clump and its corresponding name.

Standards

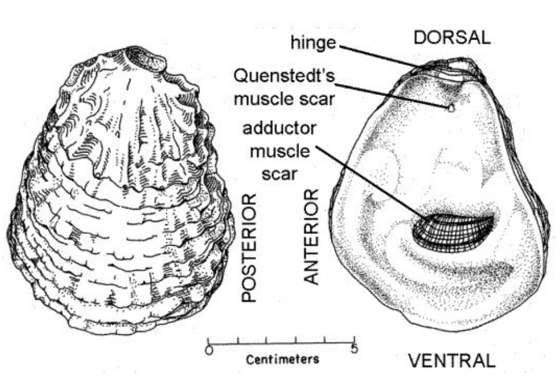
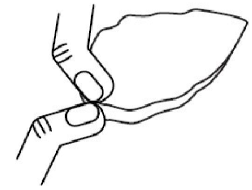
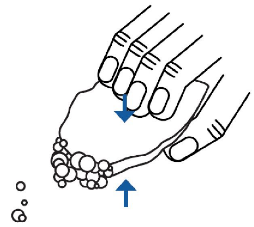
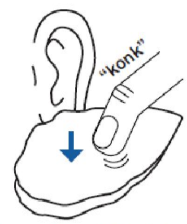
NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
    - Interdependence
- Grade 7, Unit 4
    - Dynamic Equilibrium: Other Organisms

Spat-on-Shell Observations

Directions: *Pass the oyster clump around your group. Take a very close look at it. Talk about what you see and what you are curious about with your group.*

Observations What do you see, smell, feel, hear? (Let's hold off on tasting.) Make sure you discuss things such as colors, texture, shapes, sizes, live vs. dead oysters, etc. Be specific and FILL UP THIS BOX!
Questions Make note of anything your observations leave you wondering about. Don't be shy!

Oyster Shell Anatomy (with no spat!)	Alive vs. Dead
	 A Dead Oyster Is Gaping Open  To Check If Oyster Is Dead, Gently Try to Pry It Open  Dead Oyster Will Discharge Bubbles When Lightly Squeezed  Dead Oysters Sound Hollow When Lightly Tapped

Sketch
Now that you have taken a close look at your oyster clump it's time to sketch it. Make sure you sketch both sides of your clump. Draw the spat too! Use labels.

Side 1	*Side 2*

Once you put your oyster clump into the classroom tank, how will you be able to distinguish it from all the other clumps? What unique feature(s) does your oyster clump have?

Name your oyster clump! ____

Ocean Acidification and pH

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 11, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	3	Classroom	Math

Summary

This lesson provides an introduction to acids and bases. It begins with looking at the acid content of several items around the house. Then, there is a discussion of pH and what it means. After that, the students complete an experiment where they look at the effect of Carbon Dioxide in water. Finally, they watch a video on ocean acidification and oysters.

Objectives

- What is pH?
- What does Carbon Dioxide do to the pH of the ocean?
- How does the pH of the ocean affect oysters?

Materials and Resources

Supplies

- Erlenmeyer Flask Scrap
- Paper Matches (for teacher only)
- Water Indicator solution (or possibly pH meter, but it is hard to fit in an erlenmeyer flask)

Before you get started

Tips for Teachers

- During the lab, make sure that you are the only person who handles matches.
- For older students or advanced students, feel free to discuss that "acid" is the concentration of H+ ions. For younger students, it is probably best to talk about "more" or "less" acidity.

Preparation

N/A

Background

Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide (CO2) from the atmosphere. An estimated 30–40% of the carbon dioxide from human activity released into the atmosphere dissolves into oceans, rivers and lakes. This lesson looks at the effect on pH of creating "pollution" in water. Students will first experiment with what pH is and understand acids. Then, they will do an activity where they pollute the water with carbon dioxide and consider the dissolved oxygens.

Instruction Plan

Engage

At the front of the room, have beakers of each of the following:

1. Tomato Juice
2. Vinegar
3. Lemon Juice

4. Water

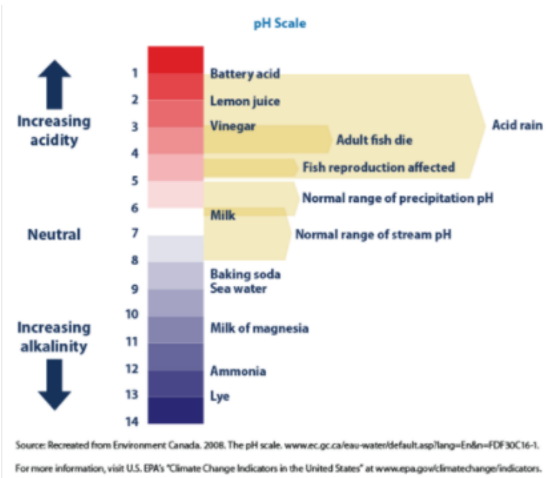
Ask students what an acid is. Ask them what they think of when they hear the word "acid." Ask students to hypothesize about which of the following items will be the most "acidic" and rank the substances in order from most acidic to least. Write students' hypotheses on the board. Save for later in the lesson.

Explain

Explain that pH is the scale by which acids and bases are measured. The lower the pH, the more acid there is. Explain that a pH of 7 is neutral.

Then, using your pH meter, test the pH of the substances and discuss whether or not hypotheses were correct.

Now put the following diagram up (or distribute on a worksheet):



Discuss the pH of the substances on the board. Then have students complete the "pH and Powers of 10" worksheet.

Elaborate

Do the ocean acidification experiment. Then, have students read the article "Are Oysters Doomed?" Discuss the effect of Carbon Dioxide emissions on Oysters.

Evaluate

Ocean acidification and oysters film and discussion:

http://www.pmel.noaa.gov/co2/story/Ocean+Acidification's+impact+on+oysters+and+other+shellfish

Standards

CCLS - ELA Science & Technical Subjects

- - Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

CCLS - Mathematics

- - Recognize and represent proportional relationships between quantities.

NGSS - Cross-Cutting Concepts

- Patterns
    - Macroscopic patterns are related to the nature of microscopic and atomic-level structure.

NGSS - Disciplinary Core Ideas

- PS1.B: Chemical Reactions
    - Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
    - Analyze and interpret data to provide evidence for phenomena.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
    - Weather and Atmosphere
- Grade 6, Unit 4
    - Interdependence
- Grade 8, Unit 4
    - Humans and the Environment: Needs and Tradeoffs

NYS Science Standards - Key Ideas

- LE Key Idea 7
    - Human decisions and activities have had a profound impact on the physical and living environment
- PS Key Idea 2
    - Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.
- PS Key Idea 3
    - Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity

NYS Science Standards - Major Understandings

-
    - Substances have characteristic properties. Some of these properties include color, odor, phase at room temperature, density, solubility, heat and electrical conductivity, hardness, and boiling and freezing points.
    - Substances enter the atmosphere naturally and from human activity. Some of these substances include dust from volcanic eruptions and greenhouse gases such as carbon dioxide, methane, and water vapor. These substances can affect weather, climate, and living things.
    - The environment may contain dangerous levels of substances (pollutants) that are harmful to organisms. Therefore, the good health of environments and individuals requires the monitoring of soil, air, and water, and taking steps to keep them safe.

NYS Science Standards - MST

-
    - Students will access, generate, process, and transfer information using appropriate technologies.
    - Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Materials:
Erlenmeyer Flask
Scrap Paper
Matches (for teacher only)
Water
Indicator solution

Procedure:

1) Stuff a strip of paper into your Erlenmeyer flask.
2) Have your instructor light it on fire (!!!!)
3) Let it burn until it has created a lot of smoke, then cover it with a stopper.
4) Add a very small amount of water (just coat the bottom). Try not to left too much smoke escape.
5) Add the universal indicator to see the pH.

Analysis:

1) What is the pH of pure water? (look at the previous worksheet)

2) How did the pH change when the smoke was dissolved into the water?

3) In this experiment, we are looking at the effect of pollution on the pH of oceans. Write which part of the experiment represents the following real world concepts:

The ocean___________

Pollution ____________

Explain why:

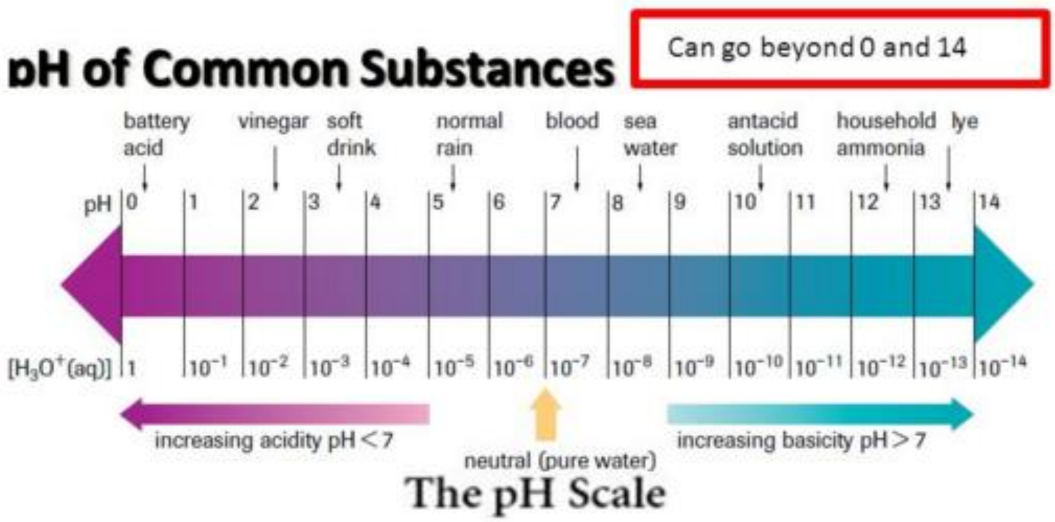
4) What conclusion can you draw about the effects of pollution on ocean pH levels?

5) Burning paper creates Carbon Dioxide. Knowing this, describe what the Carbon Dioxide does to the acid levels in the oceans.

6) In their larval stage, oysters can be dramatically affected by changes in pH. Explain what increased Carbon Dioxide levels worldwide might do to affect oysters.

7) Make a hypothesis: If oysters have shells made of Calcium, what effect might acid have on these shells?

What is the pH?



Ph is on a powers of 10 scale.

This means that something with a pH of 4 is 10 times more acidic than something with a pH of 5.

Answer the following questions:

1) **Example**: A lemon has a pH of 2 and an apple has a pH of 4. How much more acidic is a lemon than an apple?
A lemon is 2 spaces away from an apple on the pH scale so it is 10 x 10 =100 times more acidic than an apple. Shortcut: the number of spaces on the pH scale is the number of 0's on the scale.

2) If a banana has a pH of 5 and lemon has a pH of 2, how much more acidic is a lemon?

3) Cola has a pH of about 2. How much more acidic is it than pure water?

4) If an apple is 1000 times more acidic than water (pH 7), what is the pH of an apple? Why?

5) How much more acidic is Hydrochloric acid than water? Be careful with your 0's!

6) Hot sauce has a pH of 5. If Dr. Pepper is 100 times more acidic, what is its pH?

7) Mountain Dew has a pH of 4. Root beer has a pH of 6. How much more acidic is Mountain Dew than root beer?

Our Questions So Far

BOP Curriculum
bop-curriculum@nyharbor.org
Jan 17, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Oyster Tank Investigation	6-8th	1	Classroom	Science

Summary

Students add new questions about oyster reef associate species to the class' list, Student Questions as of (today's date). Students then sort this list of Student Questions as of (today's date) of questions in a two ways. The first sort is completely open-ended. The second sort asks students to consider different ways of looking for answers to each question.

Objectives

- Manipulate and evaluate students' questions without needing to answer them right away.
- Evaluate different approaches to finding answers to different kinds of questions.

Materials and Resources

Before you get started

Tips for Teachers

- This lesson use Student Questions as of (today's date). This is a list of questions generated by your students during the prior two lessons in this series: "Part 2 - What Do Oysters Need in our Classroom Tank?" and "Part 3 - Will Our Oysters Do Better in the ORS or in the Classroom Tank?" This list must be typed-up and numbered in advance of this lesson!
- We encourage you to keep the activity open to lots of different kinds of questions, especially questions about other ORS organisms. In our experience, those are interesting, exciting critters that generate a lot of great student curiosity and questioning!

Preparation

- Type up the list of Student Questions as of (today's date) using questions that you posted above the classroom tank (and created in the lesson "Part 2 - What Do Oysters Need in Our Classroom Tank?"). It's important to number the questions, so students can refer to them easily during class.
- Add to the the list of Student Questions as of (today's date) any other interesting questions you've overheard, or that students have written down, which did not make it to the list above.
- Consider re-typing the students' predictions in the form of questions from the Lesson "Part 3 - Will Our Oysters Do Better in the ORS or in the Classroom Tank?"

Instruction Plan

Engage

1. Each student gets the Student Questions as of (today's date) and the Species ID pages out of the BOP ORS Field Manual.
2. Ask your students:
   - Look at this giant list of questions you all have articulated in the past few lessons! Are you surprised by anything about the list?
   - Think about some of the other organisms you saw at the Oyster Restoration Station. Let's add some questions about those to our list.
3. Track questions about other ORS organisms on a board, so students can include them at the end of the list of Student Questions as of (today's date).

4. If you brought any ORS organisms back to your classroom tank, this would be a good moment to remind students of that, and perhaps invite a few students to observe the tank and add questions to the list while others continue with the main activity.

Explore

1. Ask your students to categorize the questions, using any categories they like.
2. Rules:
   - Every question needs a category.
   - Don't make a "miscellaneous" category. Instead, come up with a substantive way to categorize each and every question.
   - If it helps, you can slightly change some of the questions, or turn one question into two related questions.
3. Note: This sort is meant to help the students read all the questions and to help them recognize that there are different ways of thinking about questions. It can also give you an idea of how the students are understanding the questions.

Elaborate

Lead a discussion about the first sort. Possible discussion prompts:

- Let's hear the categories that some students came up with.
- Do some of you have other systems of categories?
- What was the trickiest question to categorize? How did you deal with it?
- What types of things does it look like our class is particularly interested in?
- Are there questions you found difficult to understand? Are there ways to clarify those?
- Do you have additional questions for the list at this time?
- After sorting the questions, what did you notice about a question that you hadn't noticed before?

Evaluate

1. Distribute Sort #2. It asks students – first individually, and then in small groups – to sort the same list of Student Questions as of (today's date) of their questions using these three categories:
   - Questions we can best answer by consulting experts – either by talking to people, or by reading things that people have written.
   - Questions we can best answer by setting up an experiment and collecting our own data.
   - Questions we can best answer by looking at someone else's data.
2. Lead a discussion about the second sort. Possible discussion prompts:
   - What were the tricky questions to sort?

- What were the most persuasive arguments that your classmates made, to convince you to switch a question from one category into another?
- What makes a great experimental question?
- Of your experimental questions, which would you most like to experiment on this year?

1. If no students mentioned the ORS or the field, follow up with the following questions:

- Could any of these questions be answered by collecting data in the field?
- Could you rewrite any of the questions to make them answerable with field data?
- Could any of these questions be answered if you had access to many people's ORS data over time?
- Of your field data questions, which would you most like to answer by collecting field data this year?

Extend

To begin to tease out the distinctions between observational and experimental studies:

1. Add a fourth category to Sort #2: Questions we can best answer by making our own observations (without setting up an experiment).
2. Discuss the process of sorting experimental from observational questions. Possible discussion prompts:
   - When we go to the field to monitor our ORS, are we doing an experiment? Always, sometimes, or never? Depending on what? Why?
   - What makes a great observational question?
   - Of your observational questions, which would you most like to pursue this year?

Standards

Sort #2 - on your own

Working by yourself, sort all the questions in the list of *Student Questions as of (today's date)* into these three categories:

Questions we can best answer by...

consulting experts -- either by talking to people, or by reading things that people have written.	**setting up an experiment and collecting our own data**.	**looking at someone else's data.**
If you have time after sorting the entire list of Student Questions as of (today's date), *go back to each category, choose one interesting question, and write about:*		
Where could we find experts on this question? "My teacher" doesn't count!	*How could we set up experiments and collect data to answer this question?*	*What kind of data would we need to answer this question. Be specific!*

Oyster Tank Topic Library

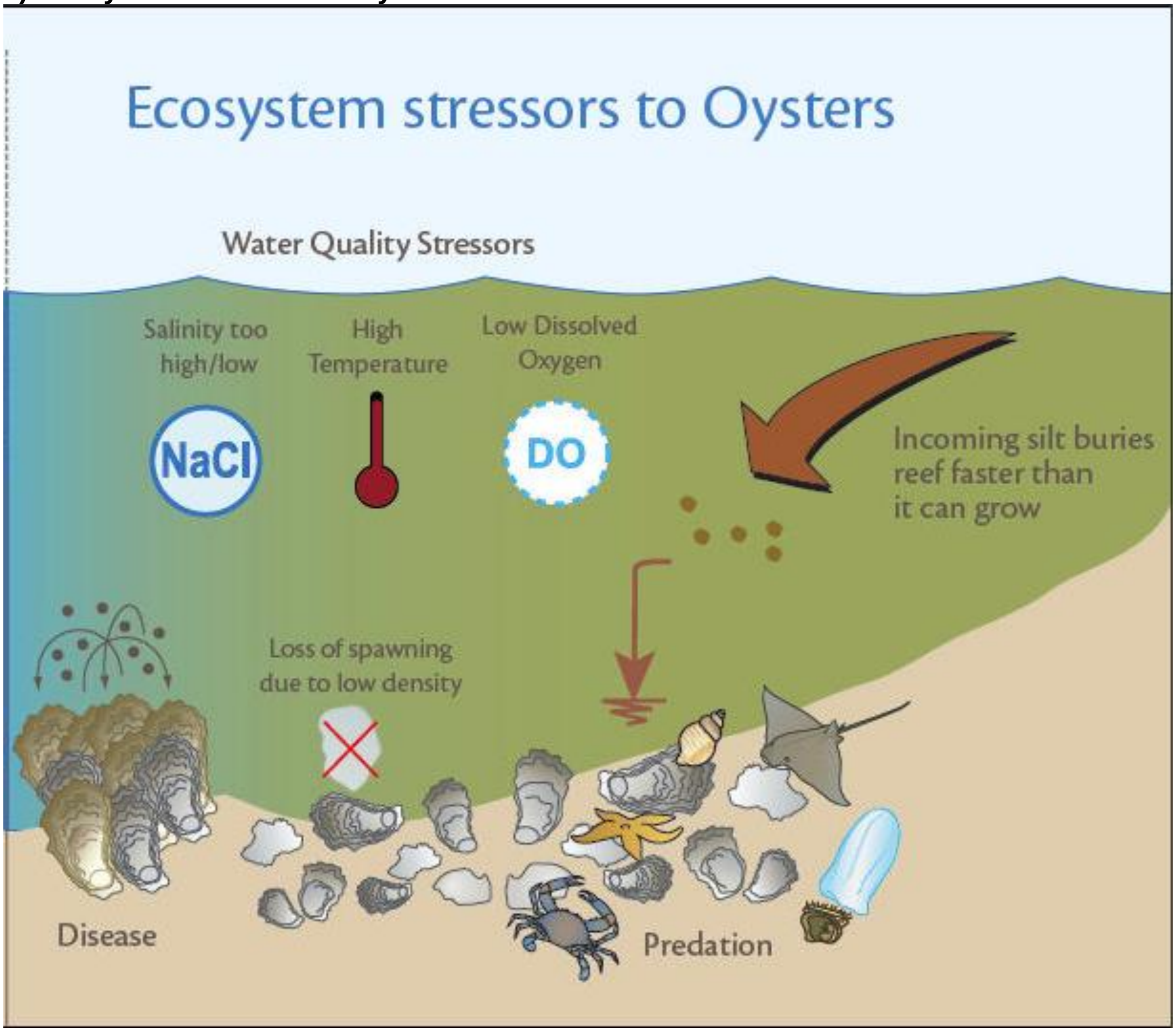
Consider as you read:
When you set up an oyster tank, should you try to imitate the conditions in the estuary?

Table of Contents:

1) Oyster Recovery Partnership "Kids Zone"
"Oysters are pretty cool creatures. They live most of their lives in a shell at the bottom of rivers or bays….Oysters eat by sucking water through their bodies, pulling out the nutrients they need to grow."

From Oyster Recovery Partnership: http://oysterrecovery.org/oysters-101/kids-corner/

2) Ecosystem stressors to oysters:



From the National Oceanic and Atmospheric Administration, "Oyster Reefs":
https://chesapeakebay.noaa.gov/oysters/oyster-reefs

3) Crunchy on the Outside, Soft and Squishy on the Inside
"Oyster predators can easily locate oyster prey and since oysters are not mobile. Once found, they have no means for escape. However, the oyster's thick shell presents a significant deterrent to oyster predators as they must first penetrate the shell before consuming the tissue.

Successful oyster predators possess specialized adaptations that help them crush, drill, or open the shell exposing the meat within. Common oyster predators include snails, crabs, starfish, flatworms, and fish (such as cownose rays, oyster toadfish, flounder, drumfish)."

From Project Ports Guide 3: https://www.billionoysterproject.org/wp-content/uploads/2013/06/curriculum_guide_3-1.pdf

4) Brackish Aquarium Setup

"Brackish water is somewhere between "pure" freshwater and "high salinity" ocean water....

Brackish species are very adaptable.... As long as waste products (ammonia, nitrite, and nitrate) are at safe levels, the animals will do fine, even if there is a gradual change in pH, hardness, or salinity. Because these animals naturally live in an environment where water parameters may change from one spot to the next, a super-stable environment is not quite as important for brackish species."

From Fishlore.com http://www.fishlore.com/aquariummagazine/feb08/brackish-fish-tank-setup.htm

5) Creating A Brackish Habitat Fish Aquarium

What is "Brackish?"

It's not quite saltwater, but it's definitely not freshwater. Brackish waters occur all over the world where inland freshwater streams and springs meet the ocean, creating estuaries. The lower part of the Hudson River that separates New York and New Jersey, for example, is a giant brackish estuary….

The Salinity of Brackish Water

The world's marine waters have a salinity between 32 and 35 parts per thousand. Brackish water, by definition, must be lower than that...

Calculating the salinity of water is done by measuring specific gravity (SG) with a hydrometer….For practical purposes, brackish aquarium water should range between 1.002 to 1.022 SG at a temperature of 77 degrees Fahrenheit. Most brackish aquarium animals can tolerate this range. A 50/50 mix of fresh and marine water would provide a salinity of 1.012 SG – a happy medium for a general brackish aquarium...

If you want to provide the best care for your brackish animals, however, I recommend matching the salinity level to the type of brackish habitat you are trying to re-create or the type of brackish animals you want to maintain."

From Petcha.com: http://www.petcha.com/creating-a-brackish-habitat-fish-aquarium/

6) Estuarine Aquarium Keeping for Beginners

"Temperature

All aquatic animals have a range of temperatures in which they can live, and they do best when temperatures are close to the middle of that range. School classrooms are notoriously warm,

and this can 4 be a *major* factor in regards to which species will thrive. Water temperatures can easily climb into the 80 degrees Fahrenheit in a school hallway, or during the weekend if they turn the air conditioning off...

Ammonia becomes more toxic with higher aquarium temperatures and the nitrifying bacteria that comprise the biological filter will likely die if water temperatures rise above 95 degrees F.

You do not have to be concerned about cold-water periods. As the water temperature in your aquarium decreases, the critters will simply slow down and may stop eating entirely. It should not be a problem if your water temps decrease to 50°F, or even colder during school vacations."

"Oxygen

….Water can hold less dissolved oxygen (DO) as it gets warmer and saltier. Estuarine water usually holds between 5 and 8 parts per million (ppm) oxygen...Fish will begin to get stressed in DO levels of 3 and 5 ppm and will get very stressed in water below 3 ppm. All tanks should have several sources of oxygen…

Animals use more oxygen when they are active and also after eating, while they digest food. Active animals (such as fish that don't stop swimming around the tank) use more oxygen than more sedentary species. Animal metabolisms increase with rising water temperatures, so animals also use more oxygen as the temperature increases. It is important to remember that the bacteria in the biological filter… also use oxygen.

Dead animals and uneaten food left in the tank are decomposed by huge numbers of bacteria, which use oxygen. These bacteria can cause the oxygen in your tank to decrease to a harmful level for your animals. Therefore you should not have uneaten food or dead animals present in your aquarium."

"Tank Size

The volume of water in the tank, the surface area of the water/air interface and the surface area of the substrate are all very important.... Most estuarine animals stay close to the bottom of the tank, so you should try to maximize the bottom surface area of an estuarine aquarium. For instance it is better to purchase a 20-gallon long aquarium instead of a 20-gallon tall model. The long model has more bottom surface area than the 20-gallon tall aquarium model. The surface area of a tank is important in gas exchange (namely oxygen)...

The surface area of the substrate, or bottom of the tank, is also very important. Bacteria grow on the surface of aquarium substrate. These bacteria are part of the biological filter.... A larger bottom area will give you more substrate surface area for the bacteria to grow, which increases your biological filter. This is a good thing. Crushed coral and gravel have a lot more surface area for bacteria growth than sand, because sand is made of such small grains that they pack closely together, leaving few nooks and crannies."

"Aging The Aquarium or Cycling the Biological Filter

One of the most critical steps in starting up an aquarium is giving the aquarium enough time for the biological filter bacteria population to build up or "cycle." Animals excrete ammonia waste (NH_3), which is toxic. Animal feces, uneaten food and dead animals will also add ammonia during decomposition. This ammonia will build up unless you frequently change a lot of water (impractical), or your biological filter converts it first to nitrite (also toxic) and then to nitrate (not toxic) through the nitrogen cycle. It takes time for your nitrifying bacteria population to build up, and this process is called aging or cycling. The nitrobacter and nitrosomonas bacteria, which do

this important job, are found in all aquatic environments, and they are in the river or bay water that you fill your tank with."

From the Chesapeake Bay National Estuarine Research Reserve in Virginia.
http://www.vims.edu/cbnerr/_docs/education_docs/EstAquKeepwriteup.pdf

7) Creating Oyster Habitat- What Makes a Good Site?
By Don Meritt, Sea Grant Shellfish Specialist

….This article will address some of the basic issues that need to be considered in choosing sites for oyster restoration.

Salinity
Perhaps the most important factor for oysters is salinity. Oysters can survive in salinities from under 5 ppt to full strength ocean water and more (ocean water is around 35 ppt). These low or high salinity levels can cause of physiological stress. Unless your site is in a fresh water or ocean region, salinity will vary from season to season and year to year... A good indicator of a site's suitability is live oysters nearby….

Dissolved Oxygen
It's important that oysters have enough oxygen. The absence of oxygen, or anoxia, can especially occur in summer months when bacteria… use up dissolved oxygen in the water. Winds, currents and plant activity (photosynthesis) as well as direct transfer from the air to the water all contribute to adding oxygen to the water. Locating oyster reefs in areas with good circulation, where the water is well mixed from top to bottom, should help….

Disease
Oysters in many prime growing regions are under attack by… MSX disease… and Dermo disease (but these oyster diseases do not harm people). The microorganisms that infect oysters are also influenced by salinity. MSX is only found in areas where salinities are moderately high, above 14 to 16 ppt. Dermo disease is better able to survive in lower salinity waters.

Predation
While the oyster is wonderfully adapted for thriving in a wide range of conditions, it is still vulnerable to attack by predators such as oyster drills, boring sponges, and blue crabs. Consider predators and parasites that may invade the oyster reef you are planning to construct. In other words, try to locate reefs at sites where predatory organisms are less common.

Bottom Characteristics
Oysters grow best on hard substrates. Think of an oyster reef as the foundation of a house: no one would build a house directly on top of mud – it would sink until it encountered a bottom solid enough to hold up the rest of the structure. The foundation of a reef must be strong enough to keep the oysters from sinking into the ground and strong enough to withstand storms and other forces – particularly waves and heavy current surges – that could tear it apart.

Exposure: Physical and Human
Heavy wave action, for example, can actually lift oysters and shells and transport them to locations far from where they were originally placed. This is especially true in shallow water areas. Any reefs in water less than six to twelve feet deep should not be located in areas where severe winds will cause heavy wave action. Even if the force of the waves does not move the oysters, it may stir up sediments, and that could bury the oysters. Exposure to runoff that carries toxic substances should also be avoided.
From Maryland Aquafarmer Spring 2001

8) Environmental Factors Affecting Oyster Populations
The list below is the table of contents from a chapter entitled, “Environmental Factors Affecting Oyster Populations” from a 1964 scientific publication from NOAA about the American oyster.

As you read the list, what do you recognize? What would you like to know more about?

A couple fun terms:

- Gastropods are snails. Gastro = gut, and pod = foot. Does it make sense to you somehow that “gut-foot” = snail?

- Commensals are different species that live together. One of the species benefits from the relationship, and the other species is unaffacted. “Com” = sharing, and “mensal” = a table. Does it make sense to you somehow that “sharing-a-table” = commensal?

Excerpted from “The American Oyster, *Crassostrea virginica* Gmelin,” from the NOAA Northeast Fisheries Science Center’s (NEFSC) “Classic Publications” page, which includes NEFSC literature “from pre-computer days.” The excerpt is here.

9) Problems with low dissolved oxygen in the East River:

Although the East River's water quality has steadily improved, it still has problems with eutrophication, turbidity, and low levels of dissolved oxygen. As suspension filter feeders, oysters have a great capacity for water filtration. On a per-area basis, oyster reefs are estimated to remove 25 times more nitrogen than salt marshes do (Waldman 1999). Oysters remove phytoplankton, particulate organic carbon, sediments, pollutants, and microorganisms from the water and they use most of the organic matter that they filter (Tolley et al.).

Oysters are generally hardy creatures (Waldman 1999) but... their development and mortality are influenced by salinity, current velocity, and dissolved oxygen levels. Oysters generally tolerate salinity levels between 15-25 ppt….Current velocity can affect oyster growth because currents bring food and oxygenated water to the reefs (Brumbaugh et al. 2006).

Generally, dissolved oxygen levels should consistently be above 5.0 mg/l or above. In its current state, the Lower East River barely meets this requirement during the summer and the Upper East River has dipped below this threshold (NYCDEP 2004); this affects the timing and location of oyster restoration.

Adapted from: http://www.columbia.edu/itc/cerc/danoff-burg/RestoringNYC/RestoringNYC_EastRiver.html

10) NY/NJ Harbor Estuary Map from Stevens Institute of Technology shows parameters like surface and bottom salinity, surface currents, surface air temperature, etc. Via: http://hudson.dl.stevens-tech.edu/maritimeforecast/maincontrol.shtml

Sort # 2 - in a small group

With a small group, discuss your individual responses for Sort #2.

- What does everyone agree on, if anything?

- Where do you find the most disagreement?

- Spend some time discussing the points of disagreement.

Try to persuade your groupmates and arrive at a **group consensus** to answer the following questions:

From our list of *Student Questions as of (<u>today's date</u>)*, what are the <u>top three best</u> questions to answer by…

consulting experts -- either by talking to people, or by reading things that people have written?	<u>Why</u> are these the top three best questions to answer by consulting experts?

1.	1.
2.	2.
3.	3.

From our list of *Student Questions as of (<u>today's date</u>)*, what are the <u>top three best</u> questions to answer by…

setting up an experiment and collecting our own data?	<u>Why</u> are these the top three best questions to answer by setting up an experiment and collecting our own data?
1.	1.
2.	2.
3.	3.

looking at someone else's data?	Why are these the top three best questions to answer by looking at someone else's data?
1.	1.
2.	2.
3.	3.

Sort #2 - on your own

Working by yourself, sort all the questions in the list of *Student Questions as of (today's date)* into these three categories:

Questions we can best answer by...

<table>
<tr><td>consulting experts -- either by talking to people, or by reading things that people have written.</td><td>setting up an experiment and collecting our own data.</td><td>looking at someone else's data.</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">If you have time after sorting the entire list of Student Questions as of (today's date), go back to each category, choose one interesting question, and write about:</td></tr>
<tr><td>Where could we find experts on this question? "My teacher" doesn't count!</td><td>How could we set up experiments and collect data to answer this question?</td><td>What kind of data would we need to answer this question. Be specific!</td></tr>
</table>

Sort # 2 - in a small group

With a small group, discuss your individual responses for Sort #2.

- What does everyone agree on, if anything?
- Where do you find the most disagreement?
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consulting experts -- either by talking to people, or by reading things that people have written?	Why are these the top three best questions to answer by consulting experts?

1.	1.
2.	2.
3.	3.

From our list of *Student Questions as of (<u>today's date</u>)*, what are the <u>top three best</u> questions to answer by…

setting up an experiment and collecting our own data?	<u>Why</u> are these the top three best questions to answer by setting up an experiment and collecting our own data?
1.	1.
2.	2.
3.	3.

looking at someone else's data?	<u>Why</u> are these the top three best questions to answer by looking at someone else's data?
1.	1.
2.	2.
3.	3.

Oyster Anatomy

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 8, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	2	Classroom	

Summary

Students will investigate the anatomy and morphology of an eastern oyster through observation and dissection.

Objectives

1. Dissect an oyster.
2. Observe structures of oyster's anatomy and make inferences.
3. Sketch the oyster and accurately label it.
4. Identify major body parts and structures of the oyster.
5. Design an oyster predator that takes advantage of the oyster's anatomy and morphology.

Materials and Resources

Supplies

Live adult oysters (can be purchased at Fresh Direct or Whole Foods) Live spat-on-shell (from your Oyster Restoration Station or Billion Oyster Project) Hand lenses Dissection trays or plastic plates Oyster shucking knife and glove Dissection tool Dissection microscope or hand lenses Calipers

Before you get started

Tips for Teachers

Consider partnering with BioBus for access to a classroom set of microscopes (biobus.org) This activity works best in groups of 2-3 students Consider how and when you will shuck the oysters. If possible, get enough oysters to have a set that is alive and closed and a set that is shucked shortly before students arrive in class. Tissues should be carefully dissected from one shell and remain attached to the second shell. Set the removed shell on top of the exposed body. Invite some volunteers into your classroom to help shuck oysters. Recycle your oyster shells in the estuary when your lesson is complete!

Preparation

N/A

Background

Oysters have a relatively simple anatomy that is both reliable and efficient. Taking a look at the oyster's anatomy gives us some insight into how an oyster functions within its environment. One of the most important features of the oyster's morphology is that they are filter feeders. They eat by drawing in water over their gills with the help of cilia. Suspended plankton and particles are trapped in the mucus of the gills, and from there are transported to the mouth, where they are eaten, digested, and finally expelled. An adult oyster can filter up to 50 gallons of water per day!

Instruction Plan

Engage

1. Students get into small groups
2. Each group gets a live, adult oyster. This is an oyster that is about 2 inches long, with two shells that are closed tightly.
3. Students look at the oyster carefully and either have a discussion or do a short piece of writing based on the following questions:
    - What does an oyster look like on the outside? What do you think it looks like on the inside? What body parts do you think it has in there?
    - Think about human anatomy and fish anatomy. Does the oyster have eyes, ears, mouth, lungs, heart, etc? (You may want to display or hand-out the diagrams below.) Which body parts do you think the oyster needs to survive?

Fish Anatomy

bony-fish-anatomy.gif

https://wavemakersrq.wordpress.com/2014/11/23/module-6-vertebrates-part-2-2/

Human Anatomy

Human-Anatomy-with-Organ-Diagram.jpg

http://humandiagram.info/the-complexity-of-human-anatomy-organs/human-anatomy-with-organ-diagram/

Explore

Explore the Oyster Reef Organisms

1. Get into a group of 2-3 students.
2. Students get the *Oyster Anatomy Worksheet* and the *Oyster Reef Organism Key*
3. Each group gets a spat-on-shell on a dissection tray and adds their live adult oyster.
4. Observe the spat-on-shell and look for other organisms (e.g. worms, barnacles, or crabs). Remove organisms and observe with hand lens or microscope.
5. Sketch, describe and label the organisms. Use the *Oyster Reef Organism Key* to help you identify them.
6. Make an inference: why are these organisms found among oysters?

Explore the External Anatomy

1. Examine the outside of an oyster.
    1. Identify the two shells and compare them. Think about the size, thickness and shape of the two shells.
    2. Why might the two shells be different? What part of the oyster shell do you think was attached to the reef? Why?
    3. Why does the oyster have a hard exterior? Why does it have two shells? How might this help the oyster?
2. Measure the length of the shell the “long way” and record your result. Why do you think we need to measure the size of the oyster?
3. Sketch and describe the external anatomy of the oyster. What do you see? Make some inferences: why does the outside of the oyster look this way?
4. Get an *Oyster External Anatomy Diagram.*
5. Try pulling the shells apart. What do you think holds the shells together?
6. Do you see any evidence (or artifacts) of other organisms on the oyster’s shell? What do you see?

7. Compare your sketch to the diagram. Label your sketch with the appropriate structure names.
8. Review the external anatomy with the whole class. Use the first 16 slides of the *Oyster Anatomy Slideshow*. There are "presenter notes" included that provide some additional information about the anatomy. You may also want to give a print-out of the slideshow with or without the presenter notes to each group.

Explore the Internal Anatomy

1. Get a shucked oyster on a dissection tray.
2. Describe the oyster's body. Look at it! Smell it! Touch is gently! Is the tissue hard or soft? What color(s) is the tissue? What does it smell like? Can you see or feel bones? Is there a head? Do you see blood?
3. Sketch the internal anatomy of the oyster. What do you see? Make some inferences: what are the functions of the structures you see?
4. Get an *Oyster Internal Anatomy Diagram.*
5. Compare your sketch to the diagram. Label your sketch with the appropriate structure names.
6. Review the internal anatomy of an oyster with the whole class. Use the second half of the *Oyster Anatomy Slideshow*. Again, there are "presenter notes" included that provide some additional information about the anatomy.

Explain

1. This portion of the lesson will need to be completed in a second class period.
2. Tell students: Now that you've looked carefully at the internal and external anatomy of a real oyster, we are going to make our own oyster and practice learning the names of the different parts of the anatomy.

Elaborate

Make a paper model of an oyster using the following documents:

Oyster Anatomy Paper Model Directions

Oyster Anatomy Paper Model Cutouts

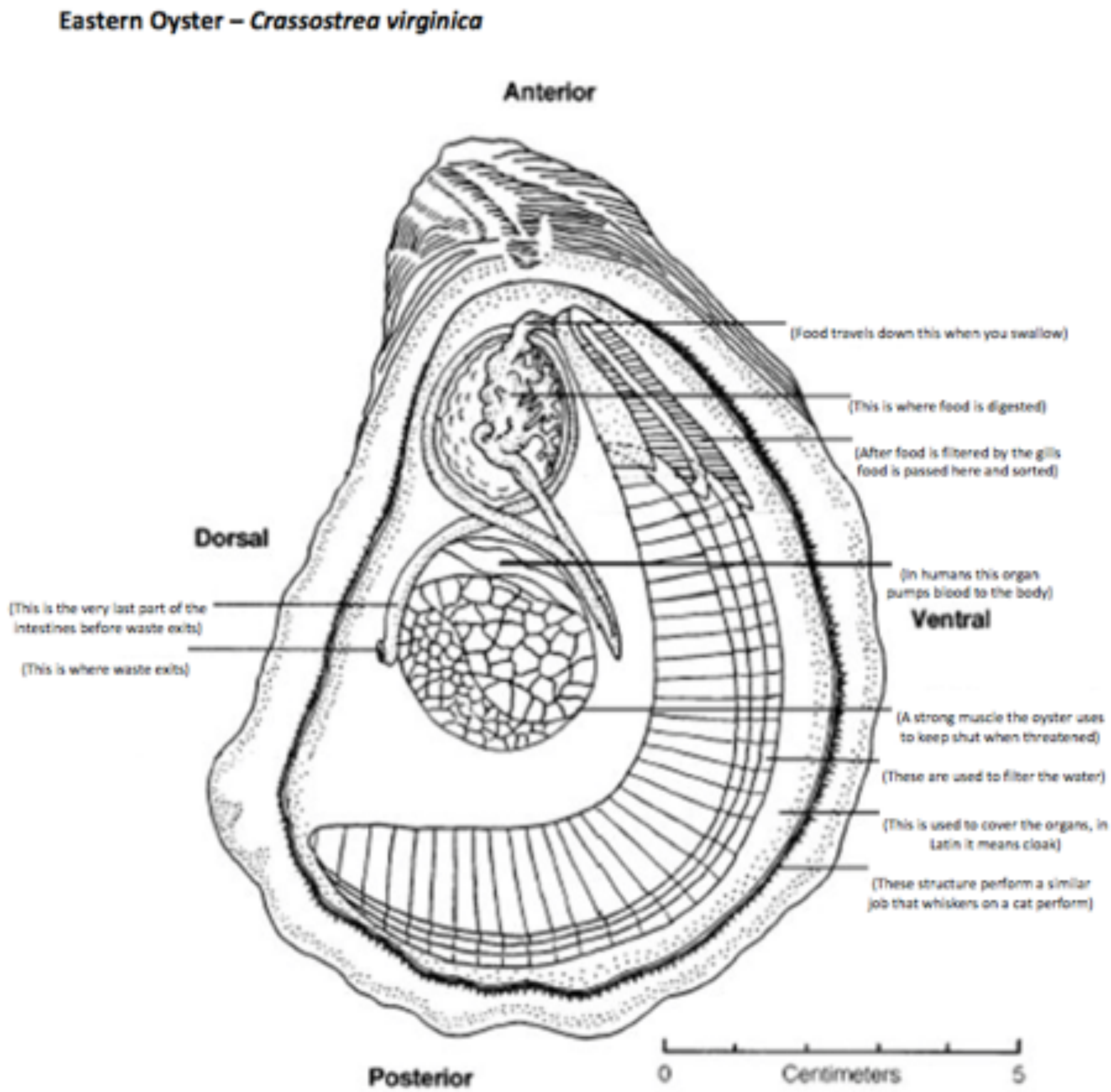
Evaluate

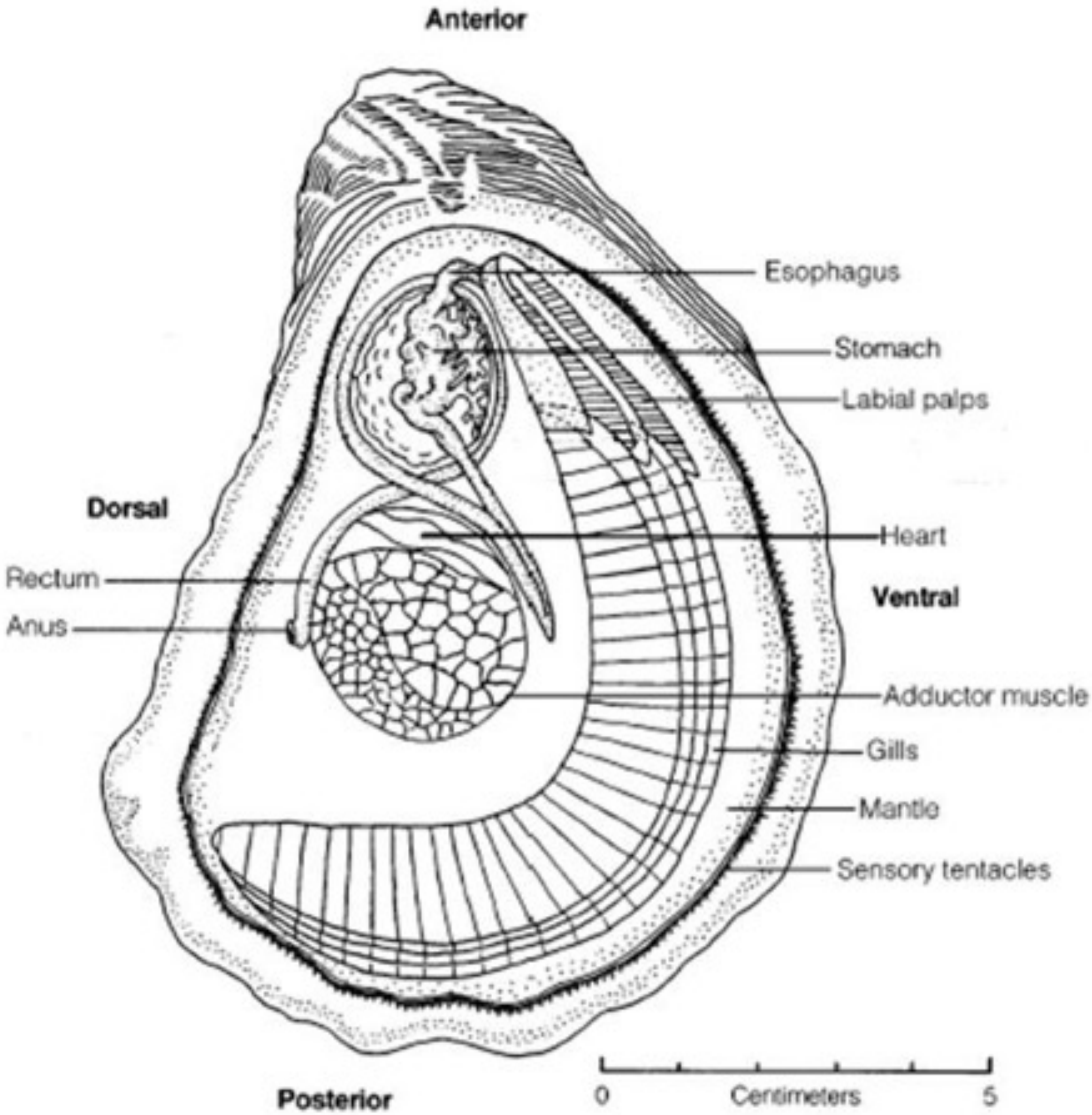
1. Students will design their own organism that is a predator of the oyster. The predator must live on or near the oyster reef. Students will sketch and describe their oyster predator. Students must specifically refer to the oyster's anatomy as they describe how their organism preys on the oyster.
2. What challenges or barriers must the predator overcome in order to prey on the oyster? How will the predator take advantage of the fact that the oyster is sessile? What part of the oyster will the predator eat? Why?

Standards

Oyster Internal Anatomy Diagram

http://03663e1.netsolhost.com/wp-content/uploads/2012/09/Oyster-Lesson-Plan.pdf





Anterior
Esophagus
Stomach
Labial palps
Dorsal
Heart
Rectum
Ventral
Anus
Adductor muscle
Gills
Mantle
Sensory tentacles
Posterior
0
Centimeters
5

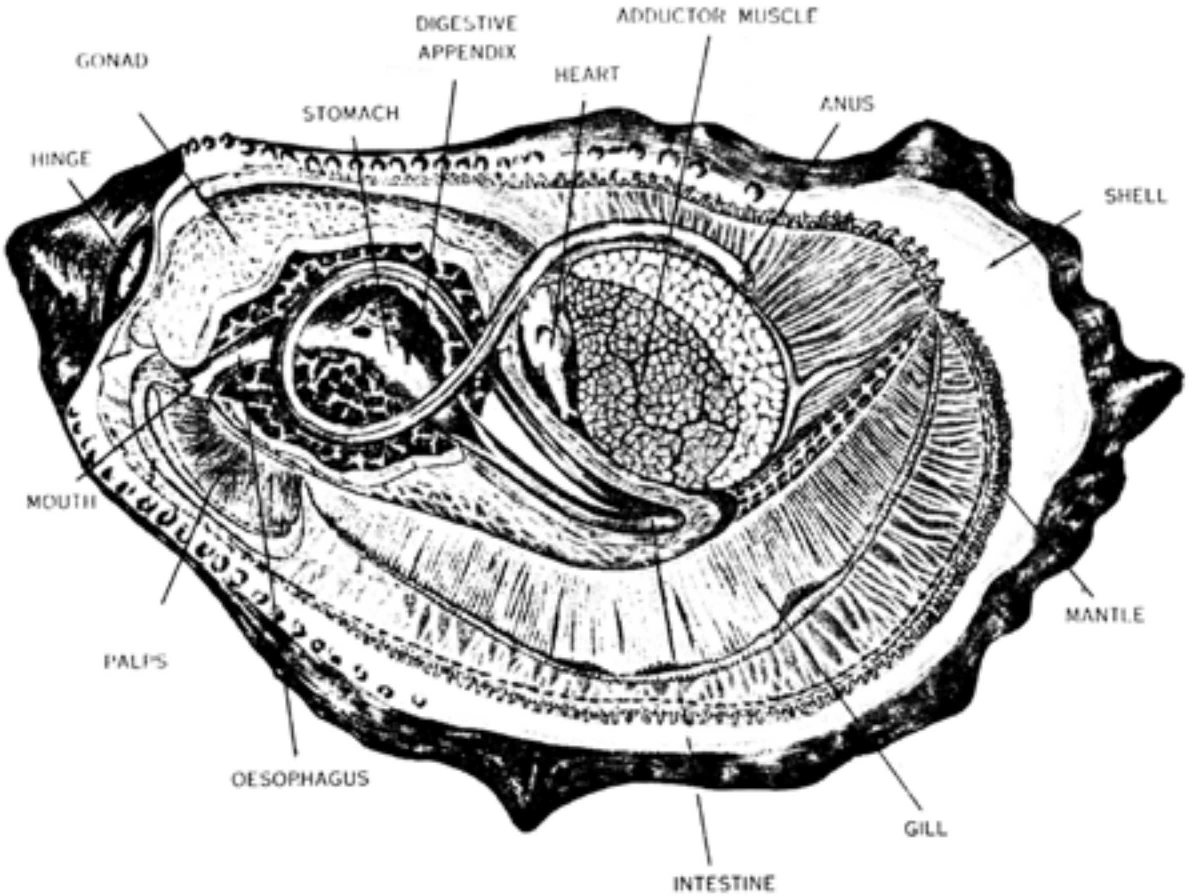
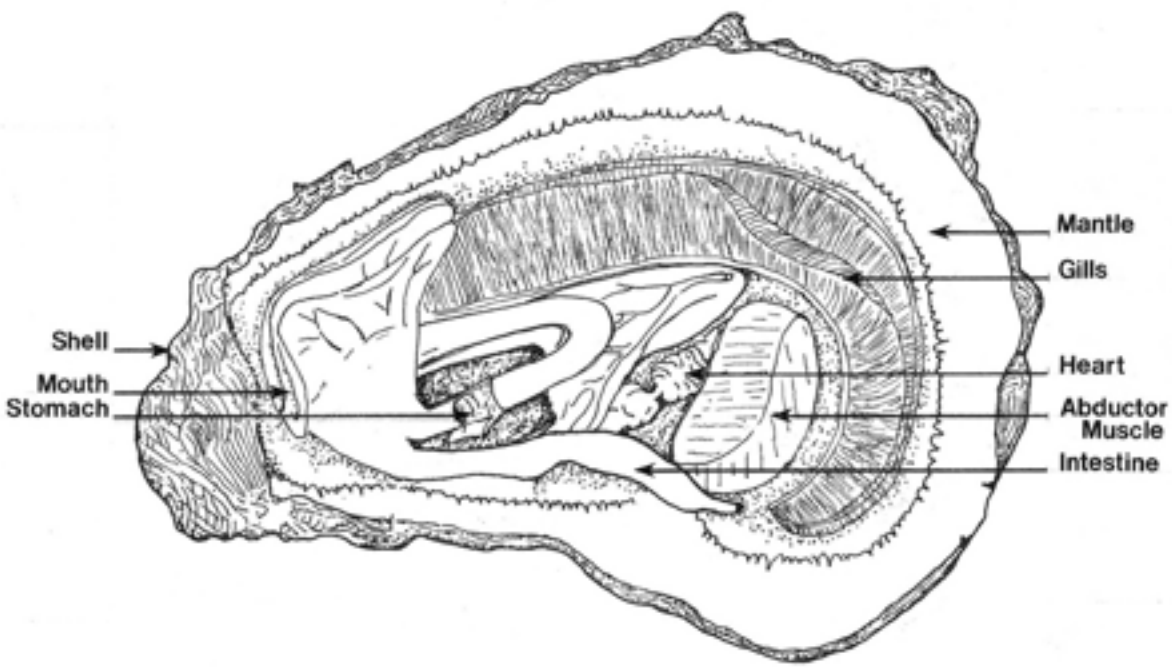


FIGURE 4. Anatomy of an oyster. *From Handbook for Oyster Farmers, Division of Fisheries, Australia.*


Mantle
Gills
Shell
Heart
Mouth
Stomach
Abductor Muscle
Intestine


Key
cut
fold
not part of anatomy
shell
left valve (inside)
adductor muscle
right valve (inside)
adductor muscle
left mantle
adductor muscle
right mantle
adductor muscle
anus
rectum
adductor muscle
heart
stomach
mouth
palps
palps
gills
adductor muscle
outside piece
inside piece
adductor muscle
gills

Commonly Seen Organisms in Oyster Gardens in the NY/NJ Harbor Estuary

A condensed, field version of 'Commonly Seen Organisms in Oyster Gardens' created by Allison Mass, June 2008, designed to help NYC oyster gardeners identify the many other organisms that may inhabit their oyster gardens.

PREDATORS: These are all organisms that can harm your oysters. They may eat the actual flesh of the oyster, weaken the shell, or simply outcompete the oysters for food and oxygen. If you see a large number of these predators in your garden, be sure to make a note in your data sheet and try to remove them. Don't forget, crabs can pinch hard!!

Oyster drills *(Urosalpinx cinerea)*: A small (up to 1 inch) gastropod (snail) with a single shell. One end is open and flared out. Oyster drills prey on oysters by using their long, rough radula (tongue like appendage) to bore a hole in the shell of the oyster and suck the meat out.

Mud Crabs: Small crabs (less than 1") with 10 legs; front legs have claws (one bigger than the other). Claws can be colored differently; the rest of the body is a lighter brown. Prey on juvenile oysters and crabs; can crush the shells of up to 1⁄2 inch bivalves!

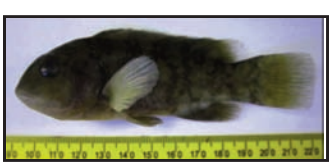
Blue Crabs *(Callinectes sapidus):* Has a wider shell than mud crabs, and larger size (up to 9 inches for adults). Last pair of legs is modified into swimmerettes. Spiny projections off the sides of the carapace (body). Olive green bluish coloring, with brighter blue color under claws and a whiter underbelly. Picture shows a juvenile.

Green Crab (*Carcinus maenas)*: Shell has 5 'teeth' (small pieces sticking out) behind each eye; shell is about 90 mm wide. Usually a darker green color on top, with a yellowish underbelly; during molting the color can become orange and blotched with white spots. Known to eat bivalves, especially juvenile oysters (the crab is limited by the oyster's size, it can't eat larger oysters.

Japanese Shore Crab *(Hemigrapsus sanguineus*): An invasive species, it first appeared on the NJ coast in 1988 and quickly spread north. Occurs in the intertidal zone, using rocks as places to hide and forage for food; also seen on oyster reefs and mussel beds. Small size (adults are usually up to 1.5 inches) with a more square shaped carapace (the part of the shell that covers the main body) than other crabs. Usually dark brown green black in color; walking legs usually banded in color. Eats blue mussels, soft shell clams, and oysters mainly; can have a large effect on these populations. Note the colored leg bands and square shaped carapace.

Flatworms: These flattened, wider worms are usually found as parasites (an animal that lives off of another, causing harm or death to the host) on larger organisms, such as oysters. Very small size (up to 1 inch). Thin, translucent body. Feed on oysters and barnacles by slipping under the shell and eating the animal from within. Species found in NY/NJ: Oyster flatworm (*Stylochus ellipticus*): pale colored with eyespecks along front margin and tiny tentacles on top of body.

Sea Robin *(Prionotus carolinus)*: A small fish (usually smaller than 1m long as adults) that lives its life near the bottom of the intertidal area. It has a bony head, and larger pectoral fins (located towards the head of the fish, under the gills). The fins almost resemble stubby 'arms' as they are very fleshy. Three spines come off of each fin and are used as feelers. Grey reddish brown coloring, with some paler spots and stripes on the back and sides; white coloring on belly; yellowish brown fins. Feeds on bivalves, worms, crustaceans, and other smaller fish.



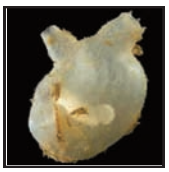
Black Fish *(Tautoga onitis*) Has very prominent 'lips' with teeth jutting outward. Usually less than 2m long as an adult. Often associated with reefs (mussel and oyster). Feeds on bivalves, snails, and crustaceans.

REEF ASSOCIATES: organisms that live with the oysters on, or around, an oyster reef. The relationship can be either mutualistic (where both parties benefit) or commensalistic (where only one party benefits, but the other is not harmed). Usually, these organisms benefit from the protection of the oyster reef and clearer water that can occur over the reef, but the oysters themselves do not benefit.

Barnacles: Small organism, sometimes found cemented along the ropes and mesh of oyster gardens and on the oysters themselves. Usually white to beige in color, and have a pyramid like shape, with plates forming a cone. The outer surface of the barnacle is hard, due to calcium carbonate shell plates. Main type of barnacles found in NYC nets is the acorn barnacles. Common species seen in NY/NJ: Northern rock barnacle which is found in more saline waters, and the Ivory barnacle which is found in lower salinity water.

Blue Mussels (*Mytilus edulis)*: Small bivalve (up to 4 inches) with 2 shells (hinged together) that occurs attached to hard substrates (rocks, pilings, ropes, etc) and usually found in clumps. Shells are smooth on the outside, blue black in color and often glossy/shiny. Mussels attach themselves using tough byssal threads which glue the bivalve to the surface.

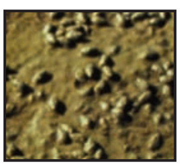
Ribbed mussel *(Geukensia demissa*; previously known as *Modiolus demissa)*: Long, thin bivalve with 2 hinged shells that have ribs running lengthwise; brownish, green brown coloring. Found in salt marshes and other estuarine areas, usually attached to the base of marsh grass and half buried in the sediment. Usually occur in clumps. Attaches to plants and each other using tough byssal threads. During low tides, shells are usually closed to prevent dehydration, but the bivalves sometimes open to take in air.



Sea Squirts/ Tunicates: Small, round, jelly like animal that can occur in large numbers on oyster gardens. Rounded, with 2 siphons on the top side. "Sea grapes" (*Molgula and Bostrichobranchus spp.)* have uneven siphons; most other species of sea squirt have even siphons. Most species live attached to hard substrates, such as ropes and oyster nets. Squeezing the sea grape can cause the siphon to shoot water out at you (hence the name, sea squirt!) Outer surfaces often covered in debris and encrusting algae.

Shore Shrimps (*Palaemonetes spp*., especially *P. pugio)*: Small (1.5 2 inches); often clear with dark streaks; with numerous legs and antennae. First and second legs have claws, others with hairlike projections for swimming. The rostrum (piece over the head) extends outward beyond the antennae. Likes to hide out in eelgrass or other seagrass beds, or congregate around pilings. Known as "grass shrimp" but are not true Grass shrimp *(Hippolyte spp.*)

Slipper shells: A small gastropod with a one-valved shell, which is found attached to the underside of hard substrates (including other shells and live organisms). The underside of the shell has a platform extending about ½ way across the shell opening. Usually white-beige in color. Often considered a "nuisance species" in oyster gardens and beds because they compete with oysters for food and space, and can inhibit oyster spat from setting to a bed. Species seen in NY/NJ: Eastern slipper shell (*Crepidula plana*): flattened, pure white, and small (up to 1 inch. Common/ Atlantic slipper shell (*Crepidula fornicata)*: has a more rounded/arched shell, with brown markings and a slightly crooked axis (tip is bent to one side); small size (1.5 inches). *Crepidula plana* (left), *Crepidula fornicata* (right)

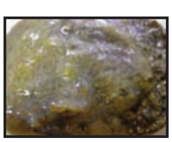


Mud Snails *(Ilyanassa obsolete)* Small (up to 3 cm) gastropod snail with a whorled, cone shaped shell. Opening to the shell is oval and large (1/2 the height of the shell). Dark black or brown in color. Often the shell is covered in mud, algae, and encrusting bryozoans. Extremely abundant in Mid Atlantic intertidal estuaries. Crawls along surface of the mud. Eats algae, worms, and detritus (dead and decaying matter) in the mud; eaten by birds.

Mud Tube Worm (*Spionidae* family, especially *Streblospio benedicti*) Polychaete (marine segmented worms) with one pair of parapodia per segment (paddle like appendages). Head is cone shaped, with 4 eyes , a pair of tentacles, and 2 pairs of gills. Reddish brown coloring with dark green around gills. Small size (up to 6 mm). Lives in fine sandy, and silty sediments that are easy to ingest. Make tubes out of sediment and mucus and live inside the tubes, right below the surface.

Amphipod (*Gammarus spp*.) Small crustaceans (like crabs, shrimp, and lobsters) that are laterally flattened. Large eyes on either side of the head. Multiple pairs of legs on the thorax.

Sand Worm (*Nereis* spp.; commonly called Clam worms) Polychaete worm, with a set of setae (bristled, spiny like projections) and parapodia (appendages) on each segment. Head has a pair of sickle shaped jaws, and short blunt palps near the eyes.

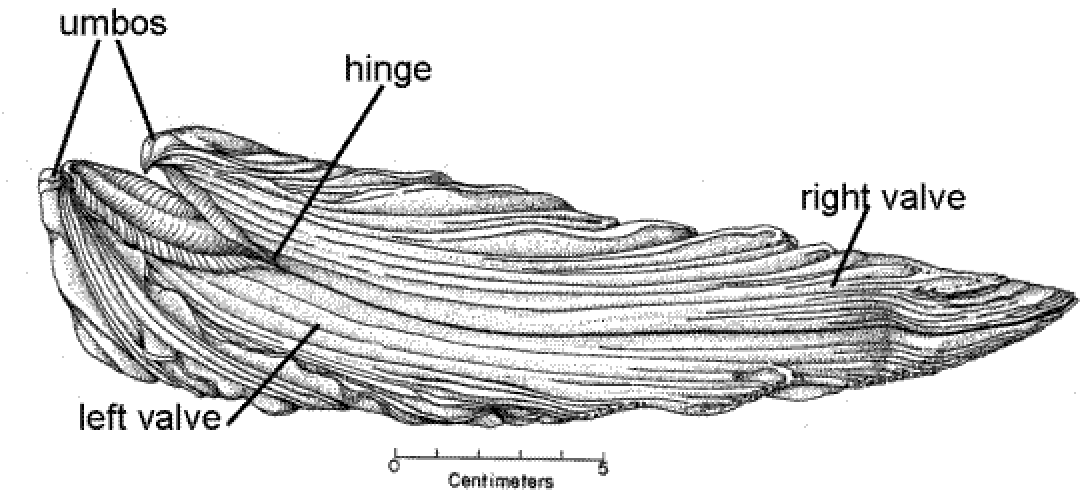


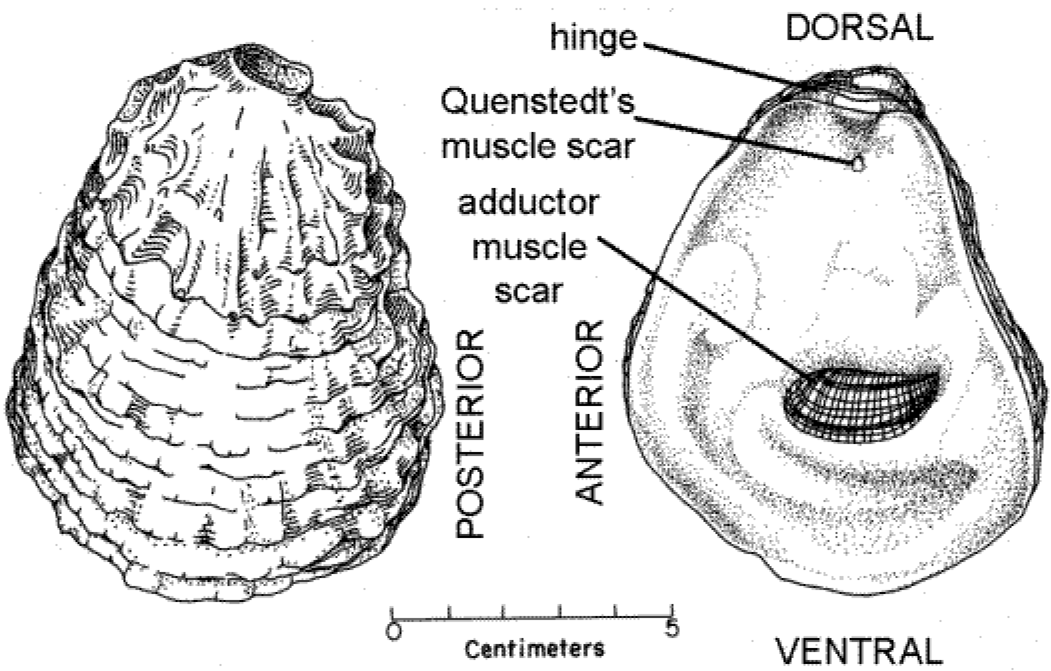
Sponges: The simplest of all true 'animals', sponges look like a plant but are really living animals. Sponges can be free standing, encrusting, and boring (becoming intertwined with their substrate). Species found in NY/NJ: Red beard sponge (*Microciona prolifera)*: a reddish orange brown sponge that encrusts on a substrate, grow up to 8 inches; in shallow subtidal estuaries. Boring sponges (*Cliona spp.)*: very small (less than 1⁄4 inch), yellowish in color; bore into mollusk shells (especially oysters!). Doesn't eat the oyster, but can weaken the shell enough for another parasite or predator to kill the oyster.

Works cited: Gosner, K.L. 1978. Peterson Field Guides' Atlantic Seashore. Houghton Mifflin Co., New York NY.

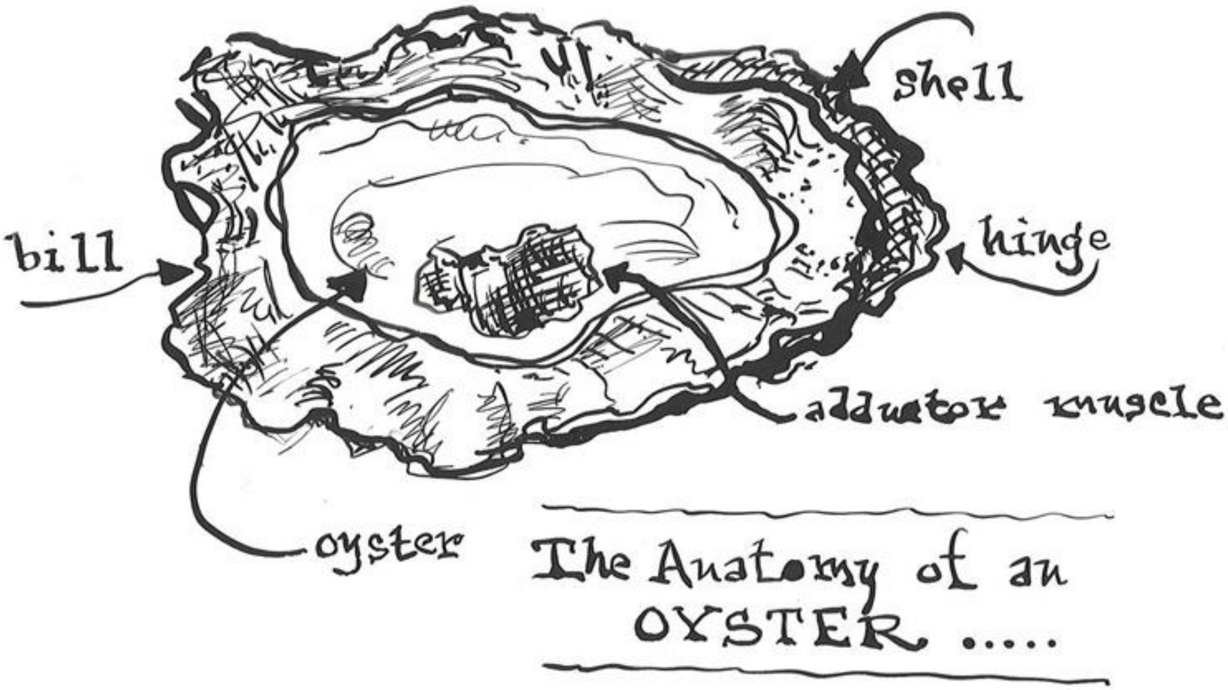
If you find an organism that you cannot identify, send a picture to mass@mail.csi.cuny.edu and we will help you identify it!

Oyster Anatomy External Diagram





http://lanwebs.lander.edu/faculty/rsfox/invertebrates/crassostrea.html



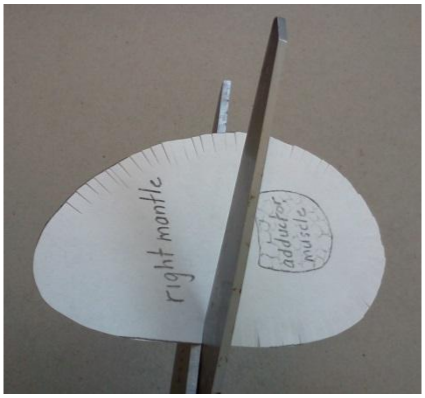
http://www.willabay.com/oysterfood.html

OYSTER ANATOMY PAPER MODEL

Materials
Oyster anatomy cut-outs
Sharp pencil
½-inch brass fastener

1. Cut out the seven (7) oyster anatomy pieces.

   Optional Make small cuts around the outside of the mantle pieces to “fringe” the edges (see photo at right). The fringes model the oyster’s tentacles.



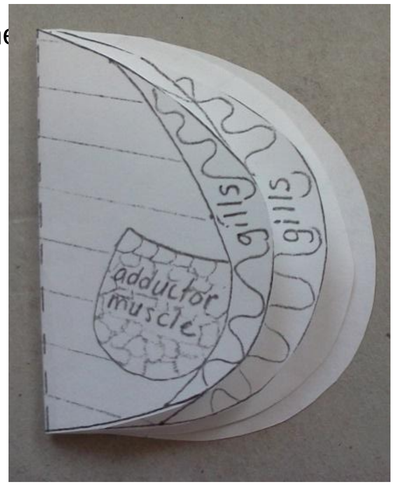
2. Locate the adductor muscle on all of the pieces. Use a sharp pencil to punch a hole through the middle of the adductor muscle on each piece.

3. Set a brass fastener in front of you with the prongs pointing up.

4. Find the **left valve**. Line up the hole in the adductor muscle over the prongs of the brass fastener and then press the **left valve** down over the fastener.

5. Find the **left mantle.** Line up the hole in the adductor muscle over the prongs of the brass fastener and then press the **left mantle** down over the fastener.

6. Find the two (2) **gills** pieces. Fold each piece along the fold lines. The gills and adductor muscle should be on the *outside* when the pieces are folded.



7. Slide the folded ***inside*** **gills** piece inside the folded ***outside*** **gills** piece. The edges of the two pieces will NOT line up.

8. Put a sharp pencil through the existing holes in the adductor muscle and then push the pencil all the way through the folded **gills**.

9. Hold the folded **gills** over the fastener. Line up the hole in the adductor muscle over the prongs and press the folded **gills** down over the fastener.

10. Fold the piece with the **visceral body** (mouth, stomach and intestines) and **heart** along the fold line. The organs should be on the *inside* when the piece is folded.

11. Find the **palps** on the **visceral body/heart** piece. Fold the **palps** along the fold line. The labels (*palps*) should be on the *inside* when the piece is folded.

12. Hold the folded **visceral body/heart/palps** over the fastener. Line up the hole in the adductor muscle with the prongs and press the **visceral body/heart/palps** down over the fastener.

13. Find the **right mantle**. Line up the hole in the adductor muscle over the prongs of the brass fastener and then press the **right mantle** down over the fastener.

14. Find the **right valve**. Hold the **right valve** with the adductor muscle facing down (blank side up) over the fastener. Line up the hole in the adductor muscle with the prongs and press the **right valve** down over the fastener.

15. Pull the prongs of the faster apart and bend them flat against the right valve to hold all of the pieces together.

Oyster Anatomy Worksheet

Explore Oyster Reef Organisms

1. Sketch, label and describe any organisms you find in your oyster cluster.

Explore the External Anatomy

2. How do the two shells compare? List similarities and differences.

3. Why might the shells be different?

4. What part of the oyster shell do you think was attached to the reef? Why?

5. Why does the oyster have a hard exterior? Why does it have two shells? How might this help the oyster?

Commented [1]: As a cool extension, might be interesting to have students discuss which of these questions addresses an observation and which addresses an inference.

6. What is the length of your oyster? (include units) __________________

7. Why do you think we need to measure the size of the oyster?
8. Sketch and describe the external anatomy of the oyster. Add labels!

9. What do you think holds the shells together?

Explore the Internal Anatomy

10. Describe the body of the oyster. Is the tissue hard or soft? What color(s) is the tissue? Can you see or feel bones? Is there a head? Do you see blood? What does it smell like?

11. Sketch the internal anatomy of the oyster. Add labels!

Oyster Decline in NY Harbor

BOP Curriculum
bop-curriculum@nyharbor.org
Mar 21, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
NY Harbor Populations Investigation	6-8th	1	Classroom	Science Social Studies

Summary

Students will analyze historical photos, maps and other resources that point at some of the causes of oyster decline in New York.

Objectives

Enumerate several ways that human actions impact an iconic local species.

Materials and Resources

Supplies

File folders

Before you get started

Tips for Teachers

- Consider whether you want to take time to discuss photographs, maps and other resources as historical or primary resources. What could be strengths or flaws of these resources as we try to learn more about the past?

Preparation

- Create one folder for each small group. Look through all the resources in New York City and Oyster Decline and put a variety in each folder.
- Consider if you want the same or different resources in each folder.

Instruction Plan

Engage

1. Students get into small groups.
2. Each student gets What Happened to Our Oysters?
3. Groups read over the quotes, discussing and taking notes on each quote.
4. Class discusses students' observations of and questions about the quotes.

Explore

1. Students get into small groups.
2. Each group gets a folder with several resources in it.
3. Each student gets a Notes on Oyster Decline Images
4. Explain: Based on the quotes we read earlier, we know that oysters declined in New York City and all over the country. Now we are going to use these resources to observe some of the reasons why.
5. Students complete their Notes on Oyster Decline Images worksheet and are given additional worksheets if necessary.
6. Students complete the "Notes/Connections" section of their worksheet in order summarize their analysis of all their resources.
7. Groups share their findings with the rest of the class.

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
  - Cause and effect relationships may be used to predict phenomena in natural systems.
  - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Energy and Matter
  - The transfer of energy can be tracked as energy flows through a designed or natural system
  - The transfer of energy can be tracked as energy flows through a natural system.
- Influence of Engineering, Technology, and Science on Society and the Natural World
  - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- Patterns
  - Graphs and charts can be used to identify patterns in data.
  - Graphs, charts, and images can be used to identify patterns in data.
- Stability and Change
  - Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems and System Models
  - Models can be used to represent systems and their interactions.
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

NGSS - Disciplinary Core Ideas

- LS1.A: Structure and Function
  - Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
- LS2.A: Interdependent Relationships in Ecosystems
  - Growth of organisms and population increases are limited by access to resources.
  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
  - Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
  - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
  - Analyze and interpret data to provide evidence for phenomena.
- Constructing Explanations and Designing Solutions
  - Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.
- Engaging in Argument from Evidence
  - Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
  - Interdependence

Observations *Use your eyes to notice things in the image. What do you see? What else do you see?*	**Inferences** *What do you think it means? Why do you think it is this way?*	**Questions** *What questions do you still have about this? What do you want to learn more about?*

Notes/Results/Sketch/Connections

Paper Watersheds

BOP Curriculum
bop-curriculum@nyharbor.org
Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	5	Classroom	Science Math Social Studies

Summary

To launch the Steward-shed Investigation, students examine NYC elevation maps to help them build a paper model of a neighborhood-as-watershed. Meanwhile, students engage with the neighborhood map and propose a smaller part of it they would like to steward. The teacher synthesizes student proposals to define a class steward-shed. Students then predict how rain water and pollution travel over land from their steward-shed into nearby waterbodies.

Objectives

- Characterize the elevation or topography of a neighborhood that is significant to them – probably the school neighborhood or the ORS neighborhood.
- Model that topography with simple materials, and identify some strengths and weaknesses of the model.
- Become familiar with the neighborhood map, and how it relates to students' life experiences in the neighborhood.
- Identify a smaller part of the neighborhood that students would like to steward – i.e. the class steward-shed.

Materials and Resources

Supplies

- Small post-it notes
- Colorful index cards or other sturdy cardstock
- Tape
- Washable markers, plus any markers or good colored pencils in red, green, orange, and blue – one set for each group.
- Highlighters or yellow markers.
- Spray Bottles
- Water
- Eyedroppers
- Cardboard or aluminum tray
- Several pieces of paper (newspaper or scrap paper)
- Tape
- Plastic wrap
- Small model pieces to represent buildings, cars, trees, etc. (optional)
- Some colorful material that will run when it's wet. You can use washable markers and spray the paper, or you can cover the paper with plastic wrap (as in photos below), and use almost anything. In the photos, we used soy sauce.

Before you get started

Tips for Teachers

- BOP's lesson "Watersheds Part 1 - Where Does the Rain Go?" is a good introduction to the idea of watersheds, and would work well prior to this one.

- [ArcGIS USA Topo Maps] features detailed topographic maps of the United States at multiple scales, made by the United States Geological Survey (USGS), a government science agency that is charged with mapping the landscape of the US and studying its resources.
    - The USGS produced printed paper versions of topographic maps until 2006, dividing the country into quadrants. This digital map blends together all of these individual maps.
    - The date on each individual map can vary, and you can assume that all of these maps are from 2006 or earlier. The topography is likely still accurate, but named places on the map may have changed (for example, the US Coast Guard station on Governors Island, part of which is now BOP headquarters!). Some of these maps may have been originally drawn in the 1960s, with small updates over time.
- The USGS Historical Map Collection has a wonderful tool on their site called "topoView". You can check topographic maps that in some cases date back to the 1800s!
    - Be aware: some maps use language that may impact you and your students profoundly. For example, older maps of Jamaica Bay include a prominently-labeled place called "Nigger Point". Make sure you look at these maps carefully before giving them to your students, and think ahead about how you want to talk with them about what they will find there.

Preparation

- Get very familiar with the neighborhood, as detailed below. The following resources are especially helpful:
    - Oasis – you can find more details about this resource in "Our Steward-shed" Library of Resources
        - For this lesson, it's especially worth looking at Oasis and clicking "Hide All" for all the layers, because then you can see topographic shading at a level of precision we haven't found anywhere else.
        - Oasis has nine levels of zoom, and this topographic shading is only visible for the five most zoomed-out views. It can look fairly subtle, but once you've studied some of the other topographic / elevation maps and have an idea of what to look for, this shading becomes intuitive and very useful. Here's an example from Canarsie:

            - If this prints well for your neighborhood, you may want to use this as the basis for the whole lesson. Below you will see examples based on a Google map printout, which can also work but requires your students to make a bigger conceptual leap.

    - Depending on your neighborhood, you may be able to read the local topographic map from ArcGIS. For example, this topo view of Sunset Park and Greenwood Cemetery is rich and legible. But in flatter areas, such as Canarsie, light brown contour lines on a dark pink background are basically illegible. Pan around and find your neighborhood to see if you can use this in-depth resource.

    - Google maps, including satellite view, street view, etc.

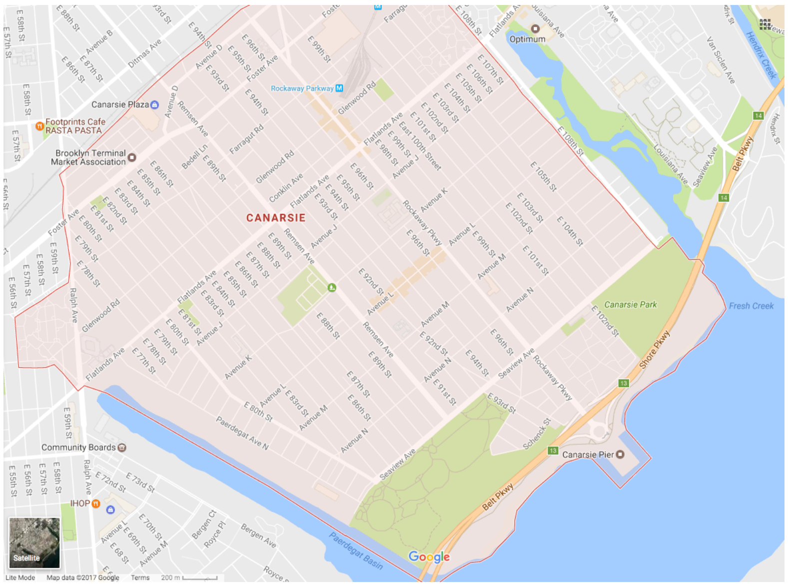
    - Book: The Neighborhoods of Brooklyn, edited by Kenneth T. Jackson and John B. Manbeck. Includes a 4-5 page summary of the history of every neighborhood in Brooklyn.

    - Book: The Neighborhoods of Queens, edited by Claudia Gryvatz Copquin and Kenneth T. Jackson. Includes a 4-5 page summary of the history of every neighborhood in Queens.

- Book: Waterfront: A Journey Around Manhattan, by Phillip Lopate Written in 2004, this book describes some of the interesting sites and wonders of Manhattan's waterfront.

- Before teaching the "Engage" section, prepare a map on which you define the boundaries of a neighborhood that is easy for your class to get to several times throughout the Steward-shed Investigation. Your students will help you narrow down this area later in the lesson, but they need a common starting point.

  - For example, if your school is in Canarsie – or perhaps if your ORS is at Sebago Canoe Club, and you visit the ORS frequently – the Google Map of the neighborhood of Canarsie might be a reasonable starting point:



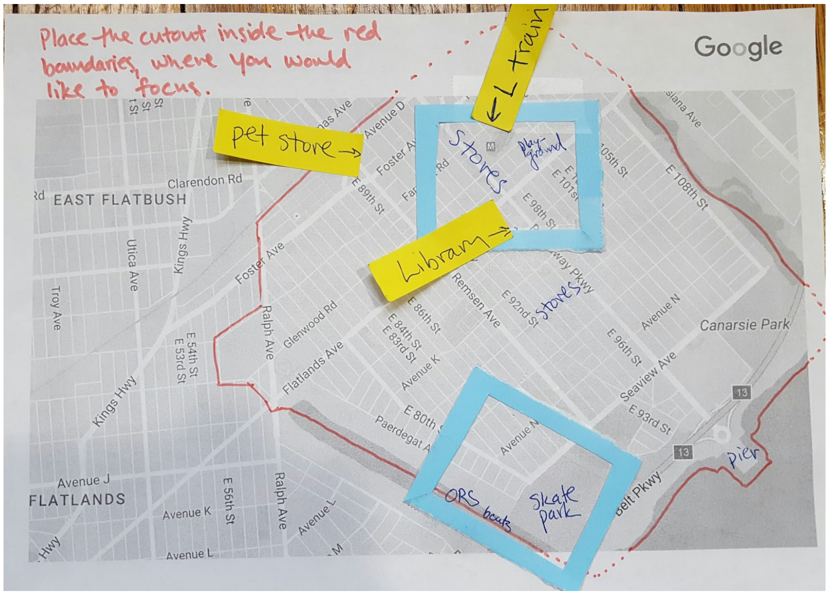
- If you think your students know this area very well and can discuss it from the map, you could leave it at that. But if you think your students might need more prompting, prepare a series of photographs and artifacts (e.g. restaurant menus, supermarket flyers, religious service schedules, etc.) from the area. During the lesson, students will use these images and artifacts as anchor-points, to help them understand and relate to the map.

- Before teaching the "Explore" section, decide whether you want to teach your students to read topographic maps. If so, allocate extra time for that learning process.

- Before teaching the "Explain" section, prepare a set of area-limiting cutouts. These are paper cut-outs (one for each group) that represents a reasonable area for the class' Steward-shed. (It's best to use colorful index cards or other sturdy cardstock.) This is the tool that students will use to identify a smaller area within the neighborhood that they care about and want to study in depth. Coordinate the size of your cutouts with the scale of the map you are handing out, and choose an area-size that allows for:

  - some topography (slope) – i.e. not completely flat like just a fixed pier
  - a range of different land uses – so there are obviously permeable and impermeable surfaces, and there are obvious sources of pollution like cars or dumpsters
  - students to visit most of the area within a few field experiences

Here's a Canarsie example of what two cutouts might look like after students place them on top of a neighborhood map with some of their notes on it:



Those would make two very good, very different steward-shed investigations – one with the train station, stores, library, and playground, and the other with the skate park, ORS, boats, and large park!

Instruction Plan

Engage

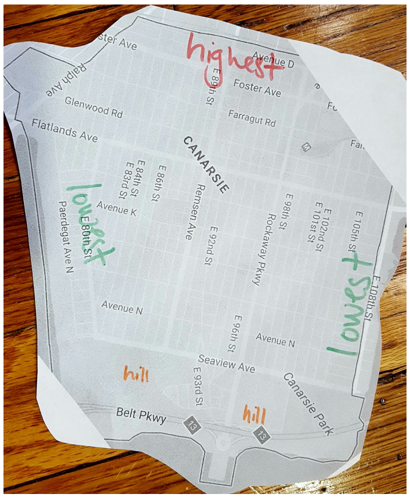
1. Students have copies of a neighborhood map, with boundaries drawn in by the teacher (see "Preparation" section above for details), and post-it notes.
2. (Optional: students view photographs and artifacts from the neighborhood, and locate those on their maps.)
3. Students make note of places on the map that are part of their lives - places they've been, school, home, things they care about, etc.
    - It's helpful for students to be able to write some things directly on the map, and identify other things with post-it notes – whichever is easier.
4. Students share experiences they've had in different locations on the map, how they move through and travel through the space, etc.
5. In small groups, students combine their annotations onto one group map.
6. As students begin to raise questions, begin keeping track of those questions.

This would be a good time to break until the next class.

Explore

1. Discuss the slides in Five views of NYC Elevations.
2. (Optional: students get USGS topographical maps of the neighborhood from ArcGIS USA Topo Maps – see "Preparation" for details.)
3. Zoom in on the view of NYC elevation that seems most useful for your neighborhood, and center on your neighborhood.
    - Students share observations, inferences, and questions.
    - Leave this up on the screen for students to consult.

4. In small groups, students get fresh photocopies of the map of the neighborhood with the teacher's boundaries drawn in (see "Preparation" above for detail).
   - Groups use the map on the screen to identify the major topographical features in the neighborhood.
   - Ideally, students label those according to the color scheme used in elevation maps:
     1. Red for the highest areas
     2. Green for the lowest areas
     3. Orange for in-between.
     4. Blue for the water (not shown in photo below)
   - Here's a Canarsie example:



A flat cut-out map with major topographical features/areas labeled, except water.

This would be a good time to break until the next class.

Explain

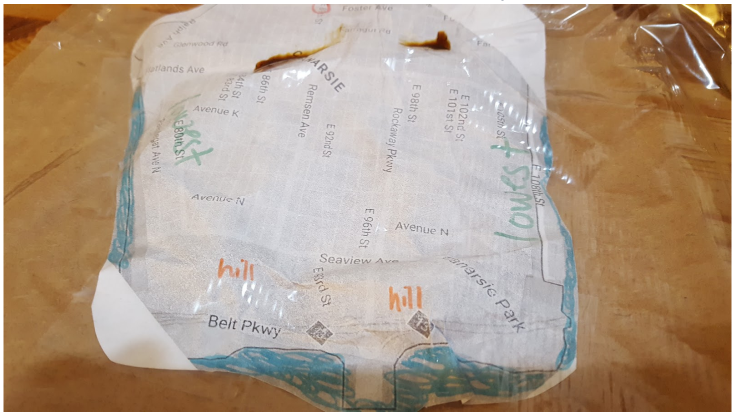
1. Using crumpled bits of scrap paper to hold up the higher-elevation parts of the neighborhood, students turn their labeled flat map into an approximate three-dimensional elevation model.
   - To hold its shape, the model must be taped down at its lowest points to something sturdy like a piece of cardboard or an aluminum tray.

The same map, manipulated to look more like the 3D topography of the neighborhood. Also the water is now colored in blue.

2. (Optional: students place a layer of plastic wrap over their models, so they can spray water on them and still keep them around for a few days.)
3. Students predict: what will happen to the water that we spray on the model?

4. Students check their predictions.

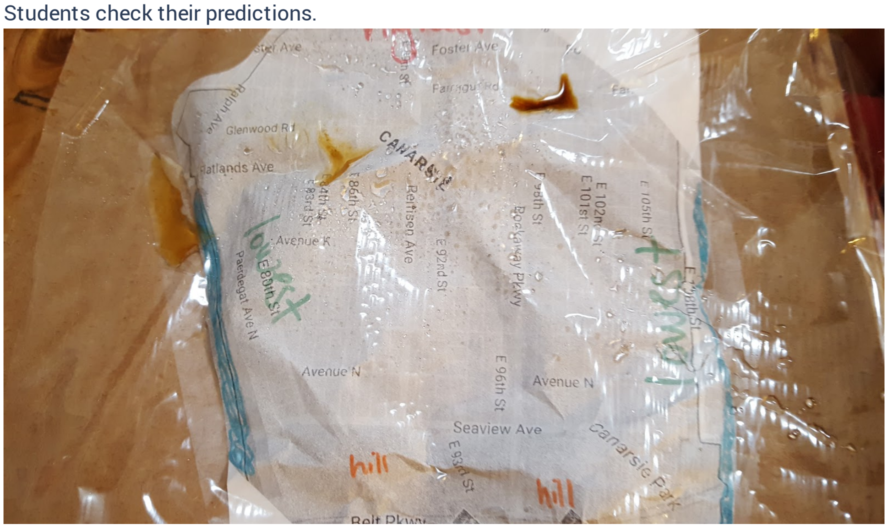
5. Students select a colorful material that will run, and place it in a location of interest on the model.



The same model, plus plastic wrap and carefully placed soy sauce

6. Students predict: what will happen to the colorful material when we spray water on the model?

7. Students check their predictions.



After one big spritz

Many spritzes later… notice the diluted soy sauce in puddles in “Paedergat Basin” (to the left) and “Jamaica Bay” (in the foreground). It’s easier to see in real life than in the photo.

8. Students write: based on these results, if we were to make another draft of this model, we would like to revise ________________________________ because ____.

This would be a good time to break until the next class.

Elaborate

1. In small groups, students get their annotated neighborhood maps, from the “Engage” section.”
2. Groups get area-limiting cutouts (see “Preparation” for detail).
3. Groups move the cutout around, discussing what they know about different parts of the neighborhood, and thinking about:
    - The neighborhood’s topography, and where the rain goes, and where the rain carries pollution with it into the water.
    - The places they care about most, for any reason, within the neighborhood.
4. Each group arrives at a proposed “Steward-shed” within the neighborhood, and tapes down their cutout to illustrate their proposal.
5. On the back of the map, they write down why this seems like an important area to steward.
6. Before the next class period, synthesize students’ suggestions into a class steward-shed area that:
    - Is small enough for students to cover most of the terrain over a few field expeditions
    - Includes some obvious sources of pollution, like cars
    - Includes some obvious variations in permeability -- basically, some area with plants and soil, and some area that’s paved
    - You will be taking your students to multiple times during this Investigation
    - Is defined in a way that makes geographic sense. You don’t need to stick with a rectangle, and you can avoid nonsensical borders that cut through the middle of buildings, for example.
7. Before the next class period, prepare a copy of the class steward-shed map for each group.

This is an important time to break until the next class.

Evaluate

1. Students have the class steward-shed outlined on a larger map.
2. Students predict: eventually the rain that falls on our steward-shed drains into a nearby body of water. What body of water is that? Where along the waterfront does rain that falls on our steward-shed enter that body of water?
    - On their maps, students highlight that portion of the waterfront.
3. Students predict: Does all of the rain that falls on our steward-shed move directly over land to that part of the waterfront? Why or why not?

Extend

Students use “Our Steward-shed” Library of Resources and The Bonus Guide to the Wonders of Your Steward-shed to investigate the history of their steward-shed.

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
    - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
    - Cause and effect relationships may be used to predict phenomena in natural systems.
- Influence of Engineering, Technology, and Science on Society and the Natural World
    - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
    - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
- Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

- Science Addresses Questions About the Natural and Material World
  - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes
- Structure and Function
  - Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
  - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
  - Structures can be designed to serve particular functions.
- Systems and System Models
  - Models can be used to represent systems and their interactions.
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
  - Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

NGSS - Disciplinary Core Ideas

- ESS2.C: The Roles of Water in Earth's Surface Processes
  - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
  - Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- ESS3.C: Human Impacts on Earth Systems
  - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- ETS1.A: Defining and Delimiting Engineering Problems
  - The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
- ETS1.B: Developing Possible Solutions
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- ETS1.C: Optimizing the Design Solution
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- LS2.A: Interdependent Relationships in Ecosystems
  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

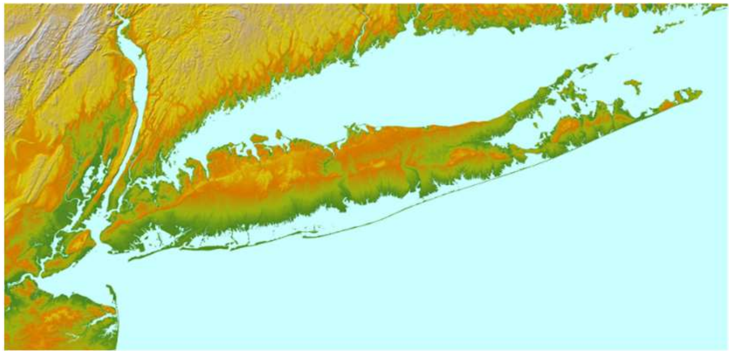
NGSS - Science and Engineering Practices

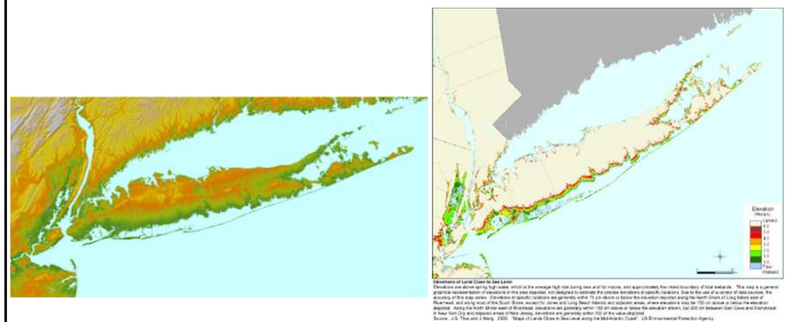
- Asking Questions and Defining Problems
  - Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
  - Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- Constructing Explanations and Designing Solutions
  - Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Developing and Using Models
  - Develop a model to describe unobservable mechanisms
  - Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.

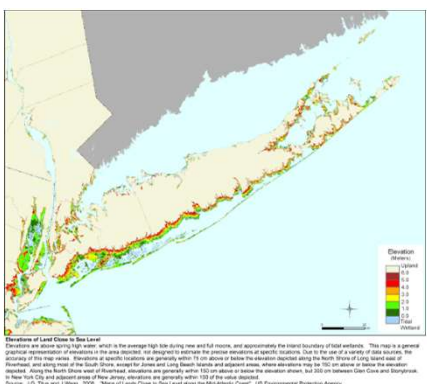
- Develop a model to predict and/or describe phenomena
- Obtaining, Evaluating, and Communicating Information
    - Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.

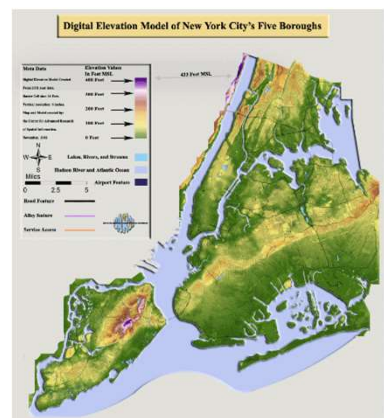
NYC Science Scope & Sequence - Units

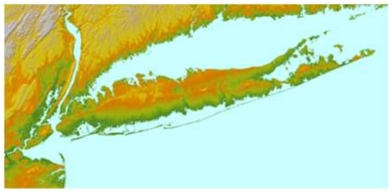
- Grade 6, Unit 2
    - Weather and Atmosphere
- Grade 6, Unit 4
    - Interdependence
- Grade 7, Unit 1
    - Geology
- Grade 8, Unit 4
    - Humans and the Environment: Needs and Tradeoffs

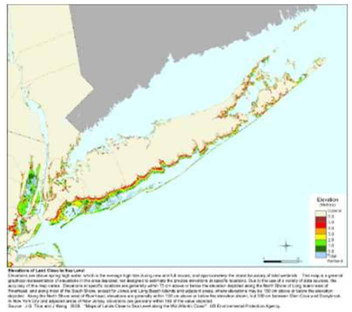


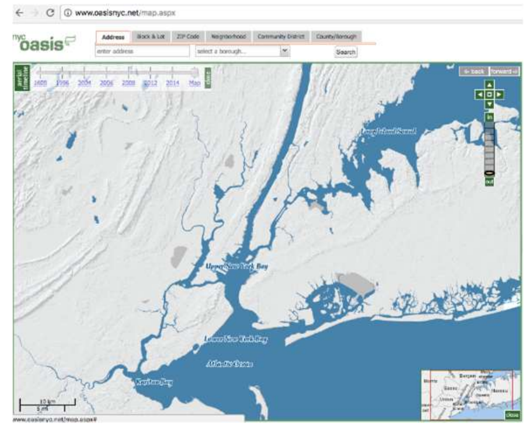


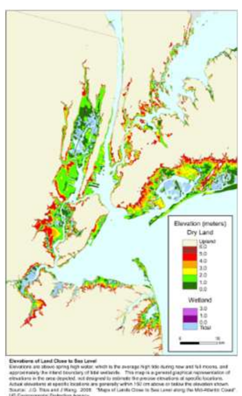

Elevation
(Meters)
Upland
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Tidal
Wetland
Elevations of Land Close to Sea Level
Elevations are above spring high water, which is the average high tide during new and full moons, and approximately the inland boundary of tidal wetlands. This map is a general graphical representation of elevations in the area depicted, not designed to estimate the precise elevations at specific locations. Due to the use of a variety of data sources, the accuracy of this map varies. Elevations at specific locations are generally within 75 cm above or below the elevation depicted along the North Shore of Long Island east of Riverhead, and along most of the South Shore, except for Jones and Long Beach Islands and adjacent areas, where elevations may be 150 cm above or below the elevation depicted. Along the North Shore west of Riverhead, elevations are generally within 150 cm above or below the elevation shown, but 300 cm between Glen Cove and Stonybrook. In New York City and adjacent areas of New Jersey, elevations are generally within 150 of the value depicted.
Source: J.G. Titus and J Wang. 2008. "Maps of Lands Close to Sea Level along the Mid-Atlantic Coast". US Environmental Protection Agency.


Digital Elevation Model of New York City's Five Boroughs
Meta Data
Elevation Values In Feet MSL
433 Feet MSL
400 Feet
300 Feet
200 Feet
100 Feet
0 Feet
N
W
E
S
Miles
0
2.5
5
Lakes, Rivers, and Streams
Hudson River and Atlantic Ocean
Airport Feature
Road Feature
Alley feature
Service Access




Elevations of Land Close to Sea Level


www.oasisnyc.net/map.aspx
oasis


Elevation (meters)
Dry Land
Wetland
Elevations of Land Close to Sea Level

"Our Steward-shed" Library of Resources

There are a *lot* of resources in this document, and some of them are a little quirky to use[1], but we promise you that even checking out a few of them will be worth it! Take your time and explore what what's interesting to you. We've got some tips below that can help you get started. You've got this!

The library is divided into the following sections:

We recommend starting with the OASIS map (#1 below), whether you're researching pollution, runoff, or your steward-shed's stakeholders. It's a community map that aggregates tons of useful information into one place, including data from both government agencies and stewardship organizations. There's even some topographical information on this map at certain scales.

After checking out OASIS, try Envirofacts (#2 below), a map from the Environmental Protection Agency (EPA), the federal agency that is charged with protecting the environment of the United States. Envirofacts will give you a very detailed picture of everything (even down to manhole covers!) that is monitored by the EPA because it could impact your local environment.

OASIS and Envirofacts can both be a little tricky to navigate, so we've put together guides on how to use both of them- they appear at the end of this library starting on page 7.

Maps to study pollution

[1] We tried out the maps on this list to explore our own neighborhoods, and quality checked by comparing what we saw outside with what we found on the maps. In the case of historical maps, we drew on our knowledge of NYC history to navigate some of the quirks. But it's always important to look at these resources with a critical eye! Think about these sources as being in conversation with each other. Like people, sources in a conversation may not agree all the time. By bringing more voices into the conversation, you'll get a better sense of the big picture in your steward-shed.

Contemporary maps that can help you identify sources of pollution in the present

1) Oasis map (city-level)
   - An interactive map that allows you to turn features on and off including open space, CSOs, community groups, etc.
   - Check and uncheck the boxes to see and hide features. If there are two boxes next to a feature, the first box is usually a symbol and the second is a written label.
   - The following tabs might help you study pollution:
     - Environmental Impact/Cleanup
     - Environmental Characteristics
     - Zoning and landmarks- look at areas zoned "industrial"
     - Land use
     - What else might help?

2) Environmental Protection Agency (EPA) databases and maps (federal level)
   - MyEnvironment page offers a snapshot of your local conditions, including air and water quality. The MyMaps section of the page is a good place to start investigating your steward-shed's conditions.
   - Envirofacts is the EPA's master database/map of places that are subject to environmental regulations or of environmental interest. It includes some information from state databases, in addition to federal databases.
     - Start by putting in your zip code to see *all* the locations in your steward-shed. What kinds of places are you seeing? Why might they be in the EPA's database? Is it hard to figure out why some places would be "of environmental interest?"[2]
     - On the Topic Searches page, you can also try separate searches to get specific information about places that produce air pollution, facilities that have permits to discharge wastewater, locations that store hazardous materials near you, etc.

3) New York State Department of Environmental Conservation (NYS DEC) databases and maps (state-level)
   - Natural Resources and Environmental Protection Maps has a list of "Chemical and Pollution Control Maps" that can be viewed online in Google Maps or via Google Earth. (You'll need to download Google Earth to see some of these maps.) These maps include things like CSOs and brownfield cleanup sites.
   - Environmental Remediation Databases
     - The DEC has three environmental remediation databases:
       - Spills- tracks all reported petroleum spills of more than 5 gallons.
       - Environmental site remediation- sites being cleaned up through one of the state's programs, like the State Superfund program or the Radiation program.
       - Bulk storage- places that store a large amount of petroleum, oil, or chemicals.

[2] You might be wondering- why are manhole covers all over this map? Underground electrical and communications infrastructure, like manholes and vaults, can fill up with water and sediment that has been polluted with oil, lead, and other contaminants from the streets and from electrical equipment. When electrical companies remove this sediment, they sometimes have to treat it as hazardous waste. This means the manholes end up falling under the "Resource Conservation and Recovery Act," the law that creates the framework for dealing with hazardous and non-hazardous solid waste.

Historical maps that can help you identify sources of pollution in the past

4) New York Public Library: NYC Fire Insurance, Topographic, and Property Maps
   - Fire insurance maps are extremely detailed historical maps that show the footprints and uses of buildings- plus a lot more! (The most common fire insurance maps you'll see are "Sanborn" maps.)
   - Today, these maps are frequently used to see if the historical use of a building or lot means the site has potential environmental risks.
   - This key explains what the colors and symbols on the buildings mean on a Sanborn map. (Other mapmakers generally used similar conventions, but here are links to keys for other maps on NYPL's list: Hyde, Bromley, Robinson. Perris eventually merged with Sanborn- the keys are similar.)
     - To start- "hazardous" buildings are marked in green. Do you see any in your steward-shed?
     - If you do find green-marked buildings, the Sanborn map key includes a "Special Hazards" section that provides more information about what kinds of businesses were considered hazardous. Do you recognize all of them? Do any of them surprise you?
   - Look for any factories in your steward-shed. (They may or may not be marked in green.) How many were there? What kind? Factories like oil refineries and shipyards regularly polluted the land, water, and air with toxic chemicals before laws were put in place to stop them.
   - Bonus: a fun way to play around with fire insurance maps to get familiar with them is NYPL's "Building Inspector" game!

Maps to study runoff

Maps that show present day features relevant to runoff

5) Satellite images- which you can see using Google Maps or Google Earth. Earth has better images, but Maps should work for this activity.
   - Go to Google Earth or Maps and click on "Satellite" in the lower left corner.
   - Start by entering your zip code into the search field.
   - From there you can drag the map around, and you can zoom in and out.

- Try to find a familiar place. Then look closely at the satellite image of that place. Check out different levels of zoom.
- What does the satellite image show you that looks like it would be impervious to water? How can you tell?
- What does the satellite image show you that looks like it might hold water for a while, or slow the water down, or let the water sink in? How can you tell?
- What does the satellite image show you that is tricky to identify or categorize?

6) Oasis map
   - The following tabs might help you study runoff:
     - Start with the “Environmental Characteristics” tab. Check the “Land cover classification” box, which will show different kinds of permeable and impermeable surfaces.
       - The key next to the box shows that there are four kinds of land covers on this map- dark green for trees, bright green for grass, beige for “impervious/other” (impermeable surfaces), and blue for water.
     - Land use
     - Transit, Roads, Reference Features
     - Water and Wetlands
     - ...what else might help?

7) NYC Open Data- Planimetric maps
   - Planimetric maps are maps made by digitally associating aerial photography with a map coordinate system. Computer programs can identify specific features on these maps, like streets, parks, boardwalks, and more.
   - NYC Open Data has planimetric maps that show one feature at a time. You can find a full list of these features here by scrolling down to “feature classes.” Click here to see a list of NYC planimetric maps (These maps should have the “authority” set to “official,” the “view types” set to “maps,” and the “tag” set to “planimetrics.”)
   - It’s probably easiest to start with OASIS, and only dive into the planimetric maps if there’s a feature not listed in OASIS you’d like to take a closer look at (like boardwalks).

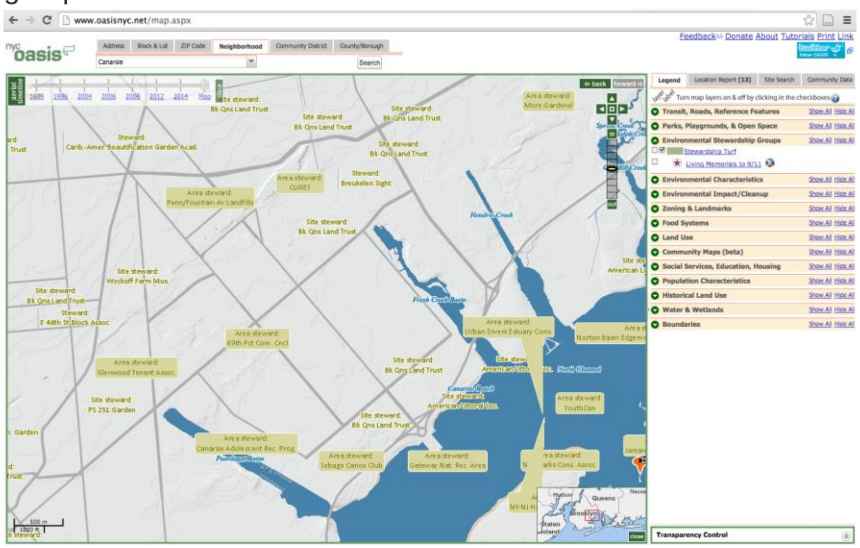
Maps that show historical geography/topography and land use

8) Mannahatta/Welikia 1609 Map
   - Map and information about Manhattan as it would have looked in 1609, before the influence of European imperialism.

Resources to research stakeholders

9) OASIS map
   - An interactive map that allows you to turn features on and off including open space, CSOs, community groups, etc.
   - Check and uncheck the boxes to see and hide features. If there are two boxes next to a feature, the first box is usually a symbol and the second is a written label.
   - The following tabs might help you learn about the population of your steward-shed and identify stakeholders:
     - Boundaries- these will show you political boundaries like city council districts.
       - Remember that your steward-shed’s elected officials work for you! They’re definitely a stakeholder in your steward-shed, and so are all the people who can vote them into office, or out of office.

        - Population characteristics
        - Social services, Education, Housing
        - Food systems
        - Zoning and Landmarks
    - OASIS can also help you find others in the neighborhood who are interested in stewardship.
        - Under “Environmental Stewardship Groups”, click the boxes next to “Stewardship Turf”. That shows you some of your neighbors and which parts of the neighborhood they are interested in stewarding.
        - To make it easier to read, you might de-select the left box, and just leave the right one checked. Then the labels are a little clearer.
        - For example, Canarsie and its waters have about a dozen different stewardship groups listed on OASIS:



        - Once you have the names of local organizations, you can select them from this list for more information.
    - To find local sites that are part of Hudson-Raritan Estuary’s “Comprehensive Restoration Plan”, first go to Oasis and check the box that says “Comprehensive Restoration Plan”, under “Environmental Characteristics.”
        - Once you have the names of local sites, select them from this list for more information.

10) Mapping the 2010 US Census
    - An interactive map that allows you to look at the map with different filters and at different scales.

11) NYC Planning
    - The NYC Department of City Planning’s “Plans/Studies” page contains plans and studies about different neighborhoods and areas- you can view by borough or citywide.
    - If you find a plan or study that affects your steward-shed, click to go to its page and look under “updates” to see if the project is ongoing. You might be able to participate in it!

    - You can also view older projects by scrolling to the bottom of each borough's page.

12) Neighborhood-level news sources:
    - Neighborhood news options that cover mostly present day, tagged by neighborhood include DNAinfo and Patch (and Bklner if you're in Brooklyn)- you can also sign up to get alerts about neighborhoods you're interested in.
    - Curbed is a useful resource in general to get a sense of issues (including environmental issues, past and present) at the neighborhood level.
    - The blog 6sqft has a history tag with interesting stories, maps, and primary source documents, along with present day coverage of NYC.
        - Use the search bar at the top to search for a specific neighborhood or waterbody. Some neighborhoods have their own tags which you can find if you scroll down to the bottom of a post.

13) Nathan Kensinger has been doing fantastic photo essays on the NYC waterfront's history, environment, and social justice issues for 10 years, particularly on "abandoned" and industrial sites. There are over 200 of them, searchable by borough.

14) The Forgotten New York blog looks at the past and present of places all over NYC, tagged by borough and neighborhood.

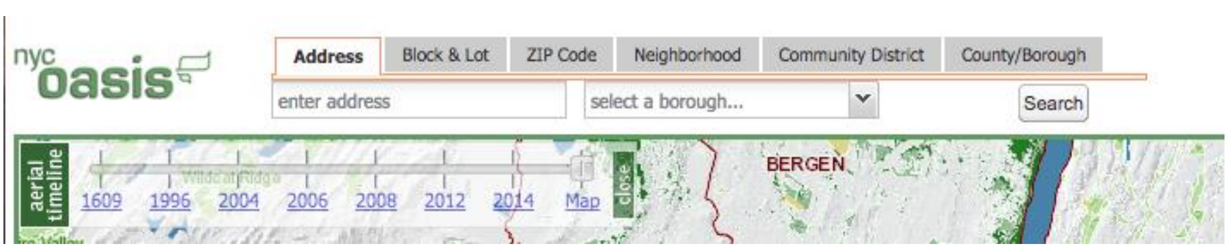
15) Book: Waterfront: A Journey Around Manhattan, by Phillip Lopate
    - Written in 2004, this book describes some of the interesting sites and wonders of Manhattan's waterfront.

16) Book: The Neighborhoods of Queens, edited by Claudia Gryvatz Copquin and Kenneth T. Jackson.
    - Includes a 4-5 page summary of the history of every neighborhood in Queens.

17) Book: The Neighborhoods of Brooklyn, edited by Kenneth T. Jackson and John B. Manbeck.
    - Includes a 4-5 page summary of the history of every neighborhood in Brooklyn.

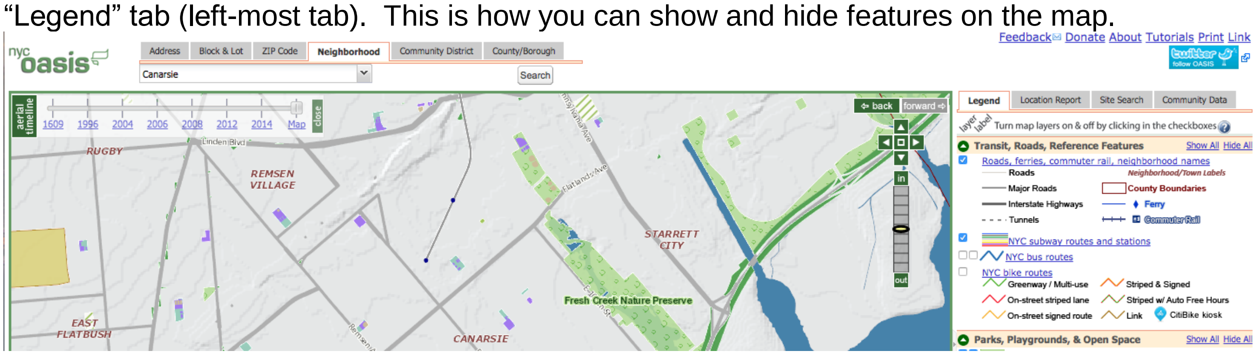
Guide to Using the OASIS Map

1. Go to the OASIS map. In the upper left hand corner, there are several options for how you can put in a location to zoom in, including by address, by neighborhood, by community district, and by county/borough.

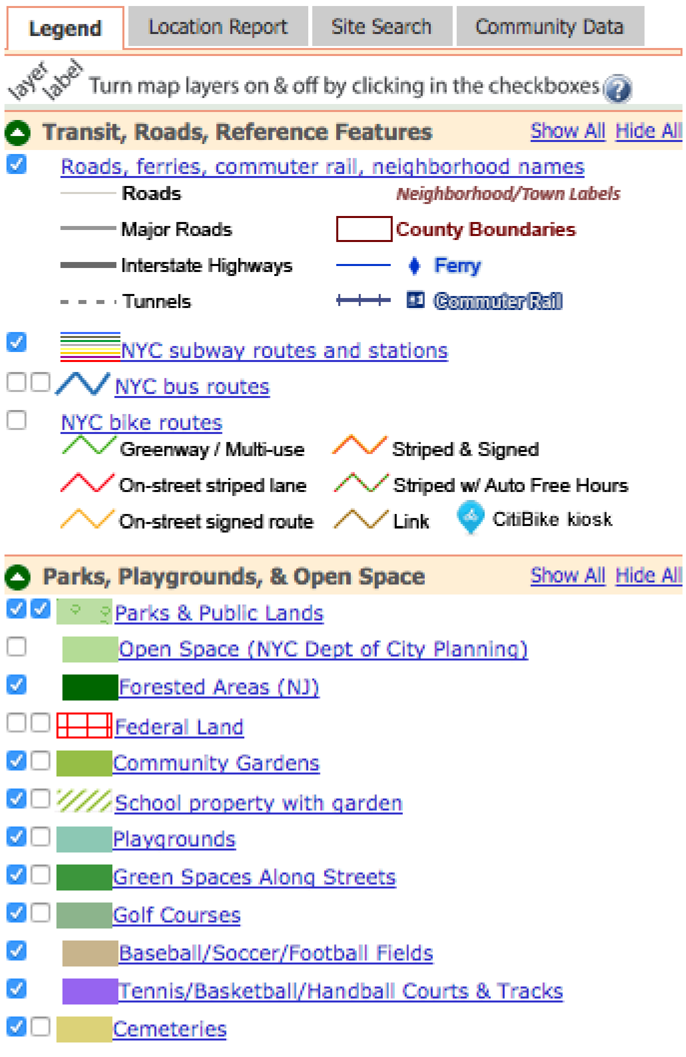


2. I chose to view the neighborhood of Canarsie, in Brooklyn. On the bottom right of the map screen, there's a small version of the NYC map with a small red box that shows the area you're looking at. On the top right corner, controls let you zoom in or out, and side to side.

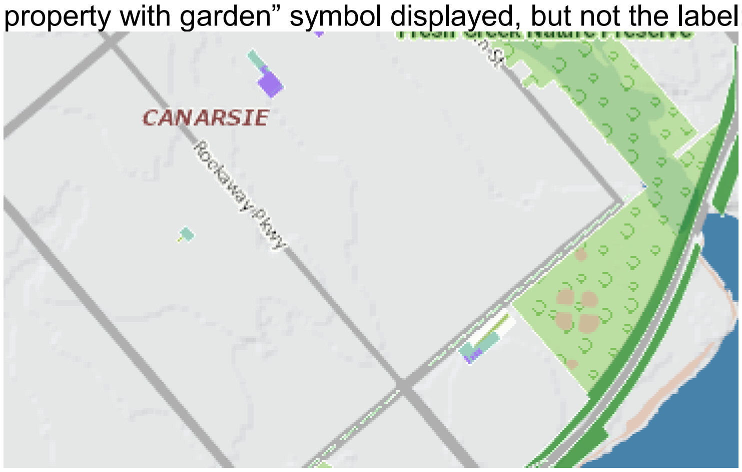
3. On the right side of the screen, there's a box with a "legend" in it. Make sure you're on the "Legend" tab (left-most tab). This is how you can show and hide features on the map.



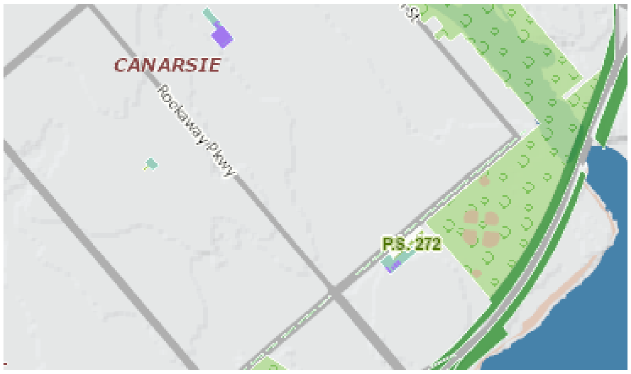
4. Maps like OASIS will often refer to "layers"- each feature you can show or hide is considered a layer. "Turning a layer on" means showing that feature. "Turning a layer off" means hiding it. The legend below shows you the default view on the OASIS map. In the default view, several layers are already turned on. Try clicking or unclicking one of these layers. What happens?



5. If there are two boxes next to a layer, the box on the left displays the symbol for that layer, and the box on the right displays the label. Here's a section of the Canarsie map with the "School property with garden" symbol displayed, but not the label:

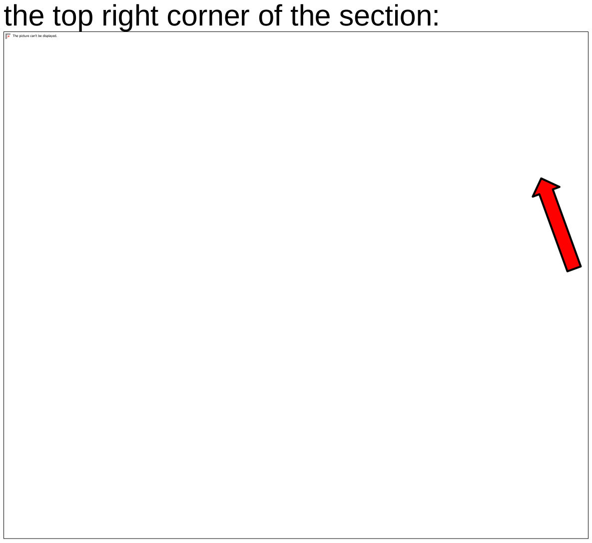


...and here it is with the label- P.S. 272 appears towards the bottom of the map:

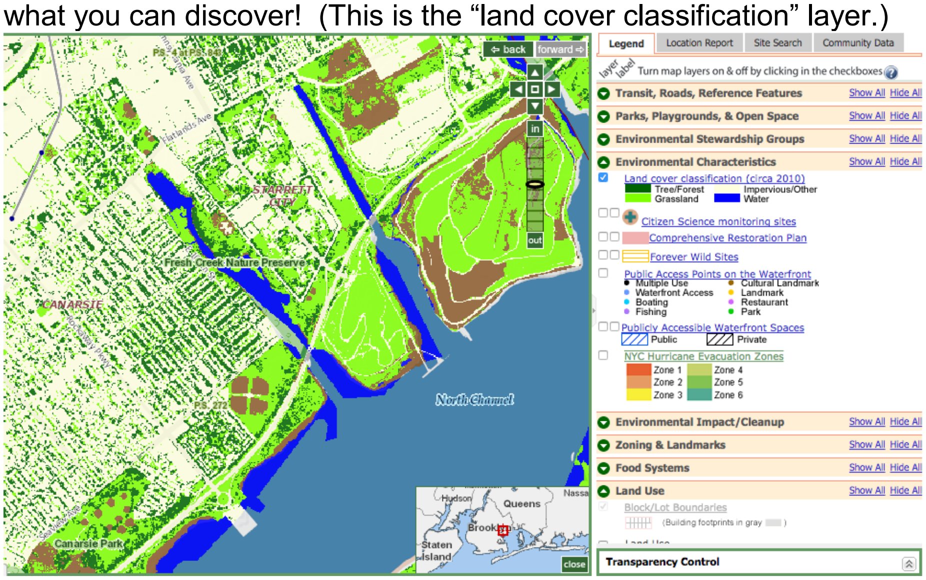


Sometimes adding the labels makes it easier to notice features on the map, and sometimes there are so many labels it makes things hard to read. Play around with it and see which display works better for you.

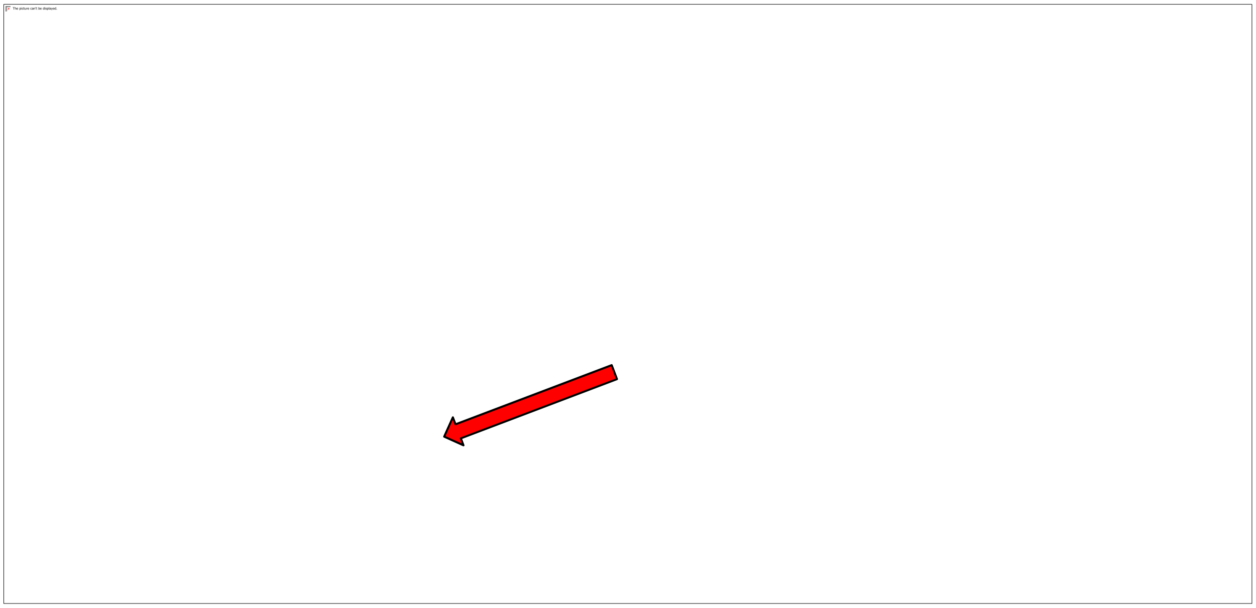
6. If you want to show or hide *all* the features in a section, you can click "show all" or "hide all" in the top right corner of the section:



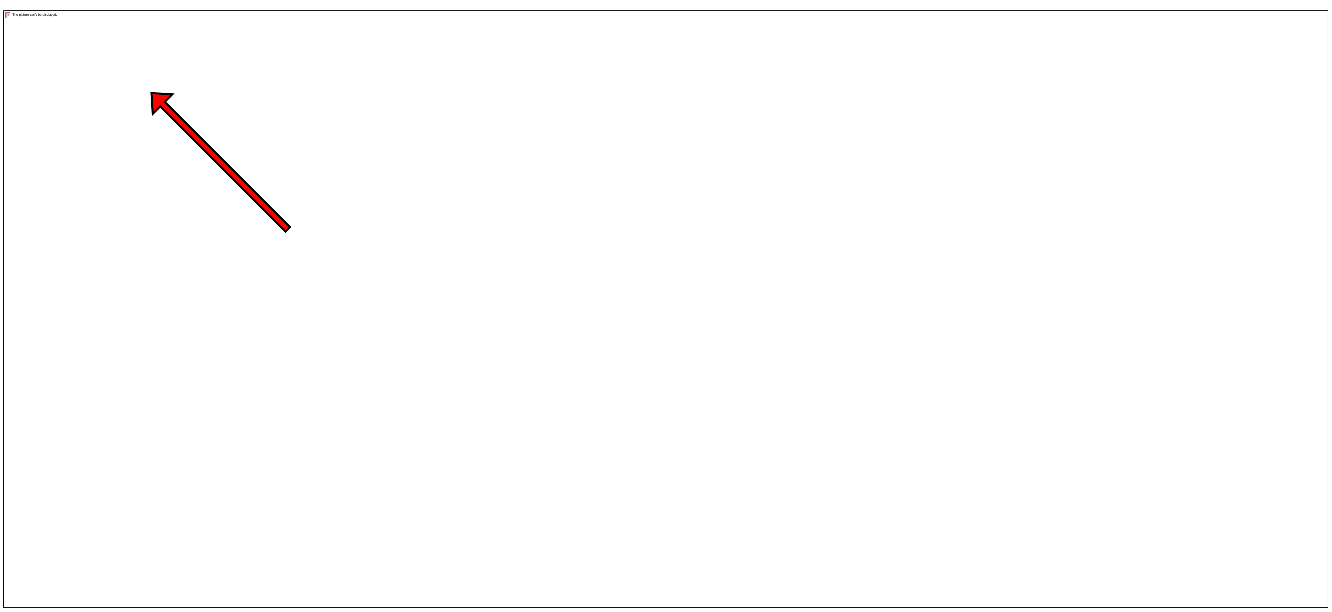
7. Turning on different layers can show you something totally new about your steward-shed- see what you can discover! (This is the "land cover classification" layer.)



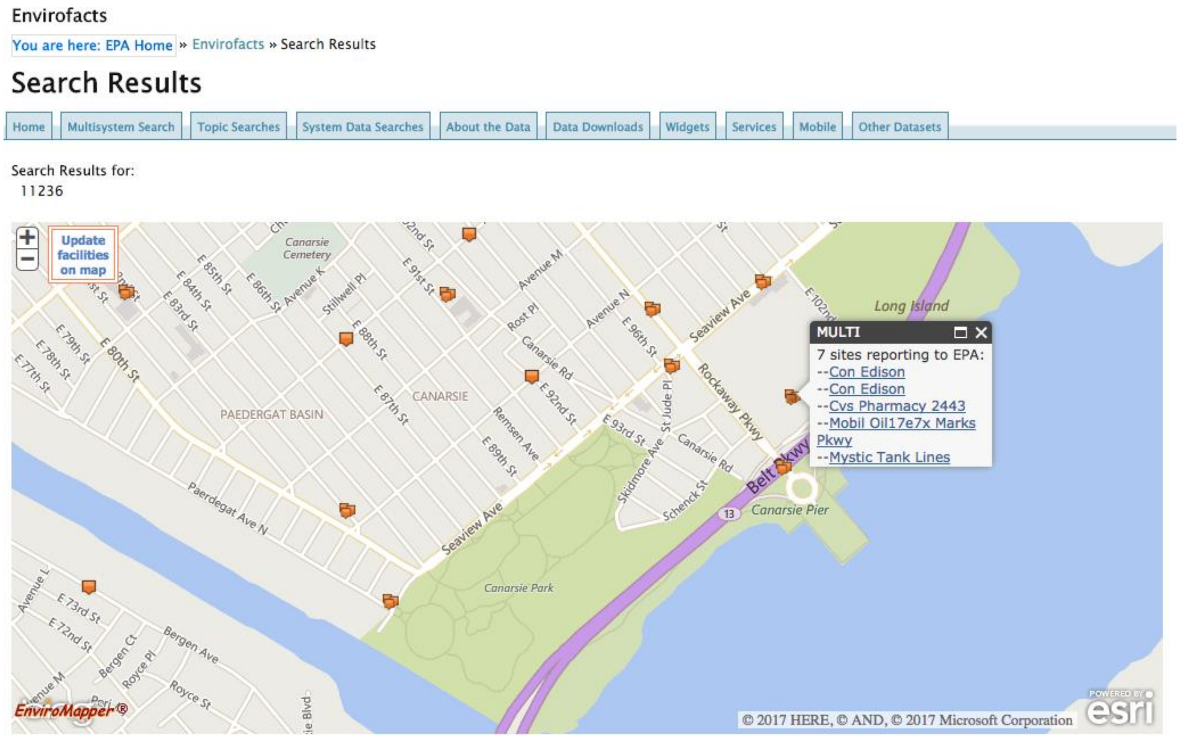
1. Start by entering your zip code in on [this page](). It will pull up a map of the area- you'll need to click the button that says "List and Map Facilities Reporting in This View" for the map to populate:



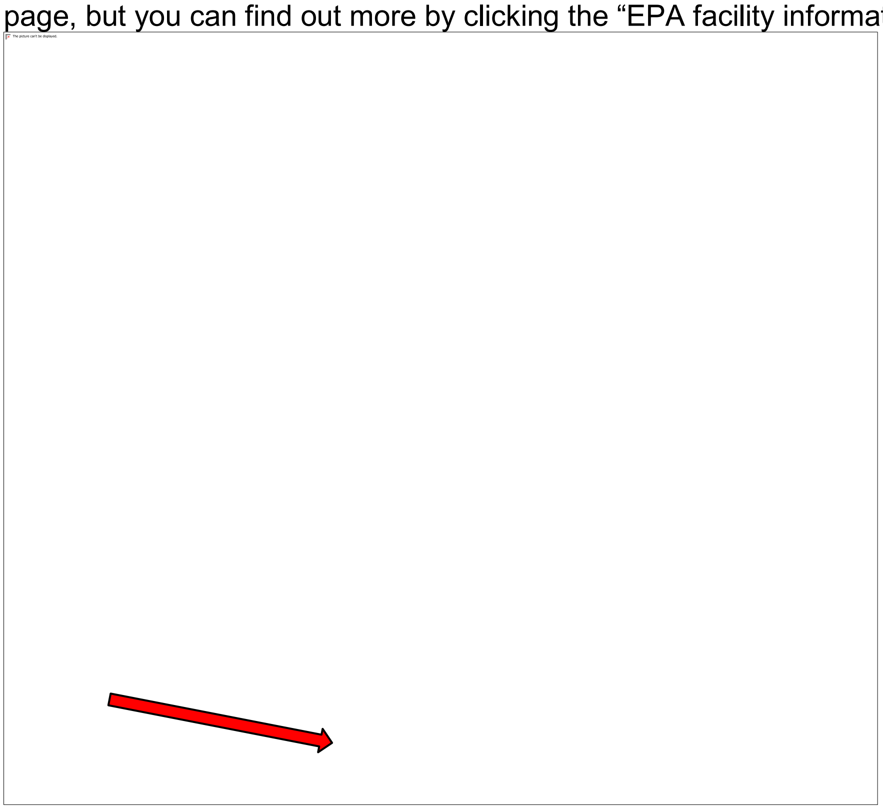
2. Orange markers will show locations in the EPA's database- but only within the zip code you originally specified. (So if you try to scroll around the map to see other places, it won't show them unless you click the box "Update facilities on map" in the top left corner.)



3. Clicking on the orange markers will pull up names of the site(s), with a link to find out more information.



4. When I click on “Mobile Oil,” it pulls up the screen below. Some information will appear on this page, but you can find out more by clicking the “EPA facility information” button:



5. This pulls up a page that tells you which EPA information systems the site is included in, and if it’s a business, it will generally tell you what kind of business. In this case, the Mobile station is found in the ICIS-AIR system, the New York- Facility Information System, and the Air Facility System.

Environmental Interests			
Information System	System Facility Name	Information System Id/Report Link	Environmental Interest Type
ICIS-AIR (AIR)	MOBIL OIL-#17-E7X MARK'S PKWY	NY0000002610700078	AIR MINOR
NEW YORK - FACILITY INFORMATION SYSTEM	MOBIL OIL-#17-E7X MARK'S PKWY	2-6107-00078	STATE MASTER
AIR FACILITY SYSTEM	MOBIL OIL-#17-E7X MARK'S PKWY	3604700586	AIR MINOR (OPERATING)

The "Supplemental Environmental Interests" field on the far right will often tell you more about why a place is being regulated by the state or federal government. In this case, New York State regulates this gas station under programs designed to protect groundwater and to prevent air pollution. Why do you think they need to do this? What effects might a gas station have on the environment?

Data Source	Last Updated Date	Supplemental Environmental Interests:
ICIS	10/19/2014	
FIS		FIS-2-6107-00078/00002 GROUND WATER PROGRAM FIS-2-6107-00078/00005 AIR PROGRAM FIS-2-6107-00078/00003 AIR PROGRAM FIS-2-6107-00078/00001 AIR PROGRAM FIS-00586 AIR PROGRAM FIS-2-6107-00078/00004 GROUND WATER PROGRAM
AIRS/AFS	05/07/2014	

The Bonus Guide to the Historical Wonders of Your Steward-shed

This bonus guide is an extension of "Our Steward-shed Library of Resources" that will help you dive deep into the history- especially the environmental justice history- of your steward-shed. Try starting by looking at the NYC Fire Insurance, Topographic, and Property Maps from the New York Public Library that we mentioned in the steward-shed library. After exploring how the land in your steward-shed was used historically, the NYPL's Old NYC Map will show you archival photos mapped to locations in your steward-shed. To find great websites on the history of your steward-shed, check out the NYPL's Best of the Web: New York City History list, and use the NYPL's other resources for specific searches. For a bloggy treatment of neighborhood history, Nathan Kensinger, Forgotten New York, Curbed, and 6sqft are fun reads.

We'll keep adding to this list as we find new resources- let us know if you find one!

1) Citywide
    - New York Public Library (NYPL)
        - Best of the Web: New York City History- list of resources about NYC history curated by the NYPL.
        - Maps
            - Old NYC Map- plots pictures from the NYPL's "Photographic Views of New York City, 1870s-1970s" collection onto a map of the city, letting you view historical photos of your steward-shed block by block.
            - NYPL Map Warper is a tool from the NYPL that lets you view and download high resolution historical maps. Many of their maps have been "rectified," which means they've been aligned over a present day map so you can view the historical map in context. (They also have a Creative Commons license so you're free to use and share them as much as you'd like!)
            - Atlases of New York City- this is where the fire insurance maps live.
        - Primary source materials (and more)
            - NYPL Digital Collections is a searchable digital archive of items from their collection, including everything from books to streaming film. Part of their collection is in the public domain so you're free to reuse and remix it!

    - Nathan Kensinger has been doing fantastic photo essays on the NYC waterfront's history, environment, and social justice issues for 10 years, particularly on "abandoned" and industrial sites. There are over 200 of them, searchable by borough.

    - The Forgotten New York blog looks at the past and present of places all over NYC, tagged by borough and neighborhood.

    - Curbed is a useful resource in general to get a sense of issues (including environmental issues, past and present) at the neighborhood level.

    - The blog 6sqft has a history tag with interesting stories, maps, and primary source documents, along with present day coverage of NYC.
        - Use the search bar at the top to search for a specific neighborhood or waterbody. Some neighborhoods have their own tags which you can find if you scroll down to the bottom of a post.

    - Book: Waterfront: A Journey Around Manhattan, by Phillip Lopate
        - Written in 2004, this book describes some of the interesting sites and wonders of Manhattan's waterfront.

- Brooklyn
    - Brooklyn Visual Heritage is a collaboration between Brooklyn Historical Society, Brooklyn Public Library, Brooklyn Museum, and Pratt to make historic images of Brooklyn searchable and accessible to the public.

    - Brooklyn Newsstand- the Brooklyn Public Library has made searchable copies of three Brooklyn newspapers (dates ranging from 1841-1955) free to the public.

    - Brooklyn Historical Society has a set of printed neighborhood guides featuring images from their archives, walking tours, and audio guides. The Fort Greene/Clinton Hill audio guide includes oral history interviews and is free to download. Guides available for the following neighborhoods: Bay Ridge/Fort Hamilton; Flatbush; Fort Greene/Clinton Hill; Fulton Ferry, Dumbo, and Vinegar Hill; Park Slope; Red Hook & Gowanus; Greenpoint; Williamsburg.

    - Book: The Neighborhoods of Brooklyn, edited by Kenneth T. Jackson and John B. Manbeck.
        - Includes a 4-5 page summary of the history of every neighborhood in Brooklyn.

- Queens
    - Book: The Neighborhoods of Queens, edited by Claudia Gryvatz Copquin and Kenneth T. Jackson.
        - Includes a 4-5 page summary of the history of every neighborhood in Queens.

Permeability Part 1 - Satellite Images

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 15, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	1	Classroom	

Summary

This is the first in a series of four lessons on the permeability of surfaces in a watershed. These lessons can be done together or individually. If you plan on doing all the lessons in the permeability series, then you should consider doing them in the order suggested: Part 1, 2, 3, and then 4. This series works particularly well after the Watersheds series of lessons. In this lesson, students study satellite images of the location you have chosen, and draw inferences about the types of surfaces to be found in that location.

Objectives

N/A

Materials and Resources

Supplies

A way for everyone to look at the same online Google Map at the same time. Google Earth generally has better images, but for this purpose you can also just look at the Satellite view on Google Maps. Projecting works best. This is also possible if everyone has their own screen and you provide very detailed instructions about what to look at when. A good color printer/copier might also be able to produce the satellite images you need, for distribution.

Before you get started

Tips for Teachers

Decide ahead of time what area you want students to model, and prepare the satellite images accordingly. It's important that students share some familiarity with this location, whether it's the location of your Oyster Restoration Station, the neighborhood of the school, or some other place that is accessible and part of your students' daily lives. Since you'll be visiting the ORS with your class anyway, the ORS could be an excellent choice. This series of Permeability lessons make more sense following the Watersheds lessons in the same unit. During the discussion, be sure to ask the students to cite specific evidence from the satellite images and/or their personal knowledge of the area, and/or encourage them to demand evidence from one another! Do your best to keep track of your students' questions and predictions, at least in your own notes. As soon as possible, post a version of those discussion notes in a place where students can also see them during the next several activities. Building models is time-consuming! If you are going to follow this series through to that stage, one way to make it very much worth the time is to arrange an opportunity for students to present their models to decision-making adults. For example, if your location includes the school grounds, could students present their model (and proposals, if you do that part), to the principal, building manager, and/or head custodian for the building?

Preparation

N/A

Background

N/A

Instruction Plan

Engage

1. Remind students that you are in the midst of the study of watersheds, and if you like, ask them to summarize their questions and insights so far about what happens to rain water after it hits the ground.

1. Show students a street map of the location you have chosen, preferably on a large screen for everyone to look at together. You can do this using Google Maps https://www.google.com/maps/
2. Ask what they know about this place.

3. Point out familiar landmarks to help them understand what they're looking at.

1. Tell your students that ultimately, you want them to be able to create a model of the surfaces around the location you have chosen. In order to do that, they need to know: what are the surfaces around that location, and how absorbent are the materials we have available for our model? You'll spend some time on both questions, starting with the location.

Explore

1. Hand out the *Surface Types Diagram* Ask your students
    - Based on your personal knowledge of the location, which surface types have you seen in the location you have chosen? Where?
    - Try to estimate what percentage of the location is covered by some of the different surfaces on the handout.
    - Encourage constructive disagreement and debate, and channel it by introducing more data...

Explain

n/a

Elaborate

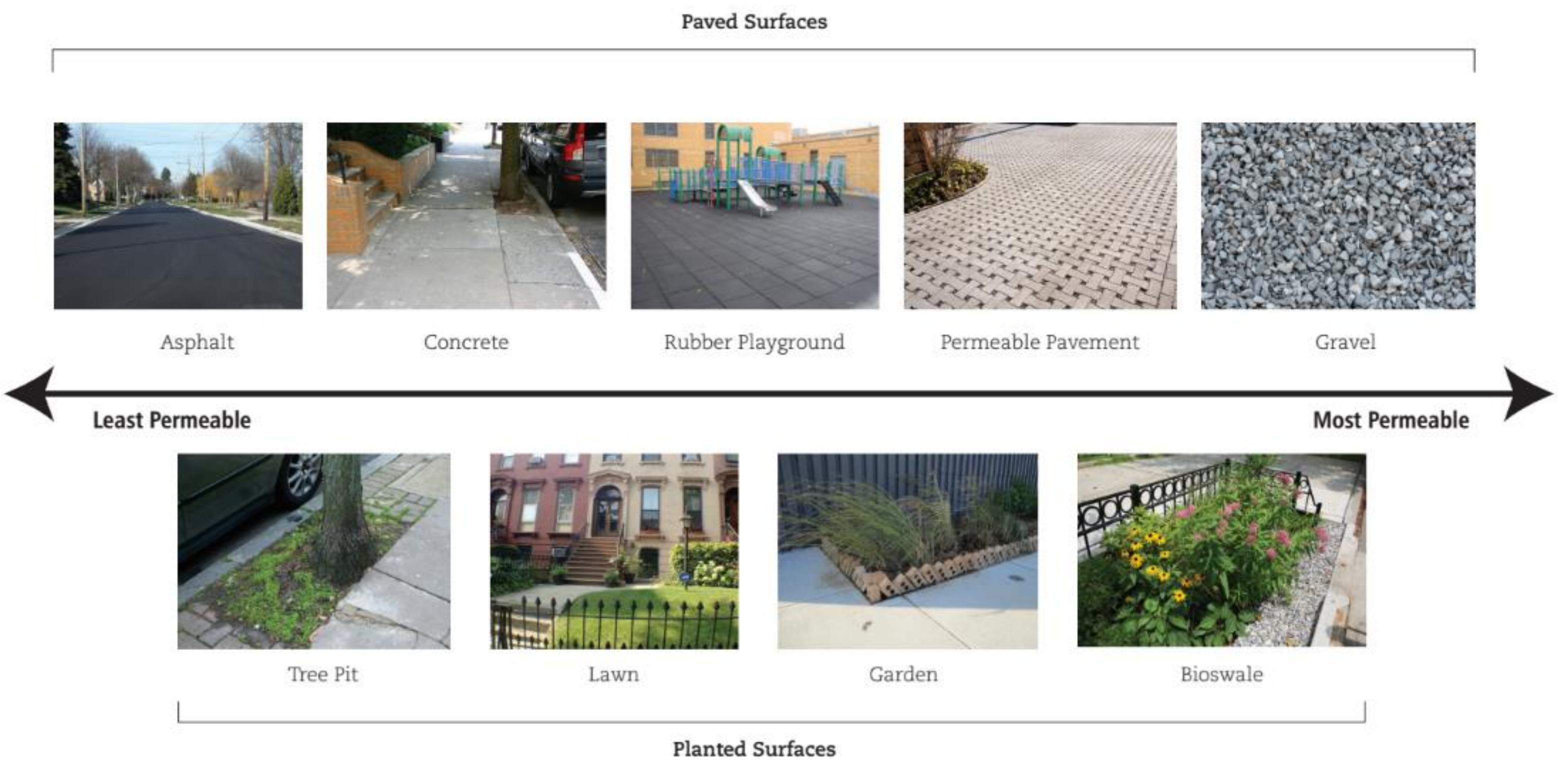
1. Look at satellite images (you can do this on Google Maps https://www.google.com/maps/) of the location you have chosen.
2. Ask your students to fill out an Observation/Inference chart based on the satellite image.
    - Under observations, ask your students to identify areas on the satellite image that look like different types of surfaces, and to describe what they can see in the image.
    - Under inferences, ask your students to predict how permeable or impermeable they think each surface is. You might postpone the use of that vocabulary until they are familiar with the concept, and for now, ask something more like:
        - Predict which surfaces could soak up rain the most, and on which surfaces the rainwater would immediately flow downhill toward another surface.
3. Lead a discussion based on the satellite image
        - During the discussion, be sure to ask the students to cite specific evidence from the satellite images and/or their personal knowledge of the area, and/or encourage them to demand evidence from one another!
        - Do your best to keep track of your students' questions and predictions, at least in your own notes. As soon as possible, post a version of those discussion notes in a place where students can also see them during the next several activities
4. Ask questions like:
    - Where do you see evidence for permeable surfaces? Where do you see evidence for impermeable surfaces?
        - Again, you can postpone using the vocabulary ("permeable" "impermeable") until students are very comfortable discussing the ideas behind the words. Then it's great to introduce the words.
    - How do you figure out some of that information from the satellite image? What areas seem most obvious, in terms of whether they are permeable or impermeable? What areas are most in doubt for you?

Evaluate

Continue the discussion by asking:

1. Do you want to revise your estimates of the percentages of different surface types?
2. What new questions do you have about the types of surfaces in our area of interest?

Standards


Paved Surfaces
Asphalt
Concrete
Rubber Playground
Permeable Pavement
Gravel
Least Permeable
Most Permeable
Tree Pit
Lawn
Garden
Bioswale
Planted Surfaces

Observation/Inference Chart

Observation ● Use your five senses. What do you see, hear, smell, taste, feel? ● Objective	Inference / Prediction ● What do you think it means? Why do you think it is this way? ● Subjective

Notes/Results/Sketch/Questions/Connections

Permeability Part 2 - Which is the best sponge?

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 15, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	1	Classroom	

Summary

This is the second in a series of four lessons on the permeability of surfaces in a watershed. These lessons can be done together or individually. If you plan on doing all the lessons in the permeability series, then you should consider doing them in the order suggested: Part 1, 2, 3, and then 4. This series works particularly well after the Watersheds series of lessons. In this lesson, students will design, perform, report to each other, and provide feedback on their own original experiments to compare different types of sponges. Students will also consider the distinction between absorbancey and permeability. If you follow the Permeability lesson series, then your students will use these same sponges in a later lesson, Part 4, to create a model of the permeability of surfaces in a local watershed you chose to focus on. This provides motivation for needing to know how the different sponges interact with water.

Objectives

N/A

Materials and Resources

Supplies

- Aluminum trays
- Water
- Aluminum foil (or something else non-absorbent like plastic, fleece or wool) different types of sponges – details in Tips for Teachers water bottle
- A way of sharing students' data, which will depend on your timing and classroom setup. This could be writing on a board, using a projector, photocopying for the next day, etc.

Before you get started

Tips for Teachers

Decide ahead of time what area you want students to model, and prepare the satellite images and possibly the outdoor expedition accordingly. It's important that students share some familiarity with this location, whether it's the location of your Oyster Restoration Station, the neighborhood of the school, or some other place that is accessible and part of your students' daily lives. Since you'll be visiting the ORS with your class anyway, that could be an excellent choice. Notes on scheduling lessons in which students design their own experiments Because some groups will work faster than others, it's important to be flexible in two ways: You need to let groups work until a critical mass have completed their testing. This amount of time will vary, and in some ways, the longer they take, the better, if that means they are really thinking and talking about what they are doing! That means you need to be prepared to let the activity run over several days, if groups are remaining focused and able to dig deeply at this moment. You also need to be prepared to wrap up quickly if groups are losing focus or not able to dig deeply at this moment. No matter how flexible you are, not every group will get all the way through their testing before you want to move on for the good of the class as a whole. That's ok! It's important to help the students feel that that's ok by making it clear that, as long as they are focused on their work and thinking carefully about what they're working on, the process is more important than the result. A very important way of accomplishing this subtle goal is to listen in on groups for several minutes at a time, so you know something about their processes, and, when the opportunities present themselves, praise students for their engaged, thoughtful processes. Don't wait for the final product to offer well-earned praise! Sponge Suggestions use a car-washing sponge to represent loose, very permeable soil use a dishwashing sponge to represent compacted, less-permeable soil use a green scouring sponge to represent compacted, barely-permeable soil use something that does not absorb like aluminum foil, plastic, or even certain types of fleece or wool where the water beads up and runs off, to represent an impermeable surface use a hard sponge that has totally dried up for the "bone-dry sponge", to represent dry soil

Preparation

N/A

Background

N/A

Instruction Plan

Engage

1. Perform this ‘demonstration’:

Where everyone can see, spill some water. You might enjoy making it look like an accident. Then point out your different materials, and ask students and let them raucously call out which sponge they think you should use to clean it up. Appear undecided for a few moments, to give everyone a chance to shout out their ideas. Perhaps toss a few sponges to students who aren’t involved yet, or who say all sponges are the same. Then choose something that won’t work very well, and try it. Let students shout at you to make a better choice. Wonder aloud, “why isn’t this working?” Let students call out their theories while you try another. Keep trying materials until you’re satisfied with the students’ energy and with the clean-up of the spill.

1. Shift gears now, praising your students if they’ve done a good job generating ideas, questions, and/or productive disagreements.

Explore

Tell your students that ultimately, they will create a model of the permeability of surfaces in the watershed location you have chosen. In order to do that, they need to know: what are the surfaces around that location, and how absorbent are the materials we have available for our model? You’ll spend some time on both, and this lesson is for learning what we need to know about our model materials. That is the purpose of doing these sponge experiments.

1. Separate students into small groups.
2. Hand out *Observation/Inference Chart.*
3. Each group gets an aluminum tray, a measuring cup and several types of sponges.
4. Ask each group to observe the different sponges and describe what they look like in the “Observation” section of the *Observation/Inference Chart.*
5. Based on these observations, predict a ranking showing which sponges will hold the most and least water, and record predictions in the “Inferences/Predictions” section of the *Observation/Inference Chart.*

Ask each group to design an experiment to test the absorbency of the different sponges. For this you can use the

Handout: Which is the best sponge?

Explain

1. Each group shows you their experimental design, i.e. the filled-in *Handout: which is the best sponge?* You can ask them questions about their plan, and ask them to solve problems with the plan before you approve it, as you see fit.
2. After you’ve approved students’ experimental designs, suggest that they create a data table in which they will record their actual results, and then let them run their experiments.

Elaborate

1. Compile groups’ results so everyone can see all of them. You might also decide to select a subset of each group’s results to share at first. Depending on your classroom setup, you might need to do this outside of class time, and continue the lesson the next day.

2. Lead a discussion in which you ask students to compare their predictions with their results.
    1. Ask them questions like:
    2. Which sponge/material held the most water? Why do you think this was the case?

3. Which sponge/material held the least? Why do you think this was the case?
4. If groups' results vary (and they probably will!), how can we make sense of that? (This can get you into a discussion where students want to know how other groups conducted their experiments. Quite possibly they can provide both positive feedback and constructive criticism on one another's experimental design!)
5. How did the size of the holes in the sponge relate to how much water it could hold? Are there other factors that seemed to help you predict the absorbency of each sponge? Are there factors that seemed to mislead you in your predictions?
6. Which sponge would you use for which job in daily life? Why?

Evaluate

1. Now remind your students that in addition to finding out which is the best sponge, they are also going to use sponges in their models of the location you have chosen, to represent surfaces with different permeability. Ask them first to write individually about, and then to discuss:
    1. Is absorbency the same thing as permeability? Put another way, do you want the same things in a sponge that you want in a nice permeable surface in your watershed?
    2. How are the two properties, absorbency and permeability, similar, and how are they different?
    3. Referring back to the Handout: Surface Types, which sponges and other materials do they think would best represent which surface types based on permeability?

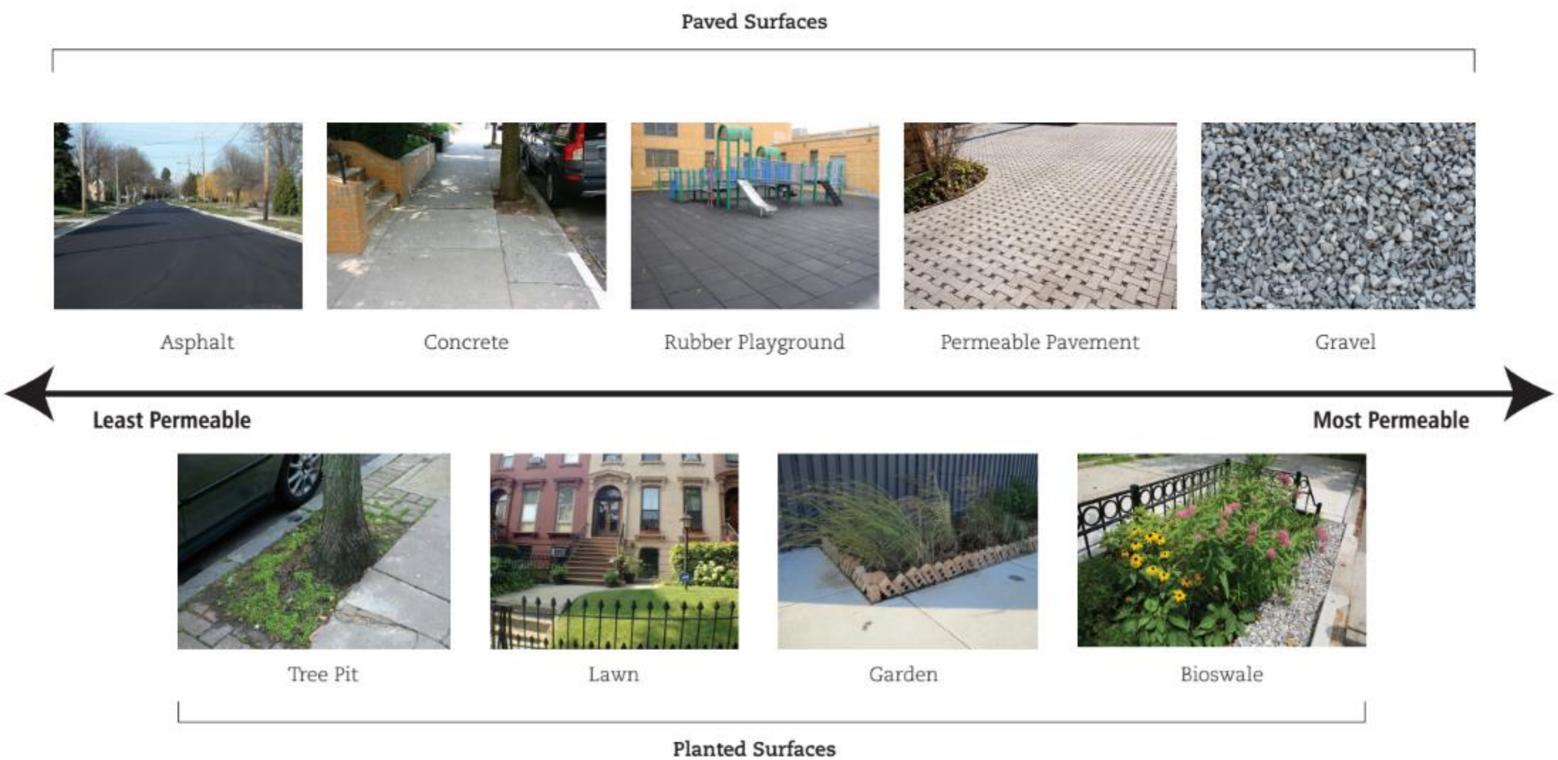
Extend

It's possible that this could lead students to want to retest all their materials, now focusing on permeability instead of absorbency. That's wonderful! If you can possibly swing it, we encourage you to postpone the other activities and go for it!

You can use the same kinds of handouts and formats, but the content will be new, richer, and deeper, because:

- students will have asked to do this
- They will have the opportunity to refine their experimental designs
- They can engage in ongoing discussion with one another about each other's experiments and analyses

Standards


Paved Surfaces
Asphalt
Concrete
Rubber Playground
Permeable Pavement
Gravel
Least Permeable
Most Permeable
Tree Pit
Lawn
Garden
Bioswale
Planted Surfaces

Observation/Inference Chart

Observation ● Use your five senses. What do you see, hear, smell, taste, feel? ● Objective	**Inference / Prediction** ● What do you think it means? Why do you think it is this way? ● Subjective

Notes/Results/Sketch/Questions/Connections

Which is the best sponge?

Your goal is to collect data that will tell us which sponge is best.

First, design your experiment:

1. How are you going to set up the sponges and the water? Sketch that part of your procedure here, with thorough labeling.

2. How are you going to measure your results? Sketch that part of your procedure here, with thorough labeling.

3. How many times do you think you need to repeat each trial? Why?

4. What are some of the things you will try to keep the same (constant), each time you test each sponge?
    a.
    b.
    c.
    d.

5. What results do you predict? Use as much or as little of this table as you like, and fill in your predicted results here. If this blank table doesn't have enough rows or columns, you can make your own on the back.

Once you've completed this assignment, show it to your teacher
before you start testing the sponges.

Permeability Part 3 - Permeability Studies in the Field

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 15, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	3	Classroom	

Summary

This is the third in a series of four lessons on the permeability of surfaces in a watershed. These lessons can be done together or individually. If you plan on doing all the lessons in the permeability series, then you should consider doing them in the order suggested: Part 1, 2, 3, and then 4. This series works particularly well after the Watersheds series of lessons. In this lesson, students will visit the location you have chosen and pour water on different outdoor surfaces to identify and quantify the real permeable and impermeable surfaces in the field. Then they compare the field observations to their earlier interpretations of satellite imagery of the same location. If you are not following the Permeability lesson series, you may wish to omit the satellite imagery portion of the "Evaluate" section of this lesson.

Objectives

- Understand that and how surfaces absorb water
- Compare permeable and impermeable surfaces
- Draw conclusions about what types of surfaces do the best job absorbing water

Materials and Resources

Supplies

In the classroom, a way for everyone to look at the same online Google Map at the same time. Projecting works best. This is also possible if everyone has their own screen and you provide very detailed instructions about what to look at when. A good color printer/copier might also be able to produce the satellite images you need, for distribution. In the classroom, a way for everyone to look at the students' field predictions and data. Most likely you'll have at least one night between the data collection in the field, and the discussion of that data in the classroom. So you can collect their work to compile the data and then hand it out.

Before you get started

Tips for Teachers

N/A

Preparation

N/A

Background

N/A

Instruction Plan

Engage

(optional but highly recommended!)

A day or two before your field visit, remind your students that they will create a model of the permeability of surfaces in that location, using the sponges and other materials they have been testing. Tell them that they will be visiting the location, in order to see for themselves what the surfaces are like – not just from satellite imagery. And in fact, they will be testing the permeability of surfaces in the field.

1. In small groups, ask students to brainstorm ways of testing the permeability of the real surfaces in the field.
2. Ask them what materials they'd like to have available.
3. You might remind them of the kinds of measuring devices that the school can usually provide, and ask them if or how they might be able to use them to gather this kind of information. That list might include things like
    1. Rulers, meter sticks, tape measures, string
    2. Timers
    3. Scales or balances
    4. Protractors
    5. Graduated cylinders or similar devices for measuring volumes
    6. Whatever else comes to mind and would be easy enough to bring to the field

1. Ask students to share ideas, take notes on those, and collect any written work you've assigned. Then it's important to gather as many of the materials they've mentioned as you can, and bring them to the field visit!

Explore

1. Take students to the location you have chosen. This would work extremely well as part of a visit to the class's ORS!
2. On the Observation/Inference chart, ask your students to:
    1. observe and list and describe all the different surfaces they encounter (concrete, asphalt, tree pit, grass, mulch, etc.) in the "Observation" section
    2. predict which surfaces are permeable and impermeable, and record predictions in the "Inferences/Predictions" section

If possible, encourage students to document the surfaces they are observing with photographs.

Explain

n/a

Elaborate

1. Now your students will test the permeability of the different surfaces. This is a fantastic opportunity to get students to design their own methods of testing! You might set particular parameters, such as: everyone has to collect at least 10 data points, and/or everyone needs quantitative data (data with a number, something you can count or measure), etc. If you need to be more directive, you could tell them how to do the testing, for example:
    1. Choose one particular surface type to experiment on.
    2. Using your water bottle, pour water on your chosen surface type.
    3. Record results in the "Notes/Results" section of the *Observation/Inference Chart.*
    4. Repeat steps 5-7 as many times as you have time for.
    5. Compare how quickly the water is absorbed (if at all) on the different surfaces.
2. If possible, encourage students to document their testing procedures with photographs.

Evaluate

At this point you may want to return to school, and complete the following in the relative quiet and predictability of the classroom.

1. Ask your students to compare the results of their field surface testing to:
    1. The predictions they made while in the field – could you always tell which surfaces were most permeable just by looking at them?
        1. If not, why might water behave differently than expected? What new questions does that raise?
    2. The Surface Types handout – are your results consistent with what it says on the handout?
        1. If not, how would you alter the handout to make it more accurate, based on your testing?
    3. What they thought they were seeing on the satellite images from Part I of the Permeability lesson series – what did you find easy to spot in satellite images, and what seems harder to gauge without going to the site and testing it for yourself?

Extend

(highly recommended!)

Lead another class discussion about students' field-based experimental designs.

1. Start by posting/distributing their data.
2. Start with open-ended questions like:
    1. What do you notice about these data?
    2. What questions do you have?
    3. Are there any surprises? Any contradictions?

       Encourage students to speak to one another, not just to you, and encourage them to follow up on each other's comments and questions. For instance:
        1. if Student A asks a question about Student B's data, ask Student B if they'd like to try answering that question.
        2. Then ask Student B's partners if they'd like to add anything.
        3. Then ask Student A if they are satisified with that answer, or if they have any follow-up questions.
        4. Then ask Student B and group if they have any follow-up questions.

           Of course, it's possible to overdo this kind of prompting, but when it works, it can create powerful exchanges of ideas!
3. Ask a couple of groups to describe and demonstrate how they did their testing. Choose groups that used slightly or very different methods.
4. Then ask those groups and the rest of the class:
    1. What are some of the similarities between these two experimental designs (or methods of testing)?
    2. What are some of the differences?
    3. What are some of the pros and cons of the different choices that each group made in their experimental design?
    4. If you were to repeat this testing, what would you do the same as one of these groups, and what would you do differently? Why?
    5. Do you think each group tested permeability, absorbency, both, or neither? Why?

Permeability Part 4 - Build a Permeability Model of a Watershed

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 15, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	2	Classroom	

Summary

This is the fourth in a series of four lessons on the permeability of surfaces in a watershed. These lessons can be done together or individually. If you plan on doing all the lessons in the permeability series, then you should consider doing them in the order suggested: Part 1, 2, 3, and then 4. This series works particularly well after the Watersheds series of lessons. In this lesson, students will create a model of the permeable and impermeable surfaces in a location that you have chosen and visited in previous lessons. They will use this model to make judgments about what they think the surfaces should be in that location. Optionally, they can also build a model of their proposed surfaces.

Objectives

N/A

Materials and Resources

Supplies

aluminum trays Thick cardboard for the bases of the models Extra paper to ball or fold up and create elevation water aluminum foil (or something else non-absorbent like plastic, fleece or wool) different types of sponges – details in Tips for Teachers Knives and scissors to cut up the materials – or you can pre-cut the sponges into thin enough pieces for the students to cut them further just using scissors water bottle Ways to attach these materials to the base – glue, glue gun, staple gun, two-sided tape, string and a way of punching holes in the cardboard, etc. None of these joining methods works all that cleanly, so you'll want to either: Leave a lot of time for construction, but have another quiet activity for some students to do while others are still constructing, Interrupt construction to have the closing discussion, and then come back to it when you find some extra time, perhaps with students volunteering to complete construction outside of class time, or potentially with you completing the execution of the students' design. A way for everyone to look at the same online Google Map at any time. Projecting works best. This is also possible if everyone has their own screen and you provide very detailed instructions about what to look at when. A good color printer/copier might also be able to produce the satellite images you need, for distribution. Items to jog students' memories of their work so far toward this goal, such as: The satellite image of the location you have chosen The Surface Types chart Their initial predictions about which surface types could be found where on the satellite image The sponges they tested Their data from testing the sponges Photographs of their field visit Photographs they took in the field, to document the surfaces they tested Their data from testing surfaces in the field Markers in at least two colors, if you decide to build the Ideal Model

Before you get started

Tips for Teachers

At this point, you will have selected the area you want students to model, and they will have studied satellite imagery and surface types, tested different types of sponges to see how they will function in the model, and tested the permeability of real surfaces, directly, in the field. Building models is time-consuming! If at all possible, arrange an opportunity for students to present their models to decision-making adults. That can make it very much worth the time! You need at least two adults to assist with construction of each model. If you decide to build two models at once, you'll need four adults in the room for that. Sponge Suggestions use a car-washing sponge to represent loose, very permeable soil use a dishwashing sponge to represent compacted, less-permeable soil use a green scouring sponge to represent compacted, barely-permeable soil use something that does not absorb like aluminum foil, plastic, or even certain types of fleece or wool where the water beads up and runs off, to represent an impermeable surface use a hard sponge that has totally dried up for the "bone-dry sponge", to represent dry soil

Preparation

N/A

Background

N/A

Instruction Plan

Engage

Remind your students of all the work they have done so far toward this goal! Show them things like:

- The satellite image of the location you have chosen
- The Surface Types chart
- Their initial predictions about which surface types could be found where on the satellite image
- The sponges they tested
- Their data from testing the sponges
- Photographs of their field visit
- Photographs they took in the field, to document the surfaces they tested
- Their data from testing surfaces in the field

Explore

Ask your students what they noticed about people during their field visit.

- Were there people at the site? Near the site?
    - What did you notice about them?
- Was there other evidence that people use the site?
    - What do they use it for?
- Could people be using the site when we're not there and leaving no trace?
    - What might they be using it for?

Explain

n/a

Elaborate

Lead a discussion or prepare a handout in which you ask your students:

1. In the the location, why might we want some surfaces to absorb rainwater? Why might we want other surfaces to cause rainwater to runoff? Where do we want each type of surface, and why?
2. Which types of surfaces do we see the most of in our location?
3. How do you think the different surfaces will impact the local:
    1. People? – which people, using the place for what purposes?
    2. Ecosystem? – does this also affect the people, in your opinion?
       (It's important to allow students to take the position that no, the ecosystem is not important to the people. Like always, those students should be asked – ideally by other students who disagree, but also by you – to provide the evidence and reasoning that leads them to take that position. Their opinions may change over time, and it's important neither to force it nor to silence the dissent.)
4. What are some of the pros and cons of impermeable surfaces? (e.g. Impermeable surfaces are better to play basketball on because you can't dribble on gravel, but impermeable surfaces create a lot of runoff.)

Evaluate

There are two parts to the model-building activity. You can do one or the other, or you can do them in sequence, or you can divide up your class and assign one part to one group and the other part to the other group.

1. Model-building – This is where you need at least two adults for each large group of students working on a single model: one adult to assign and monitor construction tasks, and the other adult to help with technical issues.
    1. Part I: Real Model
        1. Give students a map of the watershed you are studying, and skem to use all the information they've learned about this place so far to color in different permeability zones, according to the collection of materials you are providing. So for example, they could use:
            1. Gray to color in the most impermeable (least permeable) areas, where they think the class should use tin foil in its model
            2. Pink to color in the most permeable areas, where they think the class should use a car-washing sponge
            3. Green to color in slightly permeable areas, where they think the class should use a scouring sponge
            4. Etc.
        2. Help the group reach a consensus map, and post this prominently.
        3. Guide the students in building a model to represent the consensus map.
           This is where you'll need at least two adults to support the group process.

    1. Part II: Ideal Model
        1. Give students a map of the watershed you are studying, and ask them to sketch in they think is an ideal distribution of permeable surfaces in one color, and impermeable surfaces in another color.

        1. Then lead a discussion about what students consider to be ideal, and why.

        1. If there is consensus, at this point you could:
            1. Sketch this yourself, to represent the group's ideal
            2. Assign the sketch to one or two students
            3. Ask the group to make a 3D model of the group's ideal
               If you have a group building models, you will need at least two adults, one to assign tasks and one to trouble-shoot

        1. If there is thoughtful disagreement, at this point you could:
            1. Sketch the competing visions yourself
            2. Assign the sketches to students who hold those views
            3. Split up the group further to make 3D models of their competing visions
               If you now have large groups building models, you will need at least two more adults: one to assign and monitor tasks, and one to trouble-shoot technical issues

1. Ideally, follow up by making an opportunity for students to present their models to decision-making adults!

Extension

This is a particularly good follow-up activity to do if you find that your students have noticed and raised questions about the difference between new, used and damp, and used and bone-dry sponges – either after the initial sponge-testing, or after the field visit.

Procedure - Dry vs Damp Sponges

1. Use another *Observation/Inference Chart*.
2. Hand out one sponge that is “bone dry” and one that is damp (wet all the way through and wrung out).
3. Observe the two sponges and describe what they look like in the “Observation” section of the *Observation/Inference Chart.*
4. Predict which sponge will hold more water and how much water each will hold.
5. Record predictions in the “Inferences/Predictions” section of the *Observation/Inference Chart*
6. Test the absorbency of your sponges in different conditions. Again, this is a wonderful opportunity to let students design their own tests, and compare their methodologies! If you don’t want to do that, you could provide instructions, such as:
    1. Place sponge in tray and gently hold down for 10 seconds. Do not touch the sponge in any other way.
    2. Take sponge out and squeeze it into the measuring cup and record results in the “Notes/Results” section of the *Observation/Inference Chart.*
    3. Do this with each sponge.
7. Compare your predictions with your results.
    1. Which sponge held the most water? Why do you think this was the case?
    2. Which sponge held the least? Why do you think this was the case?
    3. Why do you think one type of sponge holds more water than the other?
    4. How do you think the wetness of the soil relates to the soil’s ability to hold water? In what ways do you think sponges and soil are similar? In what ways do you think sponges and soil are different?
    5. How do the dry and damp sponges compare to the environment? Which surface types do you think are like the dry sponge? Which surface types do you think are like the damp sponge?

Standards

Pollution and Runoff Through Pipes

BOP Curriculum
bop-curriculum@nyharbor.org
Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	2	Classroom	Science, Social Studies

Summary

Where does our local land-based pollution go? What other parts of the city contribute pollution to our waterfront? To understand what pollution reaches their waterfront, and where their steward-shed's pollution travels on its way into our waterways, students will map CSOs along their waterfront and WPCPs that discharge effluent along their waterfront. They will determine what kind(s) of Storm drainage exists their steward-shed – Combined Sewer, MS4, Direct Drainage and/or Bluebelt – and make educated guesses about where those pipes and overland routes most likely discharge. Finally, they brainstorm different approaches to reducing different kinds of sewage pollution of the waterways that are relevant to their steward-shed.

Objectives

- Access local, relevant environmental information from public maps such as Oasis.
- Transfer the relevant information onto their own paper maps.
- Use their knowledge of local infrastructure and topography to make inferences about where their local Storm water and treated effluent most likely discharge.
- Represent their inferences on their own paper maps.
- Brainstorm approaches to reducing different kinds of sewage pollution.

Materials and Resources

Supplies

- Thin but impactful markers – for marking up maps
- Highlighters in two or three colors – one set for each map

Before you get started

Tips for Teachers

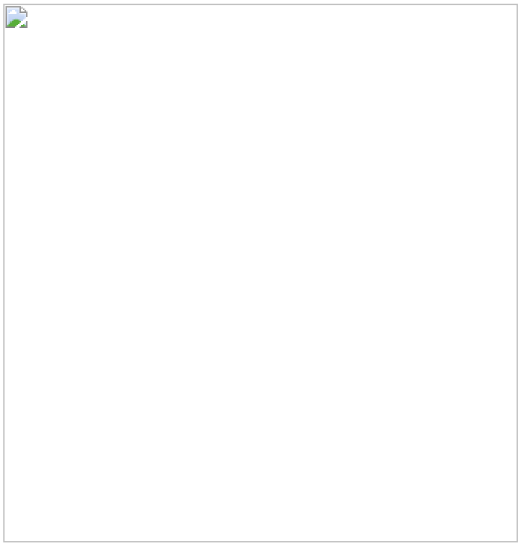
- BOP's lesson Watersheds Part 4 - Sewersheds and CSOs provides a good introduction to Combined Sewer Systems and CSOs. You might like to teach it ahead of this lesson.

Preparation

- Prepare a relatively blank map of the neighborhood+waterfront – note, this map should not be zoomed in on just the class' Steward-shed. Rather, this map should show the entire neighborhood, plus a good stretch of waterfront. Ideally it includes a "downhill" section of waterfront, where your students believe their rain water drains to.

- Remember that Storm sewers (for rain) and Sanitary sewers (for our toilets, sinks, etc.) are two different things, even though they are sometimes eventually combined.

- First determine where your Sanitary sewage is supposed to go (and where it actually goes in dry weather): http://www.nyc.gov/html/dep/html/wastewater/wwsystem-plantlocations_wide.shtml

- Then examine the New York City Sewer Systems map to determine which kinds of Storm sewer system you have in your watershed and steward-shed, and read up accordingly. (See “Background” for more detail.)

- Find the best map you can of CSOs on your waterfront. We’ve found a number of maps that dramatically understate the number of CSOs. In our experience, it’s unlikely that you’ll see a CSO on a map and then go to that place and discover there is no CSO. So in general, the more CSOs are shown on the map for your area, the more accurate we think it probably is.
  - Check the Resources at Open Sewer Atlas to see if there’s one you can use for your neighborhood. If so, you’re in luck!
  - If there isn’t, you can still use Open Sewer Atlas NYC’s All Layers Map.
    - Be sure to click the double-arrow-heads at the upper left, and then click “Legend”, so you can figure out what you’re looking at.
    - One straightforward view is to select only “CSO Outfalls”. One great feature is that you can click on each outfall to see if more information is available Here’s Canarsie, with a CSO outfall clicked in East New York, to the northeast:

        - An interesting follow-up is to add “Sewer Infrastructure”, “Major Sewer Lines”, and “CSO Drainage Areas” You still can’t tell exactly which areas drain to which CSO Outfalls, but you can make some pretty informed guesses.i

    - It’s not quite as user-friendly, but we think the Oasis map might use more recent data than Open Sewer Atlas in some cases. Under “Environmental Impact / Cleanup” select “Combined Sewer Outfalls”. The icons can be a little hard to make out, so it’s a good idea to click “Hide All” for all the other layers of the map, like we did here for Canarsie:

      In Canarsie, this looks like the same data. Check in your area to decide which is the best source for CSO information for your class.

- Look at the table in the “Evaluate” section, and choose a few scenarios that are most relevant to your steward-shed and waterfront.

    - For instance, Canarsie has substantial Direct Drainage, so in Canarsie it would be very interesting to consider untreated Storm sewage that discharges directly to the local waterfront. That’s probably a significant path for water pollution from Canarsie and to Canarsie’s waterfront.

    - But in an upland CSS area, for instance, it’s possible that untreated Storm sewage basically only reaches the waterways through CSOs – in which case, it’s probably more interesting to talk about untreated Sanitary sewage! Where does ours go? Can we figure out whose is going to our waterfront? And so on.

The following Preparation steps make sense if you are utterly fascinated by sewers and CSOs, as we are!

- Sign up to get CSO discharge alerts from the NYS DEC, for an area of your choosing. The sign-up process is a bit fussy, but you can get alerts within four hours of each discharge event.

- If you’re determined to find out all you can about where those CSOs come from, it’s also worth investigating this DEP map. If you click the “Contents” icon in the upper left, you can select “All CSO Tributary Areas” and “Combined Sewer Area Watersheds”. The data are similar to Open Sewer Atlas data, but with a few bonus nuggets for the sewershed adventurer. Here’s a screenshot of those layers of Canarsie and environs on that map:

- Check to see if your waterbody has a Long-Term Control Plan for reducing CSOs. If so, you can access a several-hundred-page report that will give you incredible details about CSO-related problems in your waterbody, and steps NYC DEP has recently taken to mitigate those problems.
    - And then be sure to check out at leat one of the following critiques of these LTCPs from S.W.I.M. Coalition (StormWater Infrastructure Matters), in order from shortest to longest:
      Clean Water Steward Workbook
      S.W.I.M. Committee member Shino Tanikawa's testimony before the New York City Council, Environmental Protection Committee Budget and Oversight Hearing March 23, 2017
      Testimony of an attorney from the National Resources Defense Council, at the same hearing

Background

So far in the Steward-shed Investigation, your students' research has focused on runoff as a major route through which land-based pollution gets transported into our waterways. It's important to understand how topography shapes that process. Now they will consider the topography-of-pipes that captures Storm water and directs it -- and its pollutants -- underground and ultimately into our waterways.

Some parts of NYC have Combined Sewer Systems (CSS), meaning that pipes direct Storm water from the ground into the same pipes that carry Sanitary sewage. Ideally that would mean that Storm water would pass through a water pollution control plant (WPCP) before reaching the waterways, but in reality the converse happens: when it rains, our local WPCPs don't have the capacity to treat the increased water volume. So, because almost anything is better than letting this combination of Storm sewage and Sanitary sewage back up into toilets, sinks, baths, and showers throughout the city, special pipes called Combined Sewer Outfalls (CSOs) divert the excess directly into our waterways. Unfortunately, it takes very little rain to make that happen.

Other parts of NYC have Municipal Separate Storm Sewer Systems (MS4s), which divert Storm water directly to the waterways. The disadvantage is that this Storm water can never be treated at a WWTP, and Storm water is responsible for a significant proportion of our water pollution. The advantage is that this Storm water does not contribute to CSO outflows -- another significant contributor to our pollution.

Compare and contrast CSS and MS4 in the CSO vs. MS4 Diagram.

Some parts of NYC have no Storm sewers at all. Storm water just travels downhill over land and into our waterways -- carrying its pollutants. When this is allowed to happen without much management, it is generally called Direct Drainage.

In contrast, a carefully managed way to discharge runoff without sewers is through a bluebelt. A large part of Staten Island drains into the Staten Island Bluebelt, a managed landscape of wetlands, streams, and ponds that conveys, stores, and filters storm water the old-fashioned way.

NYC's WPCPs process most of our Sanitary sewage, but at the end of that process, they discharge treated effluent directly into our waterways -- and that is a lot of effluent! (Here you can read more about what goes on at our WPCPs). Although treated, the effluent still:

- Contains a lot of nitrogen (from most NYC WWTPs) and phosphorus, which are considered nutrient pollution.

- Is nearly always warmer than the receiving waterbody. If you've ever suddenly changed the temperature of a fish tank, you'll understand how that could be very impactful.
- Contains a variety of other substances and materials, notably pharmaceuticals and microplastics.

To understand what pollution reaches your waterfront, and where your steward-shed's pollution travels on its way into our waterways, your students will look at:

1. CSOs along your waterfront, if any
2. WPCPs that discharge effluent along your waterfront, if any
    - It's not easy to find out exactly where each NYCity WPCP discharges its effluent. Our best guess is that it happens very close to the addresses they listed the last time they got permission to discharge from NYState.
3. What kind of sewer system is in your neighborhood (Combined Sewer, MS4, Direct Drainage and/or Bluebelt) -- and make some educated guesses about where those pipes most likely discharge.

Instruction Plan

Engage

1. Students or pairs have a relatively blank map of the neighborhood+waterfront. They draw in the boundaries of their steward-shed, and highlight the area of waterfront they think the steward-shed drains to.
2. Pairs share their maps, and share with the full class any interesting questions or points of disagreement.
3. Tell your students, "So far we have been talking about Storm water that falls on our steward-shed -- rain, snow, etc. -- but there is a lot more water coming into NYC than just our local rain!" Show NYC's Water Supply Map.
    - Ask your students, "This is where we get our tap water. What inferences can you make about the higher and lower elevation areas on this map?"
    - "Do you think our tap water is mostly flowing downhill, uphill, or on the level as it moves from these upstate watersheds into our city pipes?"
    - "Do you think that over the course of, say, a year, more rain falls on these two watersheds, or on NYC?"
    - "After we use that tap water and flush it or let it go down our drains, where do you think it goes?"

Explore

1. Show New York City's Wastewater Treatment System - Map of Plant Locations and Capacities
2. Students make observations and inferences, and raise questions -- while you record their ideas.
3. If it doesn't come up, ask your students things like:
    - "How many Water Pollution Control Plants" do we have in NYC?"
    - "Which one(s) treat the Sanitary sewage from our neighborhood and steward-shed?"
    - "Why do you think that areas 1, 2, 4, 5, and 9 span more than one landmass? Why do you think the city is piping Sanitary sewage underwater from one place to another?"
    - "Why do you think there are some orange and yellow areas with no WPCP? Does that look like the mapmaker made a mistake, or could there be other explanations?"
    - "Look at the small black dots that show the locations of the WPCPs. What do you notice about where our sewage treatment plants are located?"
    - "Where do you think the treated effluent from the WPCPs gets discharged?"
        - If it doesn't come up, tell your students, "all the treated effluent from NYC's WPCPs goes directly into our waterways."
        - Optional: "One question is, exactly where?" Then students can look at the SPDES addresses for each WPCP, map those locations, and make educated guesses about where each WPCP discharges its treated effluent.

    - "Which WPCPs do you think discharge effluent that makes its way the fastest to our waterfront? Remember how much water moves, and remember that it moves differently in different times and places!"

4. Students draw arrows on their neighborhood maps, showing how they suspect Sanitary sewage travels underground from their stewardshed, to one or more WPCPs, and then into the waterways.

Explain

1. Reiterate that there are two distinct sources of water in NYC pipes: one is the rain that falls directly on the city, and the other is piped in from upstate.
2. Show or hand out NYC Sewer Systems map. Mention that this is actually a map of Storm sewers, not Sanitary sewers. That's why it looks so different from the Map of WPCP Locations.
    - Check to see if students understand the distinction – it's about where the water comes from (local precipitation vs. plumbing) that ultimately drains into these two different sets of pipes.
3. Students locate their neighborhood and steward-shed on NYC Sewer Systems map.
4. Using highlighters on their blank paper maps, students indicate the type of Storm sewer system in their area.
    - You might remind them to start a Legend or Key to show what the highlighting means on their maps.
5. Based on the type(s) of Storm sewers in the area, students make observations, draw inferences, and raise questions in response to, "Where does our Storm sewage go?"
    - Note: in most places, it's impossible to give a complete, evidence-based answer to this question, because no public map shows all the sewage pipes. Based on the more limited information available, students should make inferences and support them with evidence and reasoning, and it's wonderful if they disagree!
6. Using a different color than they used for the Sanitary sewage arrows, students draw arrows on their neighborhood maps to show how they suspect Storm water travels from their steward-shed, overland and underground, and ultimately into the waterways, and:
    - Whether any of it ever goes to a local WPCP
    - Whether any of it goes into the waterways without being treated
    - Optional: ask students to make the thickness of an arros correspond to the proportion of the steward-shed's storm water that they think travels that route

Elaborate

If you have Combined Sewer Systems in your area:

1. Show CSO vs. MS4 Diagram
2. Ask your students, "what do you think are the pros and cons of CSS? And MS4?"
3. Show the most complete map of CSOs in your area that you can find (see "Preparation" for more detail).
4. Students locate their neighborhood and steward-shed on the map of CSOs
5. Students add the CSOs to their paper maps of their neighborhood and steward-shed.
6. Ask your students, "Do you think a lot of untreated Sanitary sewage is discharged along our waterfront?"
    - "Do you think that untreated Sanitary sewage comes from our steward-shed? If not, do you think untreated Sanitary sewage from our steward-shed gets discharged somewhere else? If so, where?"
        - Note: in most places, it's impossible to give a complete, evidence-based answer to these questions, because no public map shows all the sewage pipes. Based on the more limited information available, students should make inferences and support them with evidence and reasoning, and it's wonderful if they disagree!
7. Using yet another color, students draw arrows on their maps to show the where they suspect that untreated Sanitary sewage travels from their steward-shed into the waterways.

Evaluate

Choose a few of the following scenarios that to your class' steward-shed and waterfront (see "Preparation" section), and then ask your students to brainstorm: "what might be some different approaches to decreasing this kind of pollution of our waterways?"

Type of Sewage	Treated or Untreated	Origin on land	Discharge location
Sanitary sewage Plumbing: toilets & drains, usually indoors	Treated: WPCP	Your steward-shed	Your waterfront
			Elsewhere
		Elsewhere	Your waterfront
			Elsewhere
	Untreated: CSO	Your steward-shed	Your waterfront
			Elsewhere
		Elsewhere	Your waterfront
			Elsewhere
Storm sewage Rain and snow that fall on NYC land	Treated: only where there is a Combined Sewer System, in which case this effluent discharges from a WPCP	Your steward-shed	Your waterfront
			Elsewhere
		Elsewhere	Your waterfront
			Elsewhere
	Untreated: runoff that gets past all sewers, CSO, Direct Drainage, Blubelt, or MS4	Your steward-shed	Your waterfront
			Elsewhere
		Elsewhere	Your waterfront
			Elsewhere

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - Cause and effect relationships may be used to predict phenomena in natural systems.
- Influence of Engineering, Technology, and Science on Society and the Natural World
  - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
  - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
- Scale, Proportion, and Quantity
  - Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- Science Addresses Questions About the Natural and Material World
  - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes
- Structure and Function
  - Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
  - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

- Structures can be designed to serve particular functions.
- Systems and System Models
  - Models can be used to represent systems and their interactions.
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
  - Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

NGSS - Disciplinary Core Ideas

- ESS2.C: The Roles of Water in Earth's Surface Processes
  - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
  - Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- ESS3.C: Human Impacts on Earth Systems
  - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- ETS1.A: Defining and Delimiting Engineering Problems
  - The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
- ETS1.B: Developing Possible Solutions
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- ETS1.C: Optimizing the Design Solution
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- LS2.A: Interdependent Relationships in Ecosystems
  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

NGSS - Science and Engineering Practices

- Asking Questions and Defining Problems
  - Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
  - Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- Constructing Explanations and Designing Solutions
  - Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Developing and Using Models
  - Develop a model to describe unobservable mechanisms
  - Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
  - Develop a model to predict and/or describe phenomena
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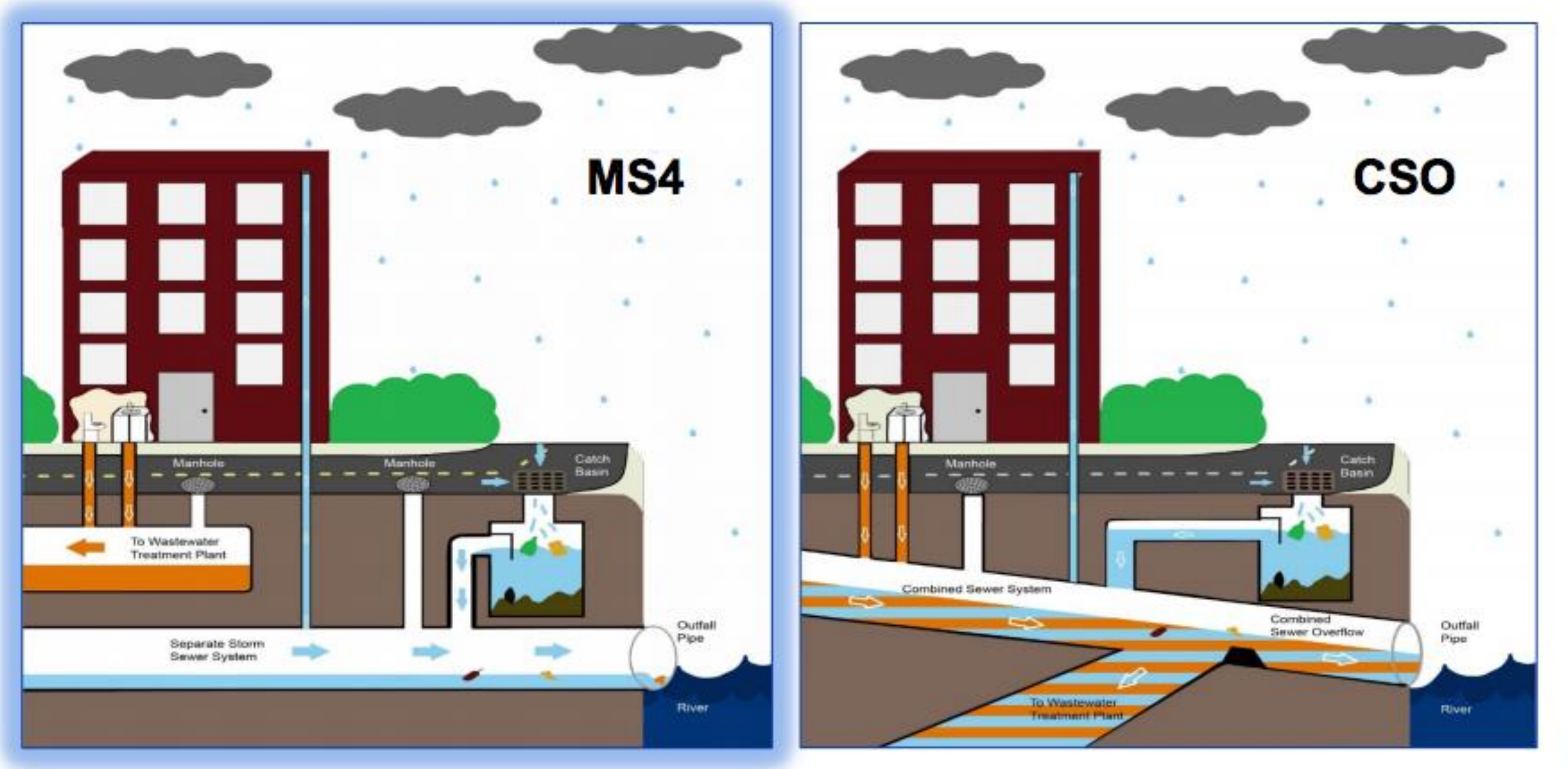
NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
  - Weather and Atmosphere
- Grade 6, Unit 4
  - Interdependence
- Grade 7, Unit 1

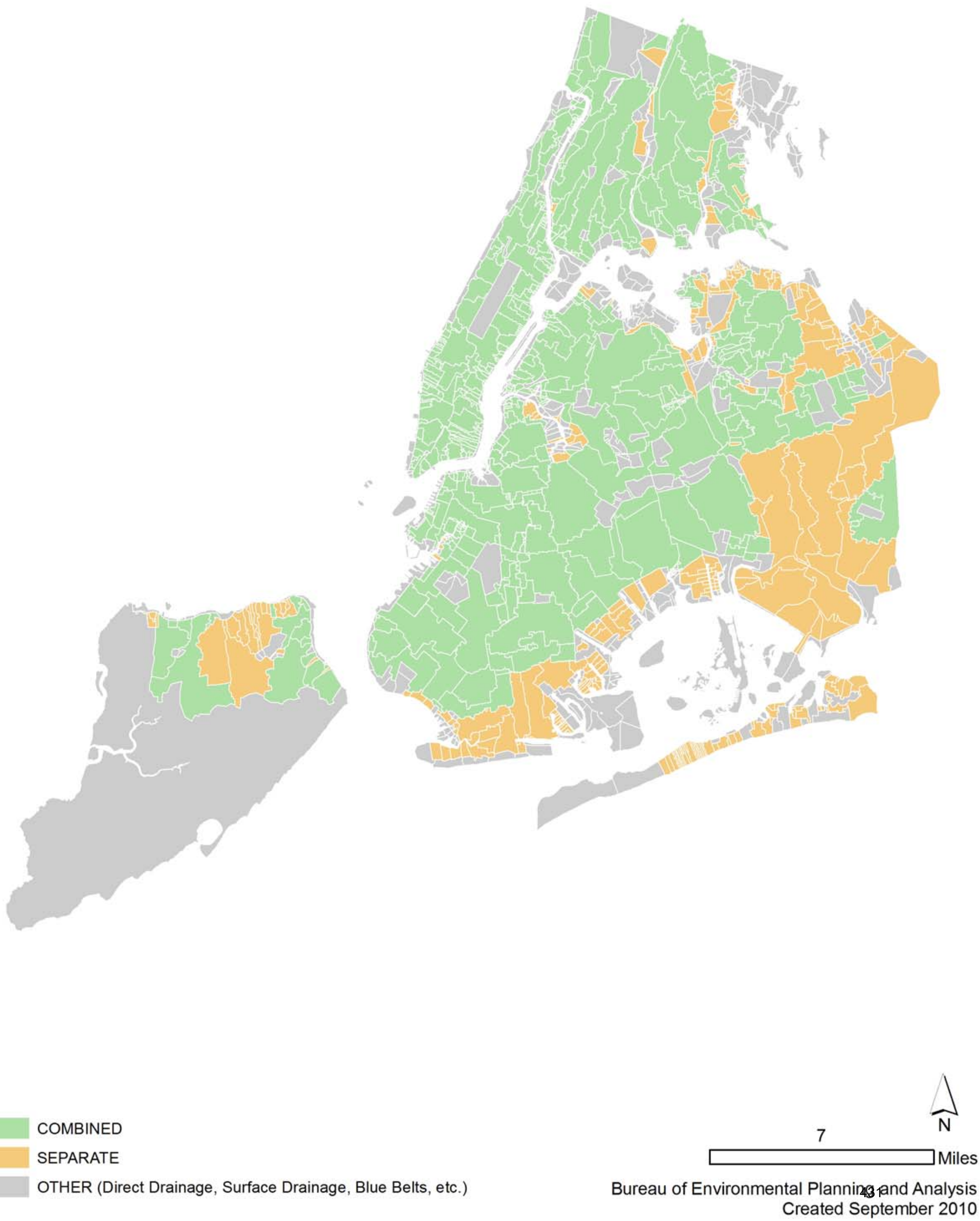
  - Geology
- Grade 8, Unit 4
  - Humans and the Environment: Needs and Tradeoffs



http://www.nyc.gov/html/dep/pdf/water_sewer/swmp-progress-report-presentation.pdf

Does it seem like the author of this diagram prefers one of these two types of Storm sewer systems?

NYC Sewer Systems



Pollution Based on Field Observations

BOP Curriculum
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Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	4	Field	Science

Summary

Students go to a specific location within their class steward-shed to observe and document sources of pollution.

Objectives

- Make a determination as to what area of their steward-shed on which to focus, based on prior knowledge and research.
- Observe sources of pollution and infer their impact on the steward-shed.

Materials and Resources

Supplies

- Clipboards

Before you get started

Preparation

- Visit your class steward-shed before this lesson. Look around for areas that may be especially interesting in terms of pollution sources that cannot be seen on the maps or resources in the previous lesson.
- Consider how big an area you want to try and cover while in the field. How big an area can your students observe and document?

Instruction Plan

Engage

1. Students get into small groups.
2. Groups get the version of their Class Steward-shed Map that is annotated with possible sources of pollution (from previous lesson Steward-shed Investigation Part 3 - Pollution Based on Maps) and their steward-shed models (from Steward-shed Investigation Part 2 - Build a Model of Your Steward-shed)
3. Be sure that the “Based on Personal Memory” and “Based on Maps” posters are available for the class to see.
4. Explain: “We will be going out into the field to look for and document sources of pollution in our steward-shed. Looking at your maps and models decide where you think would be a good place within our steward-shed to observe pollution.”
5. Groups review their maps and models and determine which specific place within the class steward-shed they would like to visit first. Students may want to investigate an area that has something of interest they could see on the map resources or an area that led them to some questions.
6. Students or groups share out where they would like to go and why.
7. After share out, make a determination (either executive or democratic) as to the specific place to go within the class steward-shed.

This would be a good time to break until the next class.

Explore

1. Go into the field.
2. Students get into small groups.
3. Each group gets a clipboard with their version of the Class Steward-shed Map that is annotated with possible sources of pollution and a clean copy of the Class Steward-shed Map.
4. Before students go off to work and explore, remind them took for both point source and nonpoint source pollution
5. Students make observations and add them to their annotated maps or clean maps.

This would be a good time to break until the next class.

Elaborate

1. Back in the classroom
2. In small groups, students review the work they completed in the field.
3. Students brainstorm what they have learned and still wonder about that area, in an open-ended way.
4. Students or groups share out some of the pollution sources they have found in the field.
    - Post their findings for the class to see under the label, “Based on Field Observation” (put this side-by-side with the other posters)
    - As questions come up, continue to post them, to see if students will be able to answer some of them throughout the remainder of their research in this Steward-shed Investigation.
5. Students begin to think about how to represent what they observed on their steward-shed models. They may need another clean copy of the Class Steward-shed Map for this purpose.
    - Students decide where to put the observed pollution on their model and what materials they should used to represent the pollution.
6. Students share out their ideas for their watershed model.
    - Take note of the materials the students mention so that you can have them ready for the next class when they actually add to their steward-shed model.

Evaluate

1. Students make inferences and brainstorm what some of the impacts might be of the sources of pollution they observed in the field.
    - Post their inferences and questions on the poster, “Based on Field Observations”
2. Ask your students, which of these sources of pollution we observed in the field do you think should be addressed first? Why? What should we focus on? The “worst” source of pollution? The easiest to address? Something else?

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Pollution Based on Maps

BOP Curriculum
bop-curriculum@nyharbor.org
Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	2	Classroom	Science, Social Studies

Summary

Students conduct research on point and nonpoint sources of pollution in their steward-shed.

Objectives

- Identify point sources of pollution in their steward-shed.
- Identify nonpoint sources of pollution in their steward-shed.

Materials and Resources

Supplies

- Post-its
- Colored pencils or markers

Before you get started

Preparation

- Explore ToxTown, a rich source of information on environmental health hazards from the National Institute of Health. Decide in advance whether you want to select relevant passages for your students – based on your knowledge of your steward-shed – or whether your students will explore ToxTown on their own. If they explore on their own, they could become anxious about the ubiquitous sources of toxins in their environment. Plan ahead how you want to help them manage that anxiety.

- Explore at least the city- and federal-level resources described in “Our Steward-shed” Library of Resources under “Maps to Study Pollution”. Based on the information available for your steward-shed, decide which resources you will encourage your students to explore. To help you quickly find the most relevant features of these map, you can consult BOP’s guides, located inside “Our Steward-shed Library”:
    - “Guide to Using the OASIS Map”
    - “Guide to Using the Envirofacts Map”

- Optional: explore the state-level resources as well. For most neighborhoods, we think those will be most useful for in-depth research, and not necessarily for your students’ first pass at this kind of research.

- Prepare a zoomed-in satellite image of your class’ steward-shed, with the boundaries drawn on it, from the lesson Steward-shed Investigation Part 1 - Paper watersheds

Background

- Good introduction to pollution in estuaries from NOAA. It's worth clicking through the tabs on "toxic substances", "nutrient pollution", "pathogens", and "invasive species" – to help you wrap your mind around the different kinds of pollution that end up in our estuary.
- Another important way of categorizing pollution is point-source vs. nonpoint-source. It's usually easier to spot point-source pollution: someone is dumping or leaking something from a specific location. Nonpoint-source pollution is a very big problem, and it's happening in your steward-shed, so it's worth teaching your students to recognize a few of the most common examples of nonpoint-source pollution:
    - Very brief introduction to oil pollution of the oceans from Smithsonian. Note that automobiles, which you will surely find in your sewer-shed, contribute a large proportion of the ocean's oil pollution.
        - Check out BOP's Very Brief Primer on Pollution from Automobiles - to give you a fuller picture of how our most ubiquitous nonpoint source of pollution continues to pollute, before, during, and long after we drive our first mile.
    - Very brief introduction to marine debris from NOAA. Note that like automobiles, most sources of marine debris are considered nonpoint sources.
        - Which types of plastic marine debris are most harmful to macroscopic animals, from Ocean Conservancy.

Instruction Plan

Engage

1. Students re-examine their Class steward-shed map (details in "Preparation" section, above).
2. Students brainstorm what they know or wonder about that area, in an open-ended way.
3. Ask your students, "based on your personal memories of this place, what kinds of pollution do you think are happening in our steward-shed?"
4. Post their responses for the whole class to see under the label "Based on Personal Memory" – so that later they can compare what they remembered with what they learned from maps, and what they learned from direct observation.

Explore

1. Students access the resources you have selected from "Our Steward-shed" Library of Resources and possibly ToxTown. (You should choose these in advance based on your steward-shed and your students – see "Preparation" for details).
2. Students or groups have Class steward-shed map, and explore the resources you have selected to annotate the map – ideally with access to post-its and colored pencils or markers – to show the sources of pollution they find in the map resources.

Explain

1. Students or groups share out some of the pollution sources they have found.
    - Post their findings for the class to see under the label, "Based on Maps".
    - As questions come up, post them, to see if students will be able to answer some of them throughout their research in this Steward-shed Investigation.
2. Most students will probably identify point sources of pollution. If some students also mention non-point sources of pollution, that is a great moment to introduce the vocabulary!
    - If students only mention point sources of pollution, ask them, "How about cars? They are a big source of pollution. Where are there a lot of cars in our steward-shed? Can you tell that on the maps? How so?"
    - And then, "what about litter? What are all the different times that there might be littering going on in our steward-shed? Is there anything on the maps to tell us where litter could be happening in our steward-shed?"

Elaborate

1. Students go back into the resources, in search of specific point sources or nonpoint sources that they had not noticed before. (They could choose between point and nonpoint, or you could divide up the two tasks, or you could assign everyone to look for both.)
2. Students add this new information to their annotated maps.
3. Students share out the new things they have noticed, while you continue to post their findings and questions.

Evaluate

1. Ask your students, "Which seems to be a bigger problem in our steward-shed, point-source pollution or nonpoint-source pollution?
    - Of course there is no wrong answer to this question, but students can make strong or weak arguments for their positions.
2. Ask your students, "Of the sources of pollution you found in the maps today, which do you think are visible to a pedestrian observer? Which might be hidden from the public view? Why might that be?"
    - This is to prepare students for the field observation in the following lesson.

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
    - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
    - Cause and effect relationships may be used to predict phenomena in natural systems.
- Influence of Engineering, Technology, and Science on Society and the Natural World
    - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
    - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
- Scale, Proportion, and Quantity
    - Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- Science Addresses Questions About the Natural and Material World
    - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes
- Structure and Function
    - Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
    - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
    - Structures can be designed to serve particular functions.
- Systems and System Models
    - Models can be used to represent systems and their interactions.
    - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
    - Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

NGSS - Disciplinary Core Ideas

- ESS2.C: The Roles of Water in Earth's Surface Processes
    - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
    - Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- ESS3.C: Human Impacts on Earth Systems
    - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for

different living things.

- ETS1.A: Defining and Delimiting Engineering Problems
  - The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
- ETS1.B: Developing Possible Solutions
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- ETS1.C: Optimizing the Design Solution
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- LS2.A: Interdependent Relationships in Ecosystems
  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

NGSS - Science and Engineering Practices

- Asking Questions and Defining Problems
  - Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
  - Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- Constructing Explanations and Designing Solutions
  - Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Developing and Using Models
  - Develop a model to describe unobservable mechanisms
  - Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
  - Develop a model to predict and/or describe phenomena
- Obtaining, Evaluating, and Communicating Information
  - Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
  - Weather and Atmosphere
- Grade 6, Unit 4
  - Interdependence
- Grade 7, Unit 1
  - Geology
- Grade 8, Unit 4
  - Humans and the Environment: Needs and Tradeoffs

“Our Steward-shed” Library of Resources

There are a *lot* of resources in this document, and some of them are a little quirky to use[1], but we promise you that even checking out a few of them will be worth it! Take your time and explore what what's interesting to you. We've got some tips below that can help you get started. You've got this!

The library is divided into the following sections:

We recommend starting with the OASIS map (#1 below), whether you're researching pollution, runoff, or your steward-shed's stakeholders. It's a community map that aggregates tons of useful information into one place, including data from both government agencies and stewardship organizations. There's even some topographical information on this map at certain scales.

After checking out OASIS, try Envirofacts (#2 below), a map from the Environmental Protection Agency (EPA), the federal agency that is charged with protecting the environment of the United States. Envirofacts will give you a very detailed picture of everything (even down to manhole covers!) that is monitored by the EPA because it could impact your local environment.

OASIS and Envirofacts can both be a little tricky to navigate, so we've put together guides on how to use both of them- they appear at the end of this library starting on page 7.

Maps to study pollution

[1] We tried out the maps on this list to explore our own neighborhoods, and quality checked by comparing what we saw outside with what we found on the maps. In the case of historical maps, we drew on our knowledge of NYC history to navigate some of the quirks. But it's always important to look at these resources with a critical eye! Think about these sources as being in conversation with each other. Like people, sources in a conversation may not agree all the time. By bringing more voices into the conversation, you'll get a better sense of the big picture in your steward-shed.

Contemporary maps that can help you identify sources of pollution in the present

1) Oasis map (city-level)
   - An interactive map that allows you to turn features on and off including open space, CSOs, community groups, etc.
   - Check and uncheck the boxes to see and hide features. If there are two boxes next to a feature, the first box is usually a symbol and the second is a written label.
   - The following tabs might help you study pollution:
     - Environmental Impact/Cleanup
     - Environmental Characteristics
     - Zoning and landmarks- look at areas zoned "industrial"
     - Land use
     - What else might help?

2) Environmental Protection Agency (EPA) databases and maps (federal level)
   - MyEnvironment page offers a snapshot of your local conditions, including air and water quality. The MyMaps section of the page is a good place to start investigating your steward-shed's conditions.
   - Envirofacts is the EPA's master database/map of places that are subject to environmental regulations or of environmental interest. It includes some information from state databases, in addition to federal databases.
     - Start by putting in your zip code to see *all* the locations in your steward-shed. What kinds of places are you seeing? Why might they be in the EPA's database? Is it hard to figure out why some places would be "of environmental interest?"[2]
     - On the Topic Searches page, you can also try separate searches to get specific information about places that produce air pollution, facilities that have permits to discharge wastewater, locations that store hazardous materials near you, etc.

3) New York State Department of Environmental Conservation (NYS DEC) databases and maps (state-level)
   - Natural Resources and Environmental Protection Maps has a list of "Chemical and Pollution Control Maps" that can be viewed online in Google Maps or via Google Earth. (You'll need to download Google Earth to see some of these maps.) These maps include things like CSOs and brownfield cleanup sites.
   - Environmental Remediation Databases
     - The DEC has three environmental remediation databases:
       - Spills- tracks all reported petroleum spills of more than 5 gallons.
       - Environmental site remediation- sites being cleaned up through one of the state's programs, like the State Superfund program or the Radiation program.
       - Bulk storage- places that store a large amount of petroleum, oil, or chemicals.

[2] You might be wondering- why are manhole covers all over this map? Underground electrical and communications infrastructure, like manholes and vaults, can fill up with water and sediment that has been polluted with oil, lead, and other contaminants from the streets and from electrical equipment. When electrical companies remove this sediment, they sometimes have to treat it as hazardous waste. This means the manholes end up falling under the "Resource Conservation and Recovery Act," the law that creates the framework for dealing with hazardous and non-hazardous solid waste.

Historical maps that can help you identify sources of pollution in the past

4) New York Public Library: NYC Fire Insurance, Topographic, and Property Maps
   - Fire insurance maps are extremely detailed historical maps that show the footprints and uses of buildings- plus a lot more! (The most common fire insurance maps you'll see are "Sanborn" maps.)
   - Today, these maps are frequently used to see if the historical use of a building or lot means the site has potential environmental risks.
   - This key explains what the colors and symbols on the buildings mean on a Sanborn map. (Other mapmakers generally used similar conventions, but here are links to keys for other maps on NYPL's list: Hyde, Bromley, Robinson. Perris eventually merged with Sanborn- the keys are similar.)
     - To start- "hazardous" buildings are marked in green. Do you see any in your steward-shed?
     - If you do find green-marked buildings, the Sanborn map key includes a "Special Hazards" section that provides more information about what kinds of businesses were considered hazardous. Do you recognize all of them? Do any of them surprise you?
   - Look for any factories in your steward-shed. (They may or may not be marked in green.) How many were there? What kind? Factories like oil refineries and shipyards regularly polluted the land, water, and air with toxic chemicals before laws were put in place to stop them.
   - Bonus: a fun way to play around with fire insurance maps to get familiar with them is NYPL's "Building Inspector" game!

Maps to study runoff

Maps that show present day features relevant to runoff

5) Satellite images- which you can see using Google Maps or Google Earth. Earth has better images, but Maps should work for this activity.
   - Go to Google Earth or Maps and click on "Satellite" in the lower left corner.
   - Start by entering your zip code into the search field.
   - From there you can drag the map around, and you can zoom in and out.

- Try to find a familiar place. Then look closely at the satellite image of that place. Check out different levels of zoom.
- What does the satellite image show you that looks like it would be impervious to water? How can you tell?
- What does the satellite image show you that looks like it might hold water for a while, or slow the water down, or let the water sink in? How can you tell?
- What does the satellite image show you that is tricky to identify or categorize?

6) Oasis map
    - The following tabs might help you study runoff:
        - Start with the “Environmental Characteristics” tab. Check the “Land cover classification” box, which will show different kinds of permeable and impermeable surfaces.
            - The key next to the box shows that there are four kinds of land covers on this map- dark green for trees, bright green for grass, beige for “impervious/other” (impermeable surfaces), and blue for water.
        - Land use
        - Transit, Roads, Reference Features
        - Water and Wetlands
        - ...what else might help?

7) NYC Open Data- Planimetric maps
    - Planimetric maps are maps made by digitally associating aerial photography with a map coordinate system. Computer programs can identify specific features on these maps, like streets, parks, boardwalks, and more.
    - NYC Open Data has planimetric maps that show one feature at a time. You can find a full list of these features here by scrolling down to “feature classes.” Click here to see a list of NYC planimetric maps (These maps should have the “authority” set to “official,” the “view types” set to “maps,” and the “tag” set to “planimetrics.”)
    - It’s probably easiest to start with OASIS, and only dive into the planimetric maps if there’s a feature not listed in OASIS you’d like to take a closer look at (like boardwalks).

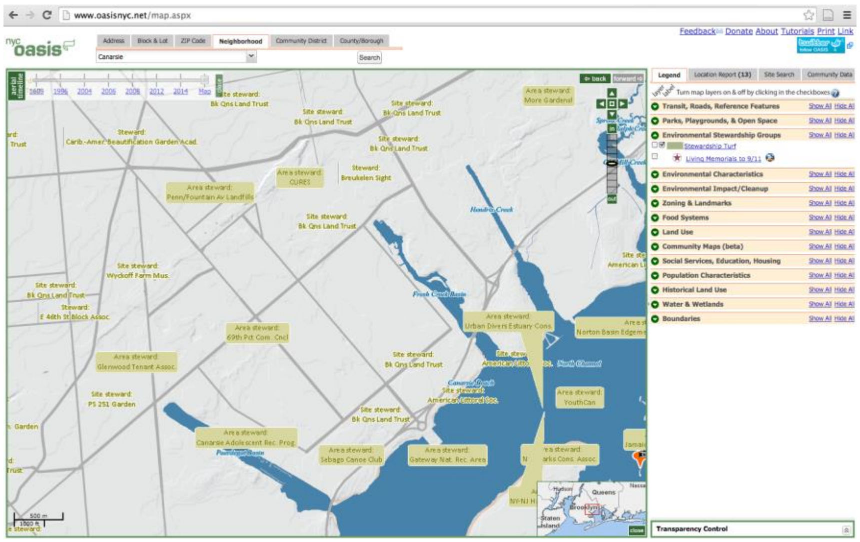
Maps that show historical geography/topography and land use

8) Mannahatta/Welikia 1609 Map
    - Map and information about Manhattan as it would have looked in 1609, before the influence of European imperialism.

Resources to research stakeholders

9) OASIS map
    - An interactive map that allows you to turn features on and off including open space, CSOs, community groups, etc.
    - Check and uncheck the boxes to see and hide features. If there are two boxes next to a feature, the first box is usually a symbol and the second is a written label.
    - The following tabs might help you learn about the population of your steward-shed and identify stakeholders:
        - Boundaries- these will show you political boundaries like city council districts.
            - Remember that your steward-shed’s elected officials work for you! They’re definitely a stakeholder in your steward-shed, and so are all the people who can vote them into office, or out of office.

    - Population characteristics
    - Social services, Education, Housing
    - Food systems
    - Zoning and Landmarks
  - OASIS can also help you find others in the neighborhood who are interested in stewardship.
    - Under “Environmental Stewardship Groups”, click the boxes next to “Stewardship Turf”. That shows you some of your neighbors and which parts of the neighborhood they are interested in stewarding.
    - To make it easier to read, you might de-select the left box, and just leave the right one checked. Then the labels are a little clearer.
    - For example, Canarsie and its waters have about a dozen different stewardship groups listed on OASIS:



    - Once you have the names of local organizations, you can select them from [this list] for more information.
  - To find local sites that are part of Hudson-Raritan Estuary’s “[Comprehensive Restoration Plan]”, first go to Oasis and check the box that says “Comprehensive Restoration Plan”, under “Environmental Characteristics.”
    - Once you have the names of local sites, select them from [this list] for more information.

10) Mapping the 2010 US Census
  - An interactive map that allows you to look at the map with different filters and at different scales.

11) NYC Planning
  - The NYC Department of City Planning’s “Plans/Studies” page contains plans and studies about different neighborhoods and areas- you can view by borough or citywide.
  - If you find a plan or study that affects your steward-shed, click to go to its page and look under “updates” to see if the project is ongoing. You might be able to participate in it!

        - You can also view older projects by scrolling to the bottom of each borough's page.

12) Neighborhood-level news sources:
    - Neighborhood news options that cover mostly present day, tagged by neighborhood include DNAinfo and Patch (and Bklner if you're in Brooklyn)- you can also sign up to get alerts about neighborhoods you're interested in.
    - Curbed is a useful resource in general to get a sense of issues (including environmental issues, past and present) at the neighborhood level.
    - The blog 6sqft has a history tag with interesting stories, maps, and primary source documents, along with present day coverage of NYC.
        - Use the search bar at the top to search for a specific neighborhood or waterbody. Some neighborhoods have their own tags which you can find if you scroll down to the bottom of a post.

13) Nathan Kensinger has been doing fantastic photo essays on the NYC waterfront's history, environment, and social justice issues for 10 years, particularly on "abandoned" and industrial sites. There are over 200 of them, searchable by borough.

14) The Forgotten New York blog looks at the past and present of places all over NYC, tagged by borough and neighborhood.

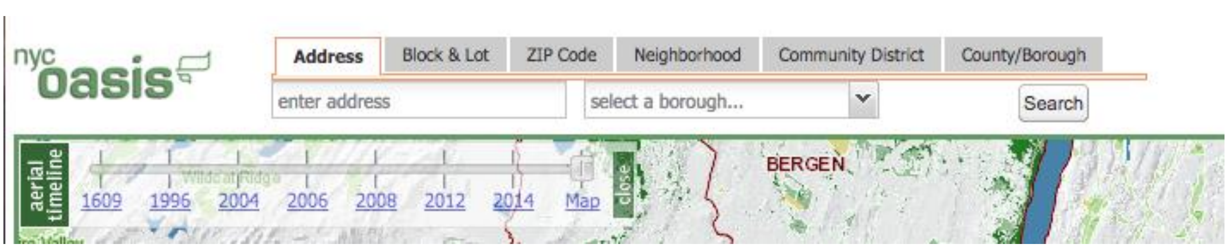
15) Book: Waterfront: A Journey Around Manhattan, by Phillip Lopate
    - Written in 2004, this book describes some of the interesting sites and wonders of Manhattan's waterfront.

16) Book: The Neighborhoods of Queens, edited by Claudia Gryvatz Copquin and Kenneth T. Jackson.
    - Includes a 4-5 page summary of the history of every neighborhood in Queens.

17) Book: The Neighborhoods of Brooklyn, edited by Kenneth T. Jackson and John B. Manbeck.
    - Includes a 4-5 page summary of the history of every neighborhood in Brooklyn.

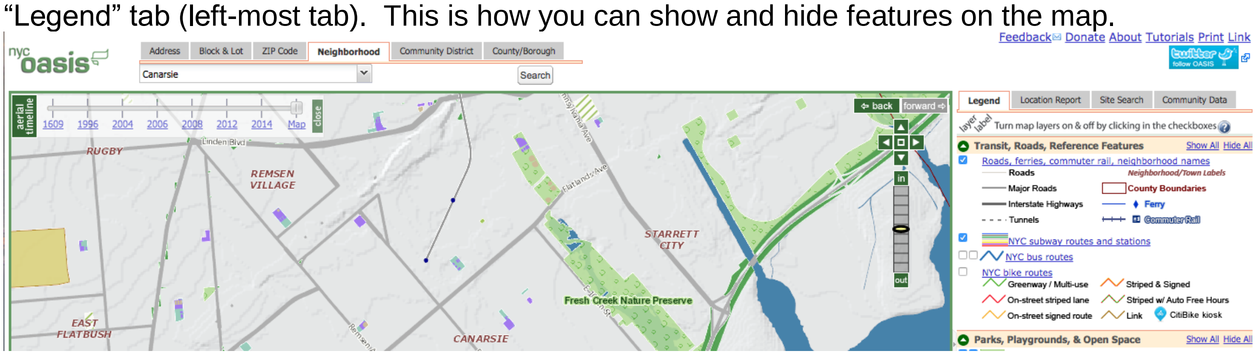
Guide to Using the OASIS Map

1. Go to the OASIS map. In the upper left hand corner, there are several options for how you can put in a location to zoom in, including by address, by neighborhood, by community district, and by county/borough.

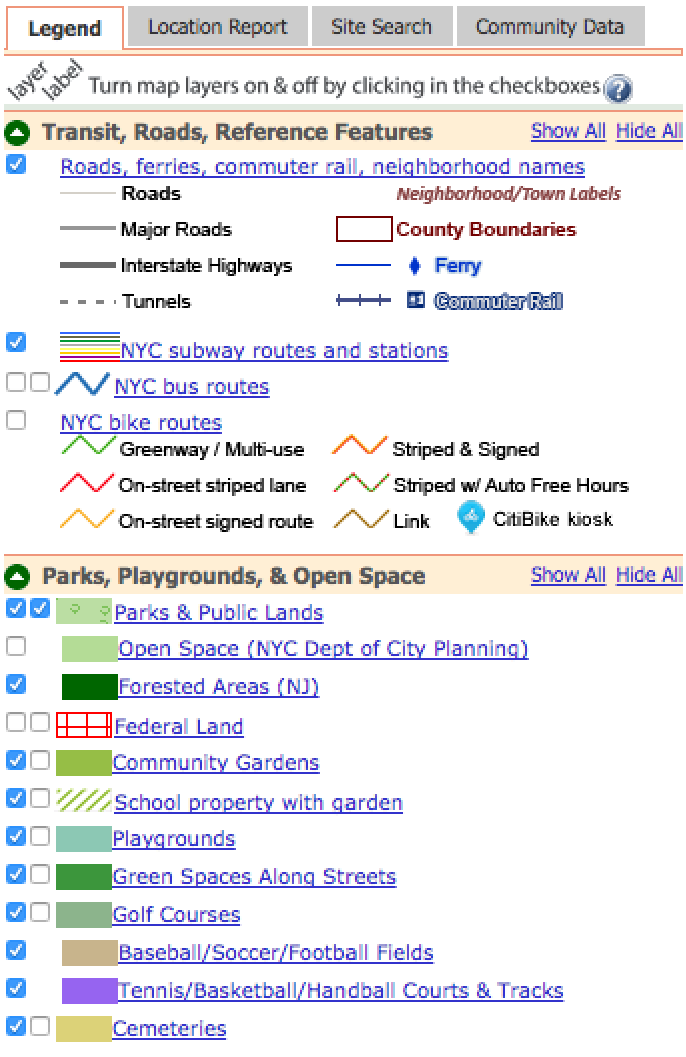


2. I chose to view the neighborhood of Canarsie, in Brooklyn. On the bottom right of the map screen, there's a small version of the NYC map with a small red box that shows the area you're looking at. On the top right corner, controls let you zoom in or out, and side to side.

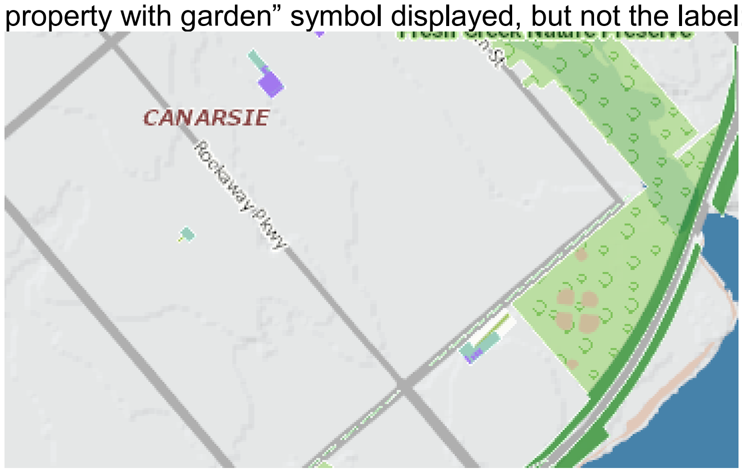
3. On the right side of the screen, there's a box with a "legend" in it. Make sure you're on the "Legend" tab (left-most tab). This is how you can show and hide features on the map.



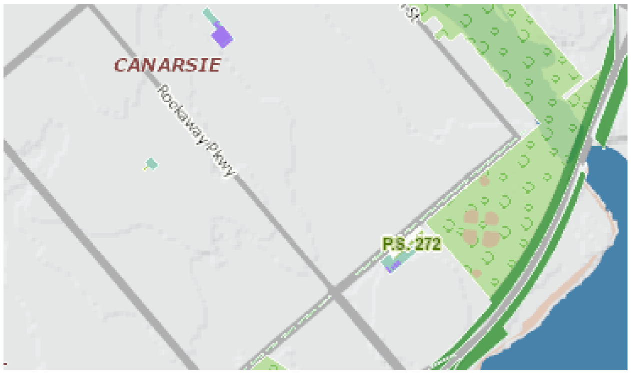
4. Maps like OASIS will often refer to "layers"- each feature you can show or hide is considered a layer. "Turning a layer on" means showing that feature. "Turning a layer off" means hiding it. The legend below shows you the default view on the OASIS map. In the default view, several layers are already turned on. Try clicking or unclicking one of these layers. What happens?



5. If there are two boxes next to a layer, the box on the left displays the symbol for that layer, and the box on the right displays the label. Here's a section of the Canarsie map with the "School property with garden" symbol displayed, but not the label:

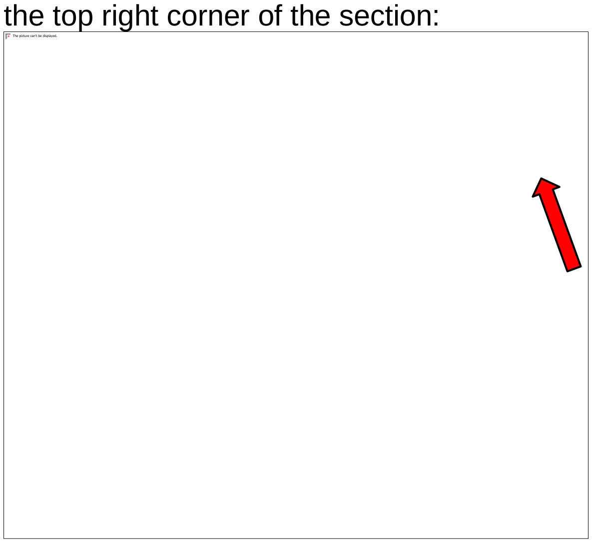


...and here it is with the label- P.S. 272 appears towards the bottom of the map:

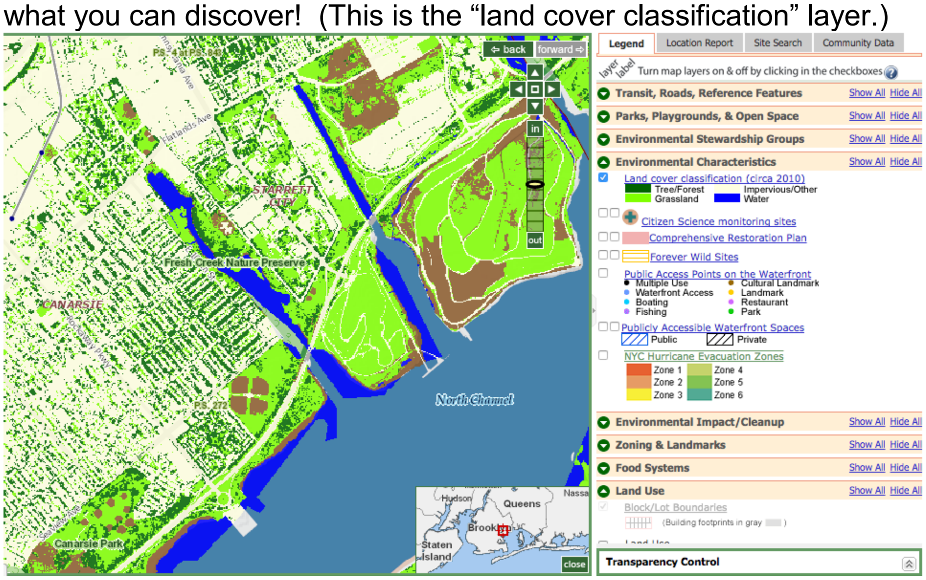


Sometimes adding the labels makes it easier to notice features on the map, and sometimes there are so many labels it makes things hard to read. Play around with it and see which display works better for you.

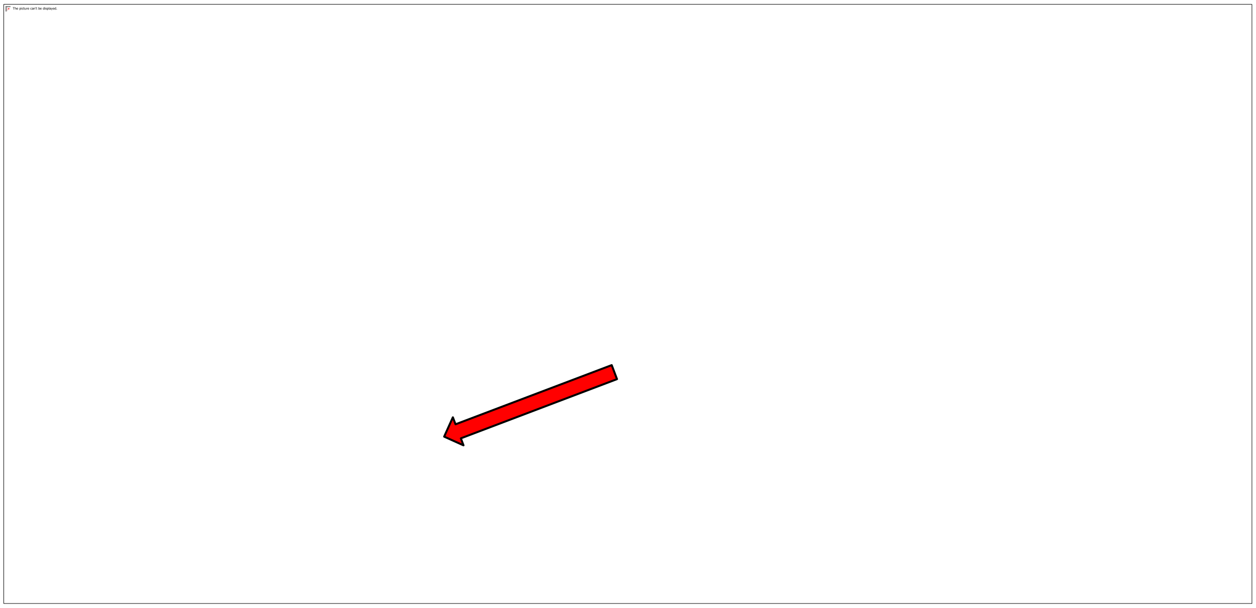
6. If you want to show or hide *all* the features in a section, you can click “show all” or “hide all” in the top right corner of the section:



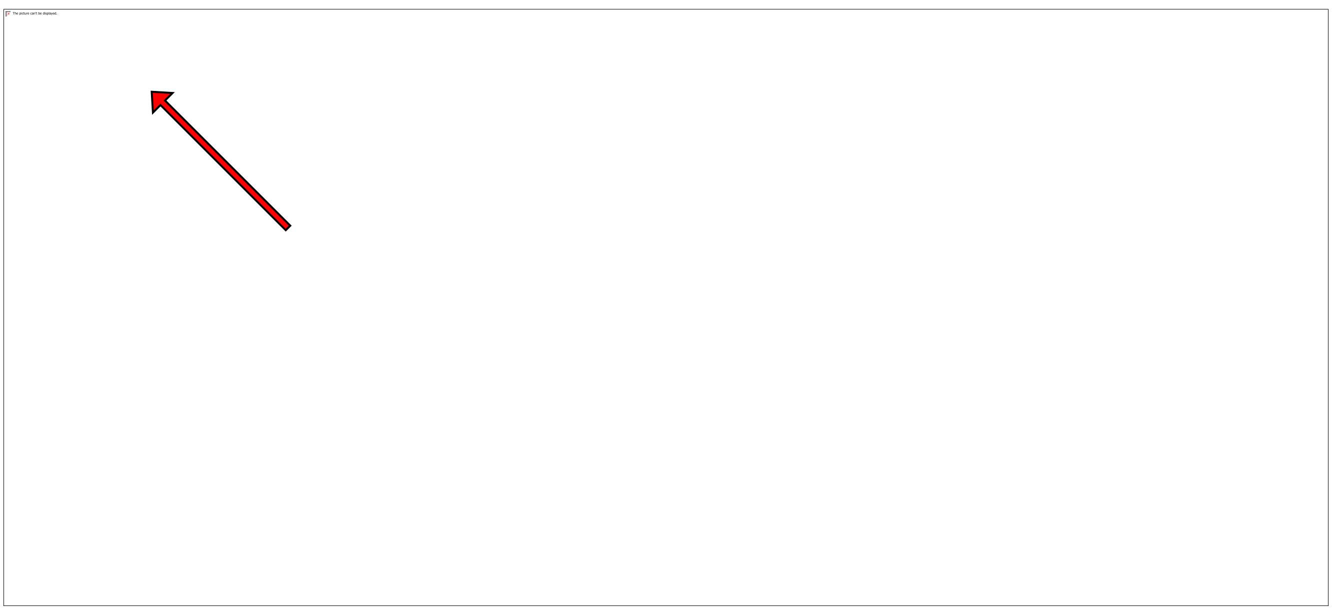
7. Turning on different layers can show you something totally new about your steward-shed- see what you can discover! (This is the “land cover classification” layer.)



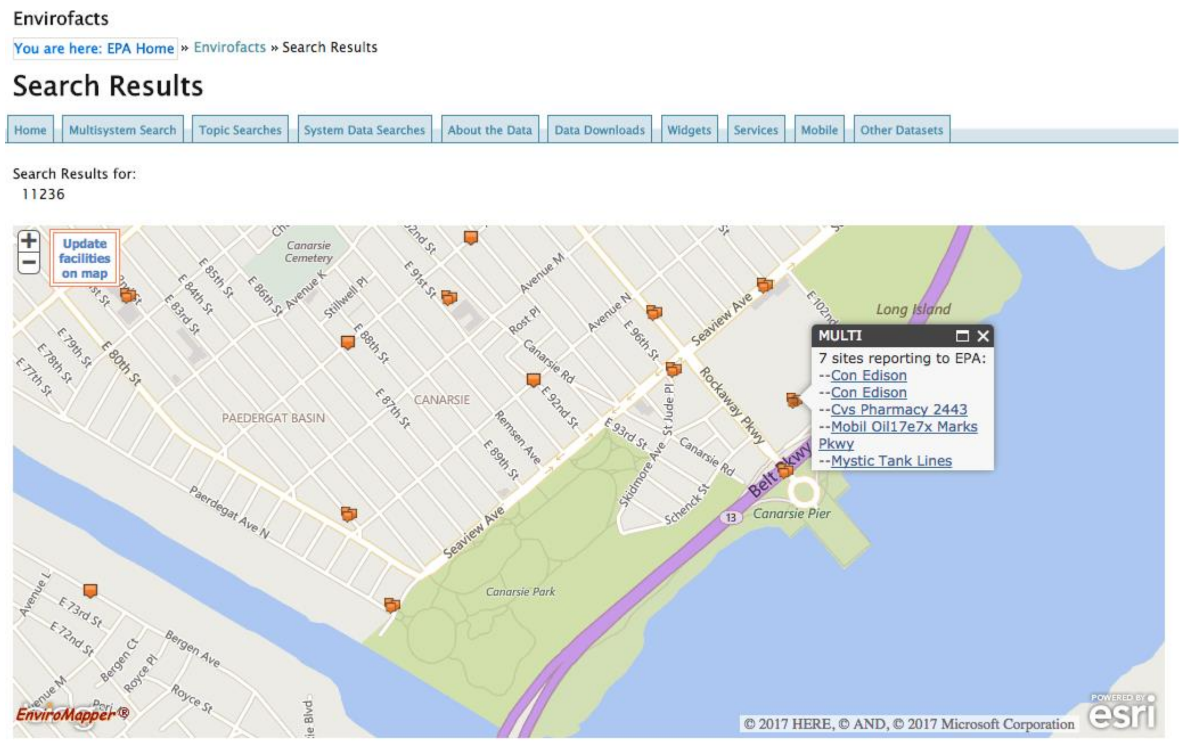
1. Start by entering your zip code in on this page. It will pull up a map of the area- you'll need to click the button that says "List and Map Facilities Reporting in This View" for the map to populate:



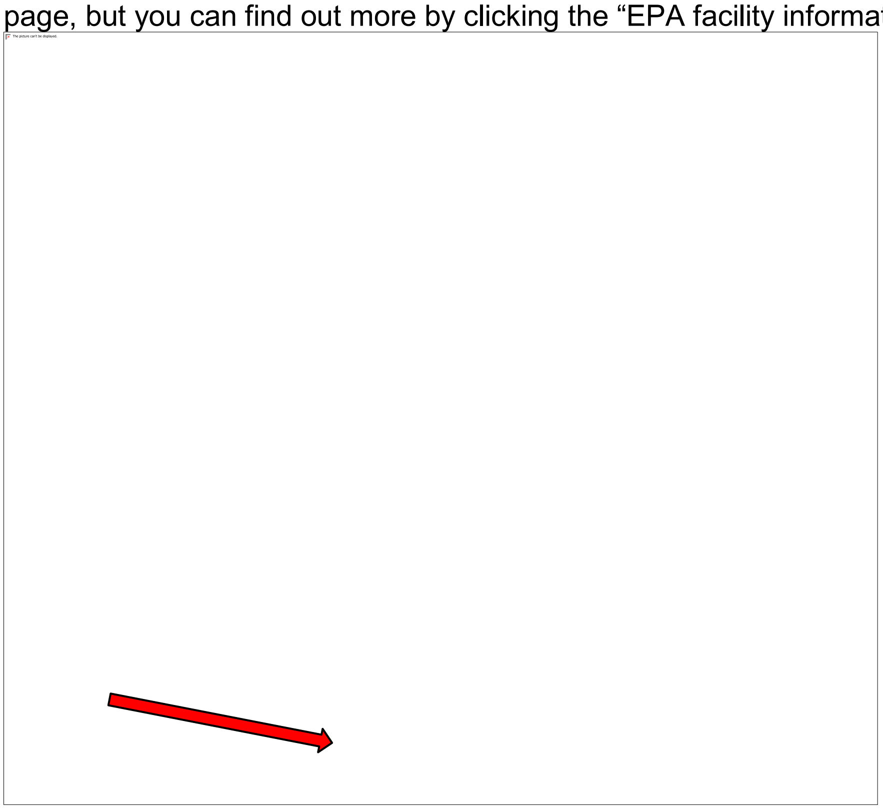
2. Orange markers will show locations in the EPA's database- but only within the zip code you originally specified. (So if you try to scroll around the map to see other places, it won't show them unless you click the box "Update facilities on map" in the top left corner.)



3. Clicking on the orange markers will pull up names of the site(s), with a link to find out more information.



4. When I click on “Mobile Oil,” it pulls up the screen below. Some information will appear on this page, but you can find out more by clicking the “EPA facility information” button:



5. This pulls up a page that tells you which EPA information systems the site is included in, and if it’s a business, it will generally tell you what kind of business. In this case, the Mobile station is found in the ICIS-AIR system, the New York- Facility Information System, and the Air Facility System.

Environmental Interests			
Information System	System Facility Name	Information System Id/Report Link	Environmental Interest Type
ICIS-AIR (AIR)	MOBIL OIL-#17-E7X MARK'S PKWY	NY0000002610700078	AIR MINOR
NEW YORK - FACILITY INFORMATION SYSTEM	MOBIL OIL-#17-E7X MARK'S PKWY	2-6107-00078	STATE MASTER
AIR FACILITY SYSTEM	MOBIL OIL-#17-E7X MARK'S PKWY	3604700586	AIR MINOR (OPERATING)

The "Supplemental Environmental Interests" field on the far right will often tell you more about why a place is being regulated by the state or federal government. In this case, New York State regulates this gas station under programs designed to protect groundwater and to prevent air pollution. Why do you think they need to do this? What effects might a gas station have on the environment?

Data Source	Last Updated Date	Supplemental Environmental Interests:
ICIS	10/19/2014	
FIS		FIS-2-6107-00078/00002 GROUND WATER PROGRAM FIS-2-6107-00078/00005 AIR PROGRAM FIS-2-6107-00078/00003 AIR PROGRAM FIS-2-6107-00078/00001 AIR PROGRAM FIS-00586 AIR PROGRAM FIS-2-6107-00078/00004 GROUND WATER PROGRAM
AIRS/AFS	05/07/2014	

The Bonus Guide to the Historical Wonders of Your Steward-shed

This bonus guide is an extension of "Our Steward-shed Library of Resources" that will help you dive deep into the history- especially the environmental justice history- of your steward-shed. Try starting by looking at the NYC Fire Insurance, Topographic, and Property Maps from the New York Public Library that we mentioned in the steward-shed library. After exploring how the land in your steward-shed was used historically, the NYPL's Old NYC Map will show you archival photos mapped to locations in your steward-shed. To find great websites on the history of your steward-shed, check out the NYPL's Best of the Web: New York City History list, and use the NYPL's other resources for specific searches. For a bloggy treatment of neighborhood history, Nathan Kensinger, Forgotten New York, Curbed, and 6sqft are fun reads.

We'll keep adding to this list as we find new resources- let us know if you find one!

1) Citywide
    - New York Public Library (NYPL)
        - Best of the Web: New York City History- list of resources about NYC history curated by the NYPL.
        - Maps
            - Old NYC Map- plots pictures from the NYPL's "Photographic Views of New York City, 1870s-1970s" collection onto a map of the city, letting you view historical photos of your steward-shed block by block.
            - NYPL Map Warper is a tool from the NYPL that lets you view and download high resolution historical maps. Many of their maps have been "rectified," which means they've been aligned over a present day map so you can view the historical map in context. (They also have a Creative Commons license so you're free to use and share them as much as you'd like!)
            - Atlases of New York City- this is where the fire insurance maps live.
        - Primary source materials (and more)
            - NYPL Digital Collections is a searchable digital archive of items from their collection, including everything from books to streaming film. Part of their collection is in the public domain so you're free to reuse and remix it!

    - Nathan Kensinger has been doing fantastic photo essays on the NYC waterfront's history, environment, and social justice issues for 10 years, particularly on "abandoned" and industrial sites. There are over 200 of them, searchable by borough.

- The [Forgotten New York] blog looks at the past and present of places all over NYC, tagged by borough and neighborhood.

- [Curbed] is a useful resource in general to get a sense of issues (including environmental issues, past and present) at the neighborhood level.

- The blog [6sqft] has a history tag with interesting stories, maps, and primary source documents, along with present day coverage of NYC.
    - Use the search bar at the top to search for a specific neighborhood or waterbody. Some neighborhoods have their own tags which you can find if you scroll down to the bottom of a post.

- Book: [Waterfront: A Journey Around Manhattan], by Phillip Lopate
    - Written in 2004, this book describes some of the interesting sites and wonders of Manhattan's waterfront.

- Brooklyn
    - [Brooklyn Visual Heritage] is a collaboration between Brooklyn Historical Society, Brooklyn Public Library, Brooklyn Museum, and Pratt to make historic images of Brooklyn searchable and accessible to the public.

    - [Brooklyn Newsstand]- the Brooklyn Public Library has made searchable copies of three Brooklyn newspapers (dates ranging from 1841-1955) free to the public.

    - [Brooklyn Historical Society] has a set of printed neighborhood guides featuring images from their archives, walking tours, and audio guides. The Fort Greene/Clinton Hill audio guide includes oral history interviews and is free to download. Guides available for the following neighborhoods: Bay Ridge/Fort Hamilton; Flatbush; Fort Greene/Clinton Hill; Fulton Ferry, Dumbo, and Vinegar Hill; Park Slope; Red Hook & Gowanus; Greenpoint; Williamsburg.

    - Book: [The Neighborhoods of Brooklyn], edited by Kenneth T. Jackson and John B. Manbeck.
        - Includes a 4-5 page summary of the history of every neighborhood in Brooklyn.

- Queens
    - Book: [The Neighborhoods of Queens], edited by Claudia Gryvatz Copquin and Kenneth T. Jackson.
        - Includes a 4-5 page summary of the history of every neighborhood in Queens.

Precision and Accuracy

BOP Curriculum
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Sep 8, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Water Quality Lessons	6-8th	2	Classroom	ELA

Summary

Students will take data using a series of different measurements. They will compare their results and determine if any of the data is meaningful, precise, reliable, or accurate.

Objectives

- Which data is meaningful?
- How do we decide that data is meaningful?
- What do we look for when we analyze data?
- What does a precise result tell us about an experiment?
- What does an accurate result tell us about an experiment?

Materials and Resources

Supplies

- 3 buckets of water with different pH (add baking soda to one bucket or vinegar to another).
- Beakers so each student group can a sample from each bucket.
- pH probe pH paper

Before you get started

Tips for Teachers

For the purpose of this lesson, we will use the words in the following ways: Precise refers to specificity. Reliable refers to consistency, Accurate is for close to the true value. Meaningful means that you can learn something new or draw a conclusion from the data. Doing this lesson with water of different pH's is a level 1 activity. For a slightly more advanced class, you could use water from different parts of the river. However, the difference in pH will be much more subtle, so subtle that your instruments might not capture it!

Background

When students are presented with data, they often draw immediate conclusions from that data. This is especially tempting with the water quality data (eg: My oysters died because the DO level was low, etc.) This lesson affords your students the opportunity to analyze when data is important and what makes it meaningful. They will then examine the difference between precise and accurate measurements and discuss what each one reveals about the experiment.

Instruction Plan

Engage

Have students taste three cups of water, one with lemon juice, one with baking soda, and one with nothing added. Ask them to describe the difference. Ask students what is the difference between the water quality? How would they describe the difference between the three kinds of water? What words would they use. Introduce the words acid, base, and pH. Have students consider what makes something take acidic or basic.

Now, introduce the word “accurate.” Have students discuss whether or not they think their earlier descriptions are accurate. Why or why not?

Is “more” or “less” an accurate measurement? What about “the same?” Is that an accurate measurement? Is it a precise measurement? Why or why not?

Now, ask students for an accurate but imprecise description and/or a precise but inaccurate description.

Explore

Now, explain to students that they are going to investigate precision and accuracy with pH. Put the mystery solution at the front of the room. Have students test 3 “mystery solutions” with 2 different tests. Have them fill out the table below.

Trial	Method tool or test name	Solution A	Solution B	Solution C
1	pH Paper			
1	Probe			
2	pH Paper			
2	Probe			
3	pH Paper			
3	Probe			
4	pH Paper			
4	Probe			

Explain

1. On the board, put up all data that students have gotten from all methods and samples in a larger format table like the one above.
2. Now, have a discussion with students about the precision, accuracy, and reliability of the different measurements and what it means. Is there any meaningful data? Why or why not?
3. Some sample discussion questions include:
    - If all the results are very close except for one, what does that mean about the result? What does that mean about the measurement?
    - If the results are precise but not accurate, what do you think the problem is?
    - If one result is accurate but the rest are not, what do you think that says about the measurement?
    - Which method gave you more precise results? Explain why
    - Which method gave you more accurate results? Explain why
    - If the probe gave you precise results but you know they are not accurate, what might you do?
    - What is the most accurate that the pH paper can be? Explain why.

Evaluate

Ask students what they might change about the experiment to

1. Make their results more precise
2. Make their results more accurate.
3. Make their results more reliable.
4. Make their results more meaningful?

Standards

CCLS - ELA Science & Technical Subjects

- - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
  - Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

CCLS - Mathematics

- - Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

NGSS - Cross-Cutting Concepts

- Patterns
  - Patterns can be used to identify cause and effect relationships.
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
  - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
  - Analyze and interpret data to determine similarities and differences in findings.
- Constructing Explanations and Designing Solutions
  - Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.

NYC Science Scope & Sequence - Units

- Grade 7, Unit 2
  - Energy and Matter

NYS Science Standards - Key Ideas

- PS Key Idea 3
  - Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity

NYS Science Standards - Major Understandings

- - Substances have characteristic properties. Some of these properties include color, odor, phase at room temperature, density, solubility, heat and electrical conductivity, hardness, and boiling and freezing points.
  - Substances are often placed in categories if they react in similar ways. Examples include metals, nonmetals, and noble gases.

NYS Science Standards - MST

- - Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Name________________

Trial	**Method** *tool or test name*	**Solution A**	**Solution B**	**Solution C**
1	Indicator			
1	pH Paper			
2	Indicator			
2	pH Paper			
3	Indicator			
3	pH Paper			
4	Indicator			
4	pH Paper			

Propose a New York Harbor population study

Your decision	**Your reasons, inspiration, and evidence from the scientific literature.** Cite sources using this format: (first author's last name, year, page number)
How many species do you propose to study at the same time? Why?	

Which species? Why?	
Does your study take place in the field, in the lab, or both? Why?	

If parts of your study take place in the field, how do you choose the field locations? Why?	

If parts of your study take place in the lab, what do you want to do in the lab that you can't do in the field? Why do you want to do it? Why can't you do it in the field?	
What's the most important thing you would find out by doing this study? Why is it so important to you? How could it be important to others?	

What are the biggest obstacles you would encounter while doing this study? How could you overcome those obstacles?	

If the study turns out the way you predict, what are the next steps in your research? Why?	

Reducing Runoff on Your Steward-Shed Model

BOP Curriculum
bop-curriculum@nyharbor.org
Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	1	Classroom	Science

Summary

Students take their research and observations from the field and synthesis them in order to decide what kind of surfaces to add to their steward-shed model.

Objectives

- Translate their research and observations into representation on a model.
- Consider some of the benefits and shortcomings of using a model as a representation.

Materials and Resources

Supplies

- Materials that can represent permeable surfaces
  - Sponges
  - Paper towel
  - Cloth
  - Oil Sorb pads (used in automotive and marine trades)
  - Cotton balls
  - Soil, moss, plant matter
- Materials that can represent impermeable surfaces (if students want something in addition to the modeling clay)
  - Aluminum foil
  - Plastic wrap
  - Stones
  - Different color clay
- Materials that can represent different kinds of pollution (optional)
- Any other reasonable materials mentioned by the students in the previous lesson (Steward-shed Investigation Part 7 - Runoff Based on Field Observations)
- Food coloring
- Spray bottle
- water

Before you get started

Tips for Teachers

- Consider having students bring in materials and supplies to represent the pollution instead of you doing it all.

Instruction Plan

Engage

1. Students get into small groups.
2. Each group gets their steward-shed model, all version of their Class Steward-shed Maps, and “Our Steward-shed” Library of Resources.
3. Students review what types of surfaces they are going to add to their model and where to put them.
4. Students discuss exactly how to put the materials on their model to make the best representation of the different surfaces
    - Place them on top of the modeling clay?
    - Push them into the clay?
    - Other ideas?

Explore

1. Each group gets the “surface” materials they need and spray bottle with water.
2. Students carefully place materials on their model.
3. Students predict: What will happen when we spray water on our model?
4. Students should start slow with spraying the water on their model and should observe the model closely after each couple of sprays.
5. Students record their observations on one of their Class Steward-shed Maps.
6. Students write: based on these results, if we were to make another draft of this model, we would like to revise ____ because ____.
7. Consider whether you want students to add pollution materials from the lesson Steward-shed Investigation Part 5 - Add Pollution to your Steward-shed Model and do a second trial with to see how pollutants interact with the different surfaces.
8. Students share their results with the class.

Evaluate

1. Ask your students the following series of questions:
    - Ask your students, What worked well about your model? What worked well about using these materials?
    - What’s wrong with this model? What doesn’t work so well about it?
    - What would you do differently if you were to do it again?
2. If it hasn’t come up in discussion, point out that the model is an imperfect representation of what happens in the steward-shed.
3. Ask your students:
    - How else (besides a 3D model) could we represent or record the pollution in our steward-shed?
    - What kinds of representations would be most useful for explaining or showing the state of the steward-shed to people who have not studied it as extensively as we have? (This could be the beginning of the discussion that leads into the stakeholders considered in Steward-shed Part 10 - Steward-shed Challenge)

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - Cause and effect relationships may be used to predict phenomena in natural systems.
- Influence of Engineering, Technology, and Science on Society and the Natural World
  - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
  - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
- Scale, Proportion, and Quantity
  - Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- Science Addresses Questions About the Natural and Material World
  - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes
- Structure and Function
  - Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
  - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
  - Structures can be designed to serve particular functions.
- Systems and System Models
  - Models can be used to represent systems and their interactions.
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
  - Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

NGSS - Disciplinary Core Ideas

- ESS2.C: The Roles of Water in Earth's Surface Processes
  - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
  - Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- ESS3.C: Human Impacts on Earth Systems
  - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- ETS1.A: Defining and Delimiting Engineering Problems
  - The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
- ETS1.B: Developing Possible Solutions
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- ETS1.C: Optimizing the Design Solution
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- LS2.A: Interdependent Relationships in Ecosystems
  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

NGSS - Science and Engineering Practices

- Asking Questions and Defining Problems

    - Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
    - Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- Constructing Explanations and Designing Solutions
    - Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Developing and Using Models
    - Develop a model to describe unobservable mechanisms
    - Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
    - Develop a model to predict and/or describe phenomena
- Obtaining, Evaluating, and Communicating Information
    - Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
    - Weather and Atmosphere
- Grade 6, Unit 4
    - Interdependence
- Grade 7, Unit 1
    - Geology
- Grade 8, Unit 4
    - Humans and the Environment: Needs and Tradeoffs

Runoff Based on Field Observations

BOP Curriculum
bop-curriculum@nyharbor.org
Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	4	Field	Science

Summary

Students go to a specific location within their class steward-shed to observe, document and test permeable and impermeable surfaces.

Objectives

- Make a determination as to what area of their steward-shed on which to focus, based on prior knowledge and research.
- Observe permeable and impermeable surface and infer how they might impact runoff.

Materials and Resources

Supplies

- Clipboards
- Water bottle full of water for each student
- Extra water
- Other reasonable materials the students suggested for simulating runoff and testing permeability

Before you get started

Tips for Teachers

- Working outdoors or in the field goes more smoothly if students have a clipboard! Trying to use folders, notebooks, or the backs of friends adds unnecessary distractions to an already distracting outdoor environment.
- You will need to bring extra water with you in the field, for use during the activity. It doesn't have to be potable water. Consider using buckets with line to get water from nearby waterbody, carrying a gallon jug of water, or buying a portable water sprayer ($15-$150 from Home Depot).

Preparation

- Visit your class steward-shed before this lesson. Look around for areas that may be especially interesting in terms of permeable and impermeable surfaces that cannot be seen on the maps or resources in the previous lesson.
- Consider how big an area you want to try and cover while in the field. How big an area can your students observe and document?
- Consider whether you want to visit the same location as Steward-shed Investigation Part 4 - Pollution Based on Field Observations.
- Prepare or have the students bring in the materials that they suggest for testing the permeability of the steward-shed.

Instruction Plan

Engage

1. Students get into small groups.
2. Groups get all versions of their Class Steward-shed Map, their steward-shed models and the
3. Be sure that the “Based on Personal Memory,” “Based on Maps” and “Based on Field Observation” posters are available for the class to see.
4. Explain: “We will be going out into the field to look for and document how runoff moves through our steward-shed and where there are permeable and impermeable surfaces. Looking at your maps and models decide where you think would be a good place within our steward-shed to observe these things.”
5. Groups review their maps and models and determine which specific place within the class steward-shed they would like to visit first. Students may want to investigate an area that has something of interest they could see on the map resources or an area that led them to some questions.
6. Students or groups share out where they would like to go and why.
7. After share out, make a determination (either executive or democratic) as to the specific place to go within the class steward-shed.

This would be a good time to break until the next class.

Explore

1. In this activity, students will be testing their predictions of where water will flow.
2. Go into the field.
3. Students get into small groups.
4. Each group gets a clipboard with their versions of the Class Steward-shed Map and a clean copy of the Class Steward-shed Map.
5. Students look at their Class Steward-shed Maps and at the surroundings.
6. Students make predictions about where the water will flow and how it will interact with different permeable and impermeable surfaces.
7. Explain: “Now you will be testing your predictions (inferences) of:
    - Where the water will flow
    - Where the water will flow fastest and most slowly
    - Where the water will pick up and drop different pollutants and litter
8. Students use their water bottles to pour water on the ground creating some flow. Students should test several locations to test their predictions from earlier.
9. Note: Students may have other tests to conduct depending on what they came up with in last lesson.
10. Students record the results of their tests on one of the copies of their Class Steward-shed Map.
11. Gather students back together.
12. Explain: if students have monitored their Oyster Restoration Station (ORS) you might want to ask them to think back to the Land Conditions data they collected for Protocol 1 - Site Conditions. See excerpt of data sheet below:

Land Conditions (Take a photograph of the water with your camera)

Shoreline type:

Bulkhead/wall | Fixed Pier | Floating Dock | Riprap/Rocky Shoreline | Dirt or Sand | Other

Estimate percent surface cover for the adjacent shoreline (about 100 x 100 feet)

_______% Impervious Surface (concrete/asphalt paths, roads, buildings etc.)

_______% Pervious Surface (dirt, gravel etc.)

_______% Vegetated surface (grass, shrubs, trees)

=______% Sum should equal 100%.

Garbage on the adjacent shoreline? Y / N

Extent/Type	Hard Plastic	Soft Plastic	Metal	Paper	Glass	Organic	Other
None							
Sporadic							
Common							
Extensive							

1. Explain: Students might want to look for places to pour the water that highlight the following features:
    - Sediment that will flow along with the water
    - Litter or oil that will flow along with the water
    - Permeable or impermeable surfaces

This would be a good time to break until the next class.

Explain

1. Back in the classroom
2. In small groups, students review the work they completed in the field.
3. Students brainstorm what they have learned and still wonder about that area, in an open-ended way.
4. Students or groups share out the results of their runoff experiments and the impermeable/permeable surfaces they found in the field.
    - Post their findings for the class to see under the label, “Based on Field Observation” (put this side-by-side with the other posters)
    - As questions come up, continue to post them, to see if students will be able to answer some of them throughout the remainder of their research in this Steward-shed Investigation.
5. Students begin to think about how to represent what they observed on their steward-shed models. They may need another clean copy of the Class Steward-shed Map for this purpose.
    - Students decide where to put the observed permeable/impermeable surfaces on their model and what materials they should used to represent them.
6. Students share out their ideas for their steward-shed model.
    - Take note of the materials the students mention so that you can have them ready for the next class when they actually add to their steward-shed model.

Evaluate

1. Ask: What happens to the rain that falls on this area?

- Examples: Slopes, hills, drains, grates, holes, cracks, curbs, roofs, downspouts, gardens, tree beds, waterbodies,

2. Follow-up with probing questions, so students don't stop at their first thought.
    - Does that explain what happens to *all* of the rainwater?
    - How much of the rainwater would you guess goes to this place vs. that place?
    - What if it rains faster or slower? Thundershower vs. drizzle?
    - What if it rains every day or just once a month?
3. Ask: are there pollutants and litter in this area?
    - Where do you think flowing rainwater would pick up different pollutants and litter?
    - Where do you think flowing rainwater would drop different pollutants and litter?

Post their inferences and questions on the poster, “Based on Field Observations”

Extend

Mini Engineering Challenge: What would we have to do in order to make rainwater flow a different way, right here on the ground in front of us?

Mini Design Challenge: What could we change or build on the surrounding buildings or ground surface that would either:

- decrease the amount of runoff that ended up in the nearby water-body or storm sewers -- in which case, where does the rainwater end up, and why is that better than runoff?
- increase and direct runoff through a particular route -- in which case, what route do you choose, and why?
- Choose one of these goals, and design for that goal.
- Then discuss: which goal is most appropriate for this location? Why? Multiple right answers are possible!

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
    - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
    - Cause and effect relationships may be used to predict phenomena in natural systems.
- Influence of Engineering, Technology, and Science on Society and the Natural World
    - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
    - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
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  -
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  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

NGSS - Science and Engineering Practices

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NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
  - Weather and Atmosphere
- Grade 6, Unit 4
  - Interdependence
- Grade 7, Unit 1
  - Geology
- Grade 8, Unit 4
  - Humans and the Environment: Needs and Tradeoffs

Runoff Based on Maps

BOP Curriculum
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Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	3	Classroom	Science Social Studies

Summary

Students collect information about permeable and impermeable surfaces in their steward-shed, first from their own local knowledge, and then using map resources. Finally, they devise methods for measuring permeability themselves, in the field.

Objectives

- Share their local knowledge of permeability in their steward-shed.
- Evaluate the different uses of different kinds of surfaces, based on their local knowledge.
- Use selected resources, such as satellite images and NYC's Oasis map, to add new information to their local knowledge base.
- In the classroom, develop a few different methods of measuring the permeability of different surfaces, which they can later use in the field.

Materials and Resources

Supplies

- Post-its
- Colored pencils or markers, preferably including dark green, light green, blue, and beige/yellow/light brown for each table.
- A bunch of materials students might think to ask for when they develop a method for measuring permeability. Some good possibilities:
  - Containers with water
  - A way to measure the water
  - A way to measure time
  - A wide tube that can hold water (e.g. a soup can with top and bottom both removed, maybe with the edges taped over to avoid sharps)
  - A way to mark the insides of the tube (duct tape, sharpies, or both together should work)
  - A way to seal the edge of the tube to pavement or a classroom substitute -- plumber's putty is perfect, but other clays and putties can also work.
  - Some soil in a tray
  - Some empty trays

Before you get started

Tips for Teachers

- Before teaching this lesson you need a defined steward-shed for your class -- which students create with you in the earlier lesson Steward-shed Investigation Part 1 - Paper Watersheds

Preparation

Explore runoff and permeability in your class' steward-shed using Google Earth/Maps Satellite View and Oasis, as described in "Our Steward-shed" Library of Resources under "Maps to Study Runoff". Based on the information available for your steward-shed, decide which resources you will encourage your students to explore.

- Optional: explore the NYC Planimetric resources as well. For most neighborhoods, we think those will be most useful for in-depth research, and not necessarily for your students' first pass at this kind of research.
- Prepare a zoomed-in satellite image of your class' steward-shed, with the boundaries drawn on it.

Instruction Plan

Engage

1. Students have a satellite map of their class steward-shed (details in "Preparation" section, above).
2. Ask your students, "Think about what happens in this place when it rains. Based on your personal memories of this place, where can the rain water sink into the steward-shed and stay there for a while? Where in this place does rain immediately run off the surface, flowing downhill?"
3. Post their responses under the label "Based on personal memory" -- so that later they can compare what they remembered with what they learned from maps, and what they learned from direct observation.

Explore

1. Students access the resources you have selected from "Our Steward-shed" Library of Resources. (You should choose these in advance based on your steward-shed and your students -- see "Preparation" for details).
2. Students or groups have maps of the class steward-shed, and explore the resources you have selected to annotate the map -- ideally with access to post-its and colored pencils or markers -- to show the permeable and impermeable surfaces they find evidence of.
    - You might instruct students to use the same color-coding that is used in Oasis under "Environmental Characteristics" -- dark green for trees/forest, light green for grassland, beige or light yellow or brown for impervious, and blue for water.

Explain

1. Students or groups share out some of the runoff information they have found.
    - Post their findings under the title, "Based on maps".
    - As questions come up, post them, to see if students will be able to answer some of them throughout their research in this Steward-shed Investigation.
2. Ask your students, "where do you think it's good for our community to have impermeable surfaces? Where do you think it's good for our community to have permeable surfaces? Why?
3. If there are differences of opinion, focus on those to motivate a second round of research in the resources you have selected.

Elaborate

1. Students go back into the resources, in search of the best and worst spots in the steward-shed for permeable and impermeable surfaces.
2. Students share out the new things they have noticed, while you continue to post their findings and questions.

This would be a good time to break until the next class.

Evaluate

1. Ask your students, “Some types of paving materials are more permeable than others. And some kinds of soils are more permeable than others. How could we measure that for ourselves, in the field?”
2. Students sketch and try out ideas in small groups.
3. Groups present their best methods to the class for feedback.
4. Based on these methods, you can prepare materials for the next lesson, Steward-shed Investigation Part 7 - Runoff Based on Field Observations.

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - Cause and effect relationships may be used to predict phenomena in natural systems.
- Influence of Engineering, Technology, and Science on Society and the Natural World
  - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
  - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
- Scale, Proportion, and Quantity
  - Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- Science Addresses Questions About the Natural and Material World
  - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes
- Structure and Function
  - Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
  - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
  - Structures can be designed to serve particular functions.
- Systems and System Models
  - Models can be used to represent systems and their interactions.
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
  - Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

NGSS - Disciplinary Core Ideas

- ESS2.C: The Roles of Water in Earth's Surface Processes
  - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
  - Water’s movements—both on the land and underground—cause weathering and erosion, which change the land’s surface features and create underground formations.
- ESS3.C: Human Impacts on Earth Systems
  - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things.
- ETS1.A: Defining and Delimiting Engineering Problems
  - The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
- ETS1.B: Developing Possible Solutions
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)
  Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.

- LS2.A: Interdependent Relationships in Ecosystems
  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

NGSS - Science and Engineering Practices

- Asking Questions and Defining Problems
  - Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
  - Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- Constructing Explanations and Designing Solutions
  - Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Developing and Using Models
  - Develop a model to describe unobservable mechanisms
  - Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
  - Develop a model to predict and/or describe phenomena
- Obtaining, Evaluating, and Communicating Information
  - Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
  - Weather and Atmosphere
- Grade 6, Unit 4
  - Interdependence
- Grade 7, Unit 1
  - Geology
- Grade 8, Unit 4
  - Humans and the Environment: Needs and Tradeoffs

Saturation and Dissolved Oxygen

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 11, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Water Quality Lessons	6-8th	3	Classroom	

Summary

Students will explore dissolving, saturation, and super saturation. They will then apply this concept to read and understand a dissolved oxygen graph. Finally, they will look at the acceptable parameters for oysters for dissolved oxygen.

Objectives

- What is saturation?
- What does it mean for something to be dissolved?
- How do I read a dissolved oxygen graph?
- What is the right amount of dissolved oxygen for my oysters?

Materials and Resources

Supplies

- Beaker
- Salt
- Scale
-
- Rulers
- Dissolved oxygen measuring device
- Stirring rod
- Hot soda
- Cold Soda

Before you get started

Tips for Teachers

The lab compares the dissolving of a solid and a gas in water and the effect of raising the temperature. Though in this activity it is meant to lead to a discussion of Dissolved Oxygen, it can also lead to a discussion about salinity or other water quality parameters. The dissolved oxygen graph requires rulers. It is impossible to read or interpret without them.

Preparation

N/A

Background

Just like humans, all aquatic living creatures – from the fish and crabs that swim through its waters to the worms that bury themselves in its muddy bottom – need oxygen to survive.

Air is a gaseous solution of nitrogen, oxygen, and a bunch of other things in smaller amount. Humans use their lungs to inhale oxygen from the air (air is about 20% Oxygen). But worms, fish, crabs and other underwater animals use gills to get oxygen from the water. As water moves across an animal's gills, oxygen is removed and passed into the blood.

Gills work better when there is more oxygen in the surrounding water. As dissolved oxygen levels decrease, it becomes harder for animals to get the oxygen they need to survive.

Scientists generally agree that creatures need dissolved oxygen concentrations of 5.0 mg/L (which is the same as a part per million) or more to live and thrive. However, the amount of oxygen an animal needs varies depending on how large or complex the animal is and where it lives.

- *Worms and clams* that live on the muddy bottom – where oxygen levels are naturally low – only need dissolved oxygen concentrations of at least 1 mg/L.
- *Fish, crabs and oysters* that live or feed along the bottom require dissolved oxygen concentrations of 3 mg/L or more.
- *Spawning migratory fish and their eggs and larvae* need up to 6 mg/L during these sensitive life stages.

Dissolved oxygen criteria chart

Areas with less than 0.2 mg/L of dissolved oxygen are called anoxic. Most animals cannot live in these areas, which is why they are often called "dead zones."

Oxygen gets into the water when:

- Oxygen from the atmosphere dissolves and mixes into the water's surface
- Algae and grasses release oxygen during photosynthesis
- Water flows into the harbor from streams, rivers and the ocean. Ocean waters generally have more oxygen than fresh water due to the constant movement and stirring of the water. River waters are fast-moving, which helps oxygen from the air mix in a little more than still water.

Most areas in the harbor that have low dissolved oxygen levels are the result of a complex interaction of several natural and man-made factors. These include temperature, nutrient pollution, how water flows in the Bay, and the shape of the Bay's bottom.

High temperatures

Temperature limits the amount of oxygen that can dissolve in water. The waters can hold more oxygen during winter than during the hot summer months.

Nutrient pollution

Too many nutrients in the water (called eutrophication) can fuel the growth of algae blooms. Oysters, menhaden and other filter feeders eat a portion of the excess algae, but much of it does not end up being consumed.

The leftover algae die and sink to the Bay's bottom, where they are decomposed by bacteria. During this process, bacteria consume oxygen until there is little or none left in these bottom waters.

Estuary

Another factor influencing dissolved oxygen levels is the division between water flowing in from the ocean and out of the freshwater rivers and streams. Water flowing from the ocean is generally salty and cooler, while river water is fresh and warmer. Because of these differences, river water weighs less than ocean water and actually floats on top of it. (Wind and other strong mixing forces may change this pattern.)

The boundary where the fresh water layer meets the saltier water layer below is called the pycnocline. The pycnocline acts as a physical barrier that prevents the two layers from mixing together. During the summer, when algae-consuming bacteria are most active, the pycnocline cuts off oxygen-deprived bottom waters from oxygen-rich surface waters. This can create large areas of low or no oxygen at the bottom of the Bay.

Shape of the harbor

The harbor bottom is not flat; rather, it has varying shallow and deep areas. In certain bowl-shaped areas of the bottom, the pycnocline can act like a "lid" that cuts off bottom waters from receiving any oxygen.

Heavily adapted from http://www.chesapeakebay.net/discover/bayecosystem/dissolvedoxygen

Instruction Plan

Engage

Have students pass around clear plastic cups with sugar dissolved and pure water. The cups should look identical. Ask them to compare them. Do they see a difference? Finally, have them taste each beaker. (Make sure that students wash their hands and then dip one finger in each cup).

When students have determined the difference, ask them where the sugar is. Introduce the idea that something can be “dissolved.”

Dissolve- to cause a solute to pass into solution, or to cause a substance (solid, liquid, or gas) to become a part of a liquid solution.

Explain that the sugar has been dissolved into the water, that is why it can’t be seen.

Explore

Define the words saturated and supersaturated.

Saturated-The point at which no more solute can be dissolved into the solution

Supersaturated- more solute is dissolved than would normally be possible at the current temperature. These solutions can be created by gradually changing the temperature.

Have the students make a hypothesis about whether they believe that heating would cause more or less

1. Solid to dissolve
2. Gas to dissolve

Once the students have made their hypothesis, have them complete the saturation lab activity.

In a class discussion, compare solids and gases dissolved into liquid.

Explain

Explain the idea of dissolved oxygen:

Dissolved Oxygen is the amount of gaseous oxygen (O2) dissolved in the water. Oxygen enters the water by direct absorption from the atmosphere, by rapid movement, or as a waste product of plant photosynthesis.

Explain that dissolved oxygen is very important for oyster growth (and all sea life).

Elaborate

In order to emphasize the dependency of Dissolved Oxygen on temperature, have students complete “Reading the DO Graph”

Evaluate

Discuss DO parameters for oysters. 5 mg/L is the minimum that oysters generally need to survive. Why do we take DO measurements in the field? Why is it important? How might the data change over time and why?

Standards

Set Up an Experimental Tank Based on Material Testing

BOP Curriculum
bop-curriculum@nyharbor.org
Jan 17, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Oyster Tank Investigation	6-8th	2	Classroom	Science

Summary

Students experiment with different materials in 1 gallon tanks in order to come up with some ideas for an experimental question to use with their second tank.

Objectives

Design an experiment based on the testing of materials.

Materials and Resources

Supplies

- 10 spat-on-shell substrate oysters
- 10 one-gallon tanks (e.g. Penn-Plax New World Habitat Tank, Small, 1 gal)
- Various materials that the students can “play with” in their smaller tanks. The more options the better! For example:
  - Instant Ocean Sea Salt
  - Aquarium Gravel (large) - 10lb bag
  - Aquarium Gravel (medium) - 10lb bag
  - Aquarium Sand
  - Undergravel filter
  - Power filter
  - Various filter media: cartridges, canisters, stones, pads, carbon, etc.
  - Tank divider
  - Air pump
  - Air pump tubing
  - Other reef associate organisms
  - Water Conditioner
  - Aquarium Bacteria
  - Bacteria supplement
  - Thermometer

Before you get started

Tips for Teachers

- One important purpose of this lesson is for the class to come to some sort of an educated agreement as to the one question on which their experimental tank should be focused. Feel free to use a different method to come to this same conclusion.

Preparation

- Set up the second tank as a baseline before class begins. This includes water that is 15ppt and an aerator.

Design an Experimental Tank

1. Sketch the original oyster tank and add labels.

2. Sketch your tank and add labels.

3. Describe the experiment you have designed in this tank of yours.

4. Imagine you are collecting data from these two tanks. Design a data sheet.

5. Write a pitch to convince the class to do your experiment.

Notes on Other Groups' Experiments

Group	Things you like about their experiment	Questions you have about their experiment

Group	Things you like about their experiment	Questions you have about their experiment

Set Up an Experimental Tank Based on Questions

BOP Curriculum
bop-curriculum@nyharbor.org
Jan 17, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Oyster Tank Investigation	6-8th	2	Classroom	Science

Summary

The class decides on a single experimental question on which to focus their second oyster tank. This lesson begins with the students working individually, then in small groups and finally as a whole class in order to choose this one experimental question.

Objectives

- Design an experiment based on a question.

Materials and Resources

Supplies

- See the Oyster Tank Guide for details on supplies and where to purchase them.

Before you get started

Tips for Teachers

One important purpose of this lesson is for the class to come to some sort of an educated agreement as to the one question on which their experimental tank should be focused. Feel free to use a different method to come to this same conclusion.

Preparation

- From the list of Student Questions as of (today's date), choose as many as possible that could become good experimental tank questions.
- Write each question on a small piece of paper. Make sure there is one piece of paper for each student in the class plus a handful of extras, even if some questions need to be repeated.

  Fold the pieces of paper and put in a hat so each student can choose one piece of paper out of the hat.
- Set up the second tank as a baseline before class begins. This includes water that is 15ppt, has an aerator and 10 oyster spat-on-shell substrates.

Instruction Plan

Engage

1. Walk around the classroom and allow each student to pick one question out of the hat. Make sure there are more questions than students, so the last student doesn't feel stuck with the last question.
2. Consider whether you want students to be able to read the question and exchange it.

Explore

1. Each student receives the Design an Experiment Handout and completes it for his/her question.
2. Students get into small groups. Ideally each group member should have a different question.
3. Students then take turns sharing their individual work with their group. Groups should spend time discussing each experimental question.
4. Once all students have had a chance to share their work, the group works together to narrow it down to one question on which they want to pitch to the class.

5. The group then discusses their chosen question in depth and prepares a short pitch for the rest of the class in order to convince the class that this is the experimental question they should focus on with the second tank.
6. Class should choose (teacher can consider how democratic to make the process) which experiment they would like to do as a class.

Elaborate

1. NOW, it is time to complete the setup of the second tank.
2. In this demo, the teacher will finish setting up the the tank and engage the students in discussion along the way.
3. Gather the class around the tank so everyone can see.
4. Note: The only things that must be placed in this second, experimental tank are water, oysters and the aerator. Other than that, what is put in the second tank is based on the experimental question the class decided upon.

Evaluate

1. Students devise a method for collecting the data. This may be done back in their groups or as a whole class.
2. Students should include in their description how often the data should be taken, what units it should be, who will take it, and how the class will keep track of it. They should also decide on a length of time for their experiment.
3. Post the experimental question above the tank and assign class responsibilities for data collection, monitoring, cage maintenance, etc.

Standards

Design an Experimental Tank

1. Sketch the original oyster tank and add labels.

2. Sketch your tank and add labels.

3. Describe the experiment you have designed in this tank of yours.

4. Imagine you are collecting data from these two tanks. Design a data sheet.

5. Write a pitch to convince the class to do your experiment.

<u>Oyster Tank Topic Library</u>

<u>Consider as you read:</u>
When you set up an oyster tank, should you try to imitate the conditions in the estuary?

1) Oyster Recovery Partnership “Kids Zone” -- a few good sentences about how oysters live.

2) Ecosystem stressors to oysters -- a diagram that shows some problems oysters can have.

3) Crunchy on the Outside, Soft and Squishy on the Inside -- about oyster shells and oyster predators.

4) Brackish aquarium setup -- one person’s opinion about setting up a brackish tank.

5) Creating A Brackish Habitat Fish Aquarium -- a second person’s opinion about setting up a brackish tank.

6) Estuarine Aquarium Keeping for Beginners -- a third person’s opinion about setting up a brackish tank.

7) Creating Oyster Habitat- What Makes a Good Site? -- about setting up oyster reefs in an estuary.

8) Environmental factors affecting oyster populations -- a list of things that affect oysters in an estuary.

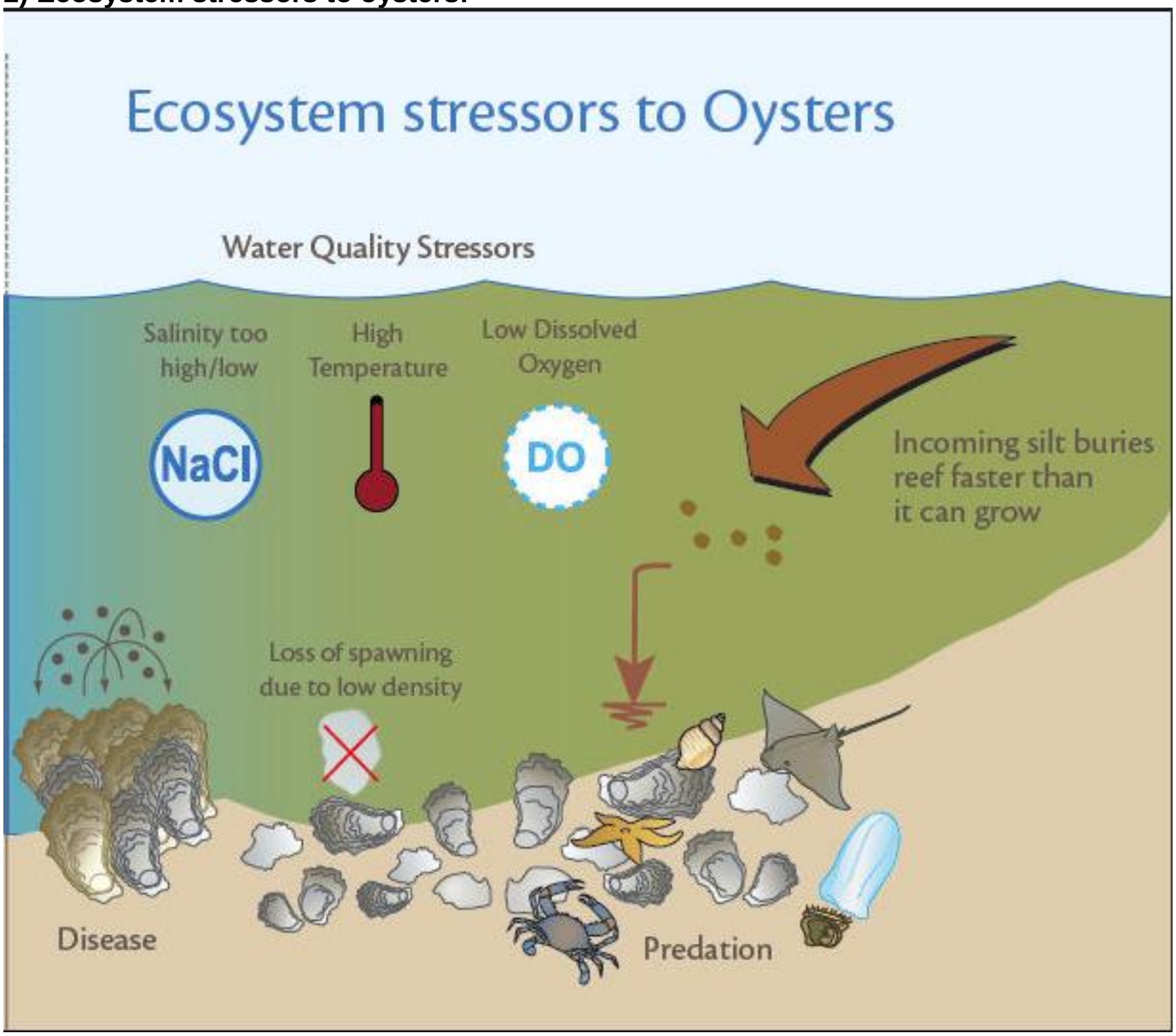
9) Problems with low dissolved oxygen in the East River -- some of the specific pros and cons of life in the East River, especially for oysters.

10) NY/NJ Harbor Estuary Map from Stevens Institute of Technology shows parameters like surface and bottom salinity, surface currents, surface air temperature, etc. -- You’ll need to access the internet for this. Once you figure out how to use this website, you can find a ton of information about your ORS site! You can find data from different times, and from different places around the city.

1) Oyster Recovery Partnership "Kids Zone"
"Oysters are pretty cool creatures. They live most of their lives in a shell at the bottom of rivers or bays….Oysters eat by sucking water through their bodies, pulling out the nutrients they need to grow."

From Oyster Recovery Partnership: http://oysterrecovery.org/oysters-101/kids-corner/

2) Ecosystem stressors to oysters:



https://chesapeakebay.noaa.gov/oysters/oyster-reefs

3) Crunchy on the Outside, Soft and Squishy on the Inside
"Oyster predators can easily locate oyster prey and since oysters are not mobile. Once found, they have no means for escape. However, the oyster's thick shell presents a significant deterrent to oyster predators as they must first penetrate the shell before consuming the tissue.

Successful oyster predators possess specialized adaptations that help them crush, drill, or open the shell exposing the meat within. Common oyster predators include snails, crabs, starfish, flatworms, and fish (such as cownose rays, oyster toadfish, flounder, drumfish)."

From Project Ports Guide 3: https://www.billionoysterproject.org/wp-content/uploads/2013/06/curriculum_guide_3-1.pdf

4) Brackish Aquarium Setup

"Brackish water is somewhere between "pure" freshwater and "high salinity" ocean water....

Brackish species are very adaptable.... As long as waste products (ammonia, nitrite, and nitrate) are at safe levels, the animals will do fine, even if there is a gradual change in pH, hardness, or salinity. Because these animals naturally live in an environment where water parameters may change from one spot to the next, a super-stable environment is not quite as important for brackish species."

From Fishlore.com http://www.fishlore.com/aquariummagazine/feb08/brackish-fish-tank-setup.htm

5) Creating A Brackish Habitat Fish Aquarium

What is "Brackish?"

It's not quite saltwater, but it's definitely not freshwater. Brackish waters occur all over the world where inland freshwater streams and springs meet the ocean, creating estuaries. The lower part of the Hudson River that separates New York and New Jersey, for example, is a giant brackish estuary….

The Salinity of Brackish Water

The world's marine waters have a salinity between 32 and 35 parts per thousand. Brackish water, by definition, must be lower than that...

Calculating the salinity of water is done by measuring specific gravity (SG) with a hydrometer.…For practical purposes, brackish aquarium water should range between 1.002 to 1.022 SG at a temperature of 77 degrees Fahrenheit. Most brackish aquarium animals can tolerate this range. A 50/50 mix of fresh and marine water would provide a salinity of 1.012 SG – a happy medium for a general brackish aquarium...

If you want to provide the best care for your brackish animals, however, I recommend matching the salinity level to the type of brackish habitat you are trying to re-create or the type of brackish animals you want to maintain."

From Petcha.com: http://www.petcha.com/creating-a-brackish-habitat-fish-aquarium/

6) Estuarine Aquarium Keeping for Beginners

"Temperature

All aquatic animals have a range of temperatures in which they can live, and they do best when temperatures are close to the middle of that range. School classrooms are notoriously warm,

and this can 4 be a *major* factor in regards to which species will thrive. Water temperatures can easily climb into the 80 degrees Fahrenheit in a school hallway, or during the weekend if they turn the air conditioning off...

Ammonia becomes more toxic with higher aquarium temperatures and the nitrifying bacteria that comprise the biological filter will likely die if water temperatures rise above 95 degrees F.

You do not have to be concerned about cold-water periods. As the water temperature in your aquarium decreases, the critters will simply slow down and may stop eating entirely. It should not be a problem if your water temps decrease to 50°F, or even colder during school vacations."

"<u>Oxygen</u>

….Water can hold less dissolved oxygen (DO) as it gets warmer and saltier. Estuarine water usually holds between 5 and 8 parts per million (ppm) oxygen...Fish will begin to get stressed in DO levels of 3 and 5 ppm and will get very stressed in water below 3 ppm. All tanks should have several sources of oxygen…

Animals use more oxygen when they are active and also after eating, while they digest food. Active animals (such as fish that don't stop swimming around the tank) use more oxygen than more sedentary species. Animal metabolisms increase with rising water temperatures, so animals also use more oxygen as the temperature increases. It is important to remember that the bacteria in the biological filter… also use oxygen.

Dead animals and uneaten food left in the tank are decomposed by huge numbers of bacteria, which use oxygen. These bacteria can cause the oxygen in your tank to decrease to a harmful level for your animals. Therefore you should not have uneaten food or dead animals present in your aquarium."

"<u>Tank Size</u>

The volume of water in the tank, the surface area of the water/air interface and the surface area of the substrate are all very important.... Most estuarine animals stay close to the bottom of the tank, so you should try to maximize the bottom surface area of an estuarine aquarium. For instance it is better to purchase a 20-gallon long aquarium instead of a 20-gallon tall model. The long model has more bottom surface area than the 20-gallon tall aquarium model. The surface area of a tank is important in gas exchange (namely oxygen)...

The surface area of the substrate, or bottom of the tank, is also very important. Bacteria grow on the surface of aquarium substrate. These bacteria are part of the biological filter.... A larger bottom area will give you more substrate surface area for the bacteria to grow, which increases your biological filter. This is a good thing. Crushed coral and gravel have a lot more surface area for bacteria growth than sand, because sand is made of such small grains that they pack closely together, leaving few nooks and crannies."

"<u>Aging The Aquarium or Cycling the Biological Filter</u>

One of the most critical steps in starting up an aquarium is giving the aquarium enough time for the biological filter bacteria population to build up or "cycle." Animals excrete ammonia waste (NH3), which is toxic. Animal feces, uneaten food and dead animals will also add ammonia during decomposition. This ammonia will build up unless you frequently change a lot of water (impractical), or your biological filter converts it first to nitrite (also toxic) and then to nitrate (not toxic) through the nitrogen cycle. It takes time for your nitrifying bacteria population to build up, and this process is called aging or cycling. The nitrobacter and nitrosomonas bacteria, which do

this important job, are found in all aquatic environments, and they are in the river or bay water that you fill your tank with."

From the Chesapeake Bay National Estuarine Research Reserve in Virginia. http://www.vims.edu/cbnerr/_docs/education_docs/EstAquKeepwriteup.pdf

7) Creating Oyster Habitat- What Makes a Good Site?
By Don Meritt, Sea Grant Shellfish Specialist

….This article will address some of the basic issues that need to be considered in choosing sites for oyster restoration.

Salinity
Perhaps the most important factor for oysters is salinity. Oysters can survive in salinities from under 5 ppt to full strength ocean water and more (ocean water is around 35 ppt). These low or high salinity levels can cause of physiological stress. Unless your site is in a fresh water or ocean region, salinity will vary from season to season and year to year... A good indicator of a site's suitability is live oysters nearby….

Dissolved Oxygen
It's important that oysters have enough oxygen. The absence of oxygen, or anoxia, can especially occur in summer months when bacteria… use up dissolved oxygen in the water. Winds, currents and plant activity (photosynthesis) as well as direct transfer from the air to the water all contribute to adding oxygen to the water. Locating oyster reefs in areas with good circulation, where the water is well mixed from top to bottom, should help….

Disease
Oysters in many prime growing regions are under attack by… MSX disease… and Dermo disease (but these oyster diseases do not harm people). The microorganisms that infect oysters are also influenced by salinity. MSX is only found in areas where salinities are moderately high, above 14 to 16 ppt. Dermo disease is better able to survive in lower salinity waters.

Predation
While the oyster is wonderfully adapted for thriving in a wide range of conditions, it is still vulnerable to attack by predators such as oyster drills, boring sponges, and blue crabs. Consider predators and parasites that may invade the oyster reef you are planning to construct. In other words, try to locate reefs at sites where predatory organisms are less common.

Bottom Characteristics
Oysters grow best on hard substrates. Think of an oyster reef as the foundation of a house: no one would build a house directly on top of mud – it would sink until it encountered a bottom solid enough to hold up the rest of the structure. The foundation of a reef must be strong enough to keep the oysters from sinking into the ground and strong enough to withstand storms and other forces – particularly waves and heavy current surges – that could tear it apart.

Exposure: Physical and Human
Heavy wave action, for example, can actually lift oysters and shells and transport them to locations far from where they were originally placed. This is especially true in shallow water areas. Any reefs in water less than six to twelve feet deep should not be located in areas where severe winds will cause heavy wave action. Even if the force of the waves does not move the oysters, it may stir up sediments, and that could bury the oysters. Exposure to runoff that carries toxic substances should also be avoided.
From Maryland Aquafarmer Spring 2001

8) Environmental Factors Affecting Oyster Populations
The list below is the table of contents from a chapter entitled, "Environmental Factors Affecting Oyster Populations" from a 1964 scientific publication from NOAA about the American oyster.

As you read the list, what do you recognize? What would you like to know more about?

A couple fun terms:

- Gastropods are snails. Gastro = gut, and pod = foot. Does it make sense to you somehow that "gut-foot" = snail?

- Commensals are different species that live together. One of the species benefits from the relationship, and the other species is unaffacted. "Com" = sharing, and "mensal" = a table. Does it make sense to you somehow that "sharing-a-table" = commensal?

Excerpted from “The American Oyster, *Crassostrea virginica* Gmelin,” from the NOAA Northeast Fisheries Science Center’s (NEFSC) “Classic Publications” page, which includes NEFSC literature “from pre-computer days.” The excerpt is here.

9) Problems with low dissolved oxygen in the East River:

Although the East River's water quality has steadily improved, it still has problems with eutrophication, turbidity, and low levels of dissolved oxygen. As suspension filter feeders, oysters have a great capacity for water filtration. On a per-area basis, oyster reefs are estimated to remove 25 times more nitrogen than salt marshes do (Waldman 1999). Oysters remove phytoplankton, particulate organic carbon, sediments, pollutants, and microorganisms from the water and they use most of the organic matter that they filter (Tolley et al.).

Oysters are generally hardy creatures (Waldman 1999) but... their development and mortality are influenced by salinity, current velocity, and dissolved oxygen levels. Oysters generally tolerate salinity levels between 15-25 ppt….Current velocity can affect oyster growth because currents bring food and oxygenated water to the reefs (Brumbaugh et al. 2006).

Generally, dissolved oxygen levels should consistently be above 5.0 mg/l or above. In its current state, the Lower East River barely meets this requirement during the summer and the Upper East River has dipped below this threshold (NYCDEP 2004); this affects the timing and location of oyster restoration.

Adapted from: http://www.columbia.edu/itc/cerc/danoff-burg/RestoringNYC/RestoringNYC_EastRiver.html

10) NY/NJ Harbor Estuary Map from Stevens Institute of Technology shows parameters like surface and bottom salinity, surface currents, surface air temperature, etc. Via: http://hudson.dl.stevens-tech.edu/maritimeforecast/maincontrol.shtml

Set Up Your Oyster Tank

BOP Curriculum
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Mar 2, 2018

Unit	Grade	Class Periods	Setting	Subject Areas
Oyster Tank Investigation	6-8th	1	Classroom	Science Math

Summary

The teacher demonstrates the set-up process for the oyster tank and discusses each step with students.

Objectives

- Make observations about each step of the tank set-up process.
- Record questions about the tank set-up process.
- Discuss and analyze choices made during tank set-up process.

Materials and Resources

Supplies

You need all the supplies listed in the Oyster Tank Guide.

Before you get started

Tips for Teachers

- This unit is designed for oyster tank novices. Oyster tanks are not difficult to care for, but they do take some close monitoring and experimentation in the first few weeks.
- In the wild, the eastern oyster can survive in a relatively wide range of water quality parameters. However, in a tank, due to the relatively small volume of water, parameters can spike or plummet very quickly. For this reason, you want to keep a close eye on the parameters, until you get the hang of feeding and caring for your oysters.
- Ideally, the students who help set up the oyster tank will also help monitor it throughout the year. If this is not possible, consider ways to keep your students informed as to the progress of the tank and health of the oysters.

Preparation

- Be sure to read the Oyster Tank Guide.
- Decide how you want fill your classroom tank with water. Option include:
  - Use the students' water from the lesson Create Brackish Water for Your Oyster Tank
  - Fill up the tank before class
  - Have the students participate in filling up the tank
- Decide if you want to add "associated oyster reef organisms." These are organisms found in your ORS that you are able to keep alive and transport back to your classroom.
- If you do not have time to add organisms during this lesson, we suggest you add them at a later date, as they can make for a very rich and dynamic oyster tank experience.

Instruction Plan

Explore

1. In this demo, the teacher will set up the final components of the tank and engage the students in discussion along the way.
2. Gather the class around the tank so everyone can see.
3. Each student gets the Aquarium Additives handout.
   - As you go through each step of the demo try to pass around something for the students to look at.

- For example, if you have the tap water condition box or an extra bottle, pass those around while you're on that step.
- Pay attention to which parts of the demo get the most responses from students. These elements may be worth spending more time on with the class. Consider pausing the demo and turning to the Oyster Tank Topic Library for a deeper dive.

4. Fill tank with water (or maybe it's already filled with the students' brackish water) and check the salinity with a hydrometer.
   - If the salinity is not 15ppt, discuss what steps are needed to make it so.
   - Questions: What salinity do we want our tank to have? What could we add or take out of the tank to achieve that salinity?
5. Add tap water conditioning drops (follow instructions included with drops).
   - Discuss with students why the water needs to be de-chlorinated before the oysters are put in.
   - Questions: What's in this bottle? Is there anything on the bottle or box that could help up figure it out? How many drops should we add for the whole tank? What is chlorine? Why is it in our tap water? Why do we need to remove the chlorine before putting the oysters in the tank?
6. Set up the DIY filter with aerator and air stone and turn it on.
   - Discuss with students the purpose of the aerator and gravel.
   - Questions: What components are making up this filter? What happens when we put it in the tank and turn it on? What do you think is the purpose of the bubbles? What do you think is the purpose of the gravel? What is growing/living on the gravel?
   - Biological filtration is a subject that could be a lesson in and of itself. If you have time to expand upon this topic, start by looking at the Oyster Tank Guide and Oyster Tank Topic Library.
7. Add the 10 spat-on-shell substrate oysters.
   - Consider making this into a ceremony where each group brings up their substrate shell and introduces the oysters to the tank.
   - The group may also want to tell the class the name of their oysters at this time.
8. Optional: Add associated oyster reef organisms.
   - Identify the organisms and discuss how these organisms will interact with the oysters and each other.
   - Questions: What organisms are we putting in the tank? Where do you think each organism belongs in the oyster reef food web? What do they eat? What eats them? How will each organism do in the tank environment?
9. Feed the oysters. See the Oyster Tank Guide for specific feeding guidelines and preparation.
   - Questions: What is this that we are feeding the oysters? What clues can we get from the packaging? Why are we feeding this to the oysters?

Standards

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
  - Interdependence
- Grade 7, Unit 4
  - Dynamic Equilibrium: Other Organisms

Small Tanks for Small Arthropods

BOP Curriculum
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Mar 21, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
NY Harbor Populations Investigation	6-8th	7	Classroom	Science

Summary

In small groups, students become stewards of a number of the small animals their class gathered from the Oyster Restoration Station (ORS) – probably some combination of arthropods including amphipods, isopods, crabs, and/or shrimp. Students develop a system for identifying and tracking their animal community, make decisions about how best to keep the animals, and develop their questions about these ORS animals.

Objectives

- Develop a system for identifying and tracking small arthropods from the ORS.
- Make and justify decisions about how best to keep those animals
- Collect data to check how well they have been keeping their animals.
- Develop questions about the animals.

Materials and Resources

Supplies

- Poster paper for each group to record baseline data
- 20 (or more) Petri dishes
- White paper to lay out under the Petri dishes, so it's easier to observe the animals on a white background
- Tweezers (one set for each table) – for transferring animals
- and/or Wide-tipped disposable pipets (which are quite reusable)– for transferring animals more gently, along with some water – one or two per table
  - You can buy 100 pipets for $5 here: http://www.premiumvials.com/3ml-plastic-transfer-pipettes-gradulated-pack-of-100/?gclid=CIbKjufbz9ICFU9WDQodaqsGpQ
  - If the tip is too narrow, you can use scissors to cut the pipet where it's wider
- Sieves, screens, or pieces of loosely-woven fabric that can be used to separate animals from water (one for each table)
- Hand lenses (two or more for each table)
- 10 (or more) one-gallon tanks (e.g. Penn-Plax New World Habitat Tank, Small, 1 gal)
- At least 30 small arthropods collected from ORS mobile trap (the more the better!)

Refer to the BOP Oyster Tank Guide on the BOP Digital Platform for details on where to purchase and how to use the materials for your small tanks.

- Cold tap water – enough to fill all the 1-gallon tanks
  - Tap Water Conditioner (de-chlorination of tank water)
  - Instant Ocean Aquarium Salt (15 lbs bag)
- OR harbor water – enough to fill all the 1-gallon tanks

-

- Shellfish Diet 1800 phytoplankton concentrate (1 quart) OR algae discs (optional for occasionally feeding the associated organisms)
- Optional: frozen brine shrimp for feeding crabs, if students don't want the crabs eating the harbor organisms
    - Purchase at your local aquarium store or Petco
- Optional: Stress Zyme (for adding more bacteria to your tank)
- Optional: Aquarium gravel (for DIY filters)
- Optional: Plastic bottles with wide mouth (for DIY filters that can fit inside the little 1-gallon tanks)
- Optional: Recycled oyster shells for substrate

Before you get started

Tips for Teachers

- Because students often ask fantastic questions without realizing it or writing them down, try to move around the room and write down the wonderings you overhear.
- Each time you move or handle your organisms, you stress them. In general, sieving or screening them is less stressful than using tweezers.
- You might first ask your students to practice using tweezers gently on other objects, such as soft-cooked rice or cut up cooked noodles. If they break the rice grains or noodle pieces, they're squeezing too hard.
- The hope is to allow students to explore and interact with these animals, and to do so gently, with awareness of how their actions affect the animals.
- During the data collection period, in the "Evaluate" section, you may want to split class time: each day students can have a certain amount of time to collect their data. If you like, you can use the remaining class time from each of those periods for students to present their experiments and data to date. Groups can present what they have so far, and that way you don't need to wait for everyone to collect all their data before getting started on presentations.
- In order to do the Extension for this lesson, you will probably need a fresh supply of animals. That means visiting the ORS again before that part of the lesson, either with or without your students.

Preparation

- You need animals from your Oyster Restoration Station (ORS), and it's best if your students have collected those animals. Ideally, schedule this lesson right after a visit to the ORS.
- For the "Elaborate" section, you probably need to make your own handout, based on which resources are available to your students in your classroom.
- So that your students have some background knowledge about these animals and the local estuarine ecosystem, we recommend that you teach the lessons Food Web and Habitat Web prior to this lesson.

Instruction Plan

Engage

1. Note: the next activity is a rich source of student questions about small arthropods. Be sure to record your students' questions and add them to your running list. You'll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

2. Each group of students has...
    - A set of small arthropods in a Petri dish with harbor water or synthetic brackish water (consult BOP Oyster Tank Guide on how to make synthetic brackish water).
    - Extra Petri dishes
    - Access to extra brackish water
    - Tweezers

- Hand lenses
- Access to a sieve or screen
- White paper taped to their lab bench, so they can see the animals more easily on a white background.

3. Students have access to BOP Species ID Cards and Food Web Cards, but they are not required to use them at this time. As they raise relevant questions, consider directing them toward those resources.

4. Students observe, sketch, and raise questions about their animals.
   - Be sure to collect students' questions – you will need them in the future lesson Propose a New York Harbor Population Study.

5. Students put animals into an aerated tank for safekeeping.

1. Students report back to the full class, with the instruction: "As you report back, try not to repeat things that your classmates have said. See if you can add an observation or a question that has not already been said."
   - Students respond to each other's presentations with follow-up questions and related observations, group by group.

2. During this discussion:
   - Post student observations and questions.
   - If possible, also project images of the relevant organisms as students talk.

This would be a good time to break until the next class

Explore

1. Note: the next activity is a rich source of student questions about small arthropods. Be sure to record your students' questions and add them to your running list. You'll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

2. Each group of students has...
   - A set of small arthropods in a Petri dish with harbor water or synthetic brackish water (consult BOP Oyster Tank Guide on how to make synthetic brackish water).
   - Extra Petri dishes
   - Access to extra brackish water
   - Tweezers
   - Hand lenses
   - Access to a sieve or screen
   - White paper taped to their lab bench, so they can see the animals more easily on a white background.

3. Students have access to BOP Species ID Cards and Food Web Cards, but they are not required to use them at this time. As they raise relevant questions, consider directing them toward those resources.

4. Students sort their animals into categories for tracking.

5. If you like, ask students to swap tables, and use each other's systems to sort and count each other's animals. That could act as a check to make sure that each system works well. Just remind them to transfer the animals extremely gently!

Students put animals into an aerated tank for safekeeping.

Explain

1. Note: the next activity is a rich source of student questions about small arthropods. Be sure to record your students' questions and add them to your running list. You'll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

2. Students make predictions about which animals will eat what. They start from the organisms at their table, and then consider all the animals from all the groups.

3. After students have recorded their food web predictions, they could:
   - Refer to the Food Web Cards, and see if they think the cards are correct
   - Describe a way to figure out who eats whom by manipulating the animals they have in the classroom
   - Or both
   - Probably a lot of excellent student questions will arise from this activity. Be sure to record them and add them to your running list of your students' questions about small arthropods!

This would be a good time to break until the next class.

Elaborate

1. Note: the next activity is a rich source of student questions about small arthropods. Be sure to record your students' questions and add them to your running list. You'll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

2. Explain:
   - "You each have a small tank, which could be enough space to support a number of small animals, if you make good decisions and take good care of them. Your job is to decide what conditions will be best for your animals in that tank.
   - "If you want to separate your animals, or use a different group of animals together in one tank, let me know. At a certain point, I will set up a discussion for those groups who want to swap animals and set up tanks with different sets of animals.
   - "Every tank must have aeration, but there are some different ways to manipulate the aeration."

3. Groups make decisions such as those below. You probably need to make your own handout that lists the decisions should make, based on the resources available in your classroom.
   - Do we put all the animals we have in the same tank, or should we separate them? If we want to separate them, we should tell our teacher within the first 15 minutes of this process.
   - Who eats what? Shall we feed our animals with some added food, like algae paste, frozen brine shrimp, and/or algae disks?
   - Shall we let the animals eat each other?
   - Shall we continue collecting harbor water, and strain it through a sieve, so we get more phytoplankton, but we don't get more amphipods and isopods?
   - Or shall we continue collecting animals from the harbor and adding them on a regular basis? (Note: you should probably offer this option only if you are willing to go collecting on a regular basis!)
   - Should our tank be covered or open to the light? How much light, and what kind/source of light?
   - Should we put a lid on top of our tank or leave it open on top? Should we seal the lid with some kind of tape?

- We need aeration, but how and how much? (You can split up the air from one pump using a manifold. Suppose the manifold splits one line into four: then you can decide how many of those four lines to put in one tank). Should we use air stones?
- Should we make a DIY filter?
- Should we have substrate in the bottom, or just water in the tank?
- Etc. The possibilities are endless!

4. Students set up their tanks and add their animals. (You will probably have to do some nimble negotiating to figure out which groups need which animals, and to distribute the animals to the groups.)

5. Groups use the method they have devised for sorting and counting their animals, and post this baseline data.

This would be a good time to break until the next class.

Evaluate

1. Note: the next activity is a rich source of student questions about small arthropods. Be sure to record your students' questions and add them to your running list. You'll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

2. Students write down what conditions they have selected for their tanks, and why.

3. Students write down when and how they need to collect data, for the purpose of showing how well their animals are doing under their chosen conditions:
   - They have to track their animals, sticking with the system they devised in the "Explore" portion of the lesson.
   - They might also want to track water parameters. For economy's sake, you could limit this to parameters that can be tracked with non-consumable materials, e.g. temperature, pH if you have a pH meter, water level, water color, etc.
   - Note: there's a decent chance that many of the animals will die within two weeks. Also, each time people handle the animals, the animals are stressed. So we recommend tracking the animals over a period of 5-10 days, and collecting data only 2 more times after the initial baseline count.

Over the next few class days, as data collection continues:

1. Groups present their systems of sorting and counting their animals, the conditions they chose for their tanks, and their results.

2. Students respond to each group's presentation with follow-up questions and suggestions.

Extend:

1. Note: the next activity is a rich source of student questions about small arthropods. Be sure to record your students' questions and add them to your running list. You'll need that list for the students to propose large-scale studies in the upcoming lesson, Propose a NY Harbor population study.

2. After getting, posting, analyzing, and discussing everyone's data, groups respond to the more specific prompt: "Define best. You tried to set up your tanks in the way that would be best for your animals. What did you mean by best? What are some other ways of deciding what is best?"

3. Groups set up their tanks afresh, in the way that is 'best' according to their now-precise definition.
   1. Note: you will likely need a fresh supply of animals for this step!

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
  - Cause and effect relationships may be used to predict phenomena in natural systems.
  - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Energy and Matter
  - The transfer of energy can be tracked as energy flows through a designed or natural system
  - The transfer of energy can be tracked as energy flows through a natural system.
- Influence of Engineering, Technology, and Science on Society and the Natural World
  - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- Patterns
  - Graphs and charts can be used to identify patterns in data.
  - Graphs, charts, and images can be used to identify patterns in data.
- Stability and Change
  - Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems and System Models
  - Models can be used to represent systems and their interactions.
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

NGSS - Disciplinary Core Ideas

- LS1.A: Structure and Function
  - Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
- LS2.A: Interdependent Relationships in Ecosystems
  - Growth of organisms and population increases are limited by access to resources.
  - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

  Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
  - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
  - Analyze and interpret data to provide evidence for phenomena.
- Constructing Explanations and Designing Solutions
  - Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.
- Engaging in Argument from Evidence
  - Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 4
  - Interdependence

Sort your small arthropods

You have a collection of small arthropods at your table. You'll be taking care of these animals, so you need a way to keep track of them. To help with the tracking, your goal right now is to sort the animals into categories.

1. Look closely at the animals at your table. Based on your observations, decide which animals belong together in one category.

   Put the animals that belong together into their own Petri dish. Transfer them very gently!

   Explain what you're noticing that makes you think these specific animals belong together in one category:

2. Now at look at the remaining organisms at your table. From those, which ones belong together? Do they all belong together? Decide how many more Petri dishes you need, so that each dish has organisms that belong together.

   Get the Petri dishes you need, and put the animals that belong together into their own Petri dishes. Transfer them very gently!

   Explain how you decided which animals belong in each dish:

3. Look at all your dishes again, and see if you're definitely still happy with the way all the animals are grouped.

Do you have some new thoughts about your groupings? You can now move some organisms around. But note: after today, you will have to stick with your way of grouping the organisms.

Explain your revised thinking:

Steward-shed Challenge

BOP Curriculum
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Apr 18, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Steward-shed Investigation	6-8th	5	Classroom	Science, Social Studies, ELA

Summary

The class divides work on two different parts of a proposal for their steward-shed: 1. One way to reduce pollution 2. One place to reduce runoff. Students identify and interview stakeholders in their community, evaluate multiple approaches, and ultimately present their proposals to local stakeholders and decision-makers.

Objectives

- Identify stakeholders within their steward-shed.
- Assess stakeholders' concerns.
- Evaluate multiple approaches to reducing pollution and/or runoff.
- Propose one approach for their steward-shed.
- Present it to stakeholders and eventually decision-makers.

Materials and Resources

Before you get started

Preparation

1. You need to have a defined "steward-shed" (see the BOP lesson Steward-shed Investigation Part 1 - Paper Watersheds). It's very helpful if your students have already explored the sources of pollution and the runoff characteristics of their steward-shed (Steward-shed Investigation Parts 2 through 8).
2. Think about how you want your RUNOFF teams to learn about currently popular Green Infrastructure designs, if at all. These are some materials you could give them, all published by organizations that promote this kind of intervention:
    - Green Infrastructure Techniques from GrowNYC (longer)
    - Types of Green Infrastructure from NYC DEP (very brief)
    - Profiles of specific projects:

- Rooftop farm at Brooklyn Navy Yard
- Gowanus sponge park
- Blue and green roof at The Osborne Association
- Green roof on Lenox Hill Neighborhood House
- Rain garden and permeable pavers at Queens College

1. One advantage of introducing this material is that your students may become familiar with vocabulary like "bioswale" and "green roof."
2. An alternative would be to see what solutions students come up with. It's likely they will think of more familiar elements like parks, gardens, and even flower pots. One advantage of that approach is that your students are likely to encounter the social implications of green infrastructure in starker contrast.

    - For example, it's easy to propose a new park, and difficult to decide what can be torn down to make way for that park. It's useful for students to grapple with that conflict.
    - By contrast, green infrastructure can give the illusion of 'having it all'. The social conflicts around green infrastructure are very real, but much harder for students to identify without much more in-depth research.
- If you decide to give the additional readings to the RUNOFF teams, consider ways to provide productive tasks for POLLUTION teams that may complete their tasks more quickly. One option is to give everyone the additional readings.

Background

Lesson Context

Per the EPA's publication, "Engaging Stakeholders in Your Watershed":

"A stakeholder is a person (or group) who is responsible for making or implementing a management action, who will be significantly affected by the action, or who can aid or prevent its implementation....

"Stakeholder involvement in watershed issues has gained momentum in recent years because of the nature of water quality problems in our country. Forty years ago, most water quality problems were linked to discharges from factories and wastewater treatment plants. Today, however, about 40 percent of our nation's waters do not meet their water quality goals because of runoff from streets, farms, mines, yards, parking lots and other nonpoint sources of pollution. Solving these problems requires the commitment and participation of stakeholders throughout our communities.

"Stakeholder involvement is more than just holding a public hearing or seeking public comment on a new regulation. Effective stakeholder involvement provides a method for identifying public concerns and values, developing consensus among affected parties, and producing efficient and effective solutions through an open, inclusive process....

"Stakeholders might be aware of localized flooding, old dump sites, popular recreational areas, and other aspects of the watershed not captured in monitoring or other reports. They can also help to identify social and environmental concerns in the watershed...."

https://cfpub.epa.gov/npstbx/files/stakeholderguide.pdf

The absolute necessity of effective stakeholder engagement is particularly clear in settings where Environmental Gentrification stands to undermine Environmental Justice. This is a live issue in NYC right now. Here are two good introductory articles based on local research:

- The dangers of eco-gentrification: what's the best way to make a city greener?
- Just Green Enough

And a few scholarly articles reporting original NYC research:

- Wiped Out by the "Greenwave": Environmental Gentrification and the Paradoxical Politics of Urban Sustainability (full text)
- From Brown to Green? Assessing Social Vulnerability to Environmental Gentrification in New York City (abstract)
- Moving out or moving in? Resilience to environmental gentrification in New York City (abstract)

Instruction Plan

Engage

1. Students revisit the watershed model with pollution added from the earlier lesson, Steward-shed Investigation Part 5 - Add Pollution to Your Steward-shed Model.
2. Play with reducing the amount of runoff, either by adding less water, or by replacing a less permeable part with a more permeable part.
    -

- Point out: "these are two different approaches to improving the water quality: 1. Reducing runoff, and 2. Reducing pollution."

- Tell students they will work for several days on one or the other project, and find out their preferences so you can split the class into two sets of small teams: RUNOFF teams and POLLUTION teams.
- The RUNOFF teams revisit their maps, models, and notes from field expeditions, to help them brainstorm possibilities in response to: "Where is the best place for us to reduce runoff in our steward-shed?"
  - Teams list pros and cons of the different ideas they have.
  - Teams list questions that have come up in the process.
- Optional (see "Preparation" section, above): RUNOFF teams also learn about some of the more common approaches to building Green Infrastructure, by consulting your selection from the following publications, all of which were produced by institutions in an effort to highlight their successes and make themselves look good.
  - Encourage your students to appreciate that bias, and to take a more critical stance. Once option is to simply ask them, "what might be some problems for the local community associated with these projects?" and "what would ensure that the local community gets its fair share of the benefit from these projects?" "What do you think would be even more fair and beneficial projects, in our community?"
    - Green Infrastructure Techniques from GrowNYC (longer)
    - Types of Green Infrastructure from NYC DEP (very brief)
    - Profiles of specific projects:
      - Rooftop farm at Brooklyn Navy Yard
      - Gowanus sponge park
      - Blue and green roof at The Osborne Association
      - Green roof on Lenox Hill Neighborhood House
      - Rain garden and permeable pavers at Queens College
- Meanwhile, the POLLUTION teams revisit their maps, models, and notes from field expeditions, to help them brainstorm possibilities in response to: "What kind or source of pollution should we reduce in our steward-shed?"
  - Teams list pros and cons of the different ideas they have.
  - Teams list questions that have come up in the process.
- Each RUNOFF team presents their work so far to one POLLUTION team, and vice versa.
- Each team meets once more on its own, to prepare an initial plan to submit to the teacher:
  - RUNOFF teams submit a specific location in their steward-shed. Eventually they will create a specific plan to reduce runoff in that location.
  - POLLUTION teams submit a specific type and source of pollution. Eventually they will propose a specific plan for reducing that kind of pollution in their steward-shed.

This would be a good time to break until the next class.

Explore

1. As a full class, students close-read and discuss the meaning of the following text from the EPA's publication "Involving Stakeholders in Your Watershed":

   "A stakeholder is a person (or group) who is responsible for making or implementing a management action, who will be significantly affected by the action, or who can aid or prevent its implementation.…

   "Stakeholder involvement is more than just holding a public hearing or seeking public comment on a new regulation. Effective stakeholder involvement provides a method for identifying public concerns and values, developing consensus among affected parties, and producing efficient and effective solutions through an open, inclusive process."

    - This would be a good time to ask students to share their experiences and observations about stakeholders, and about how groups make decisions. For instance, "Have you seen one person make a decision that affects other people, and the decision-maker didn't think ahead about how their decision would affect those other people?" and "Have you seen a group of people make a decision for themselves, together? How did they do that?" and so on.

    - Individually, students 'translate' the EPA text into everyday language.

2. Students begin their research on stakeholders, using the "Resources to Research Stakeholders" section of "Our Steward-shed" Library of Resources

This would be a good time to break until the next class.

1. Students read How shall we gather information about our steward-shed stakeholders?
    - Each team selects one method of getting information from a lot of people, and one method of targeting specific people. (This could also be split up by team. For instance one of the, POLLUTION teams could work on surveying a lot of people, and a separate POLLUTION team could work on targeting specific people).
2. Each team consider their proposal and what they already know about their stakeholders, in order to drafts a set of questions, a survey, or other appropriate instrument for gathering information about their stakeholders.
    - Teams present their instruments to one another, for feedback and revision.

This would be a good time to break until the next class. Meanwhile, you can make arrangements for students to go outside and collect data.

1. Teams survey and/or interview stakeholders to gather that information they wanted.

This would be a good time to break until the next class.

Explain

1. Teams discuss both the process and the content of what they found. For example, they can discuss things like:
    - Barriers to communication
    - Barriers to adopting the team's steward-shed proposal
    - Opportunities for communication
    - Opportunities to get support for the team's steward-shed proposal
    - perspectives that are very different from those of the team members
    - Perspectives that are similar to those of some of the team members
2. Teams write up summary of what they learned about:
    - Their stakeholders
    - Their stakeholders' interests, needs, desires, concerns.

Elaborate

Teams complete How shall we evaluate our steward-shed proposals?

Evaluate

1. Paired teams evaluate each other's proposals based on their own criteria.

2. Each team makes the proposal they think is best for their place and their stakeholders. Tell your students: "Your proposal doesn't have to make everyone happy, but you do have to take all your stakeholders into account, and you do have to consider many different ways that your proposal can affect the people and the place."

Extend

1. Students share their steward-shed proposals with stakeholders for revision.
2. Class debriefs, and decides what to do next.

Standards

NGSS - Cross-Cutting Concepts

- Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - Cause and effect relationships may be used to predict phenomena in natural systems.
- Influence of Engineering, Technology, and Science on Society and the Natural World
  - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
  - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
- Scale, Proportion, and Quantity
  - Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- Science Addresses Questions About the Natural and Material World
  - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes
- Structure and Function
  - Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
  - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
  - Structures can be designed to serve particular functions.

  Systems and System Models
  - Models can be used to represent systems and their interactions.
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
  - Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

NGSS - Disciplinary Core Ideas

- ESS2.C: The Roles of Water in Earth's Surface Processes
  - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
  - Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- ESS3.C: Human Impacts on Earth Systems
  - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- ETS1.A: Defining and Delimiting Engineering Problems
  - The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
- ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- ETS1.C: Optimizing the Design Solution
    -
    - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- LS2.A: Interdependent Relationships in Ecosystems
    - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

NGSS - Science and Engineering Practices

- Asking Questions and Defining Problems
    - Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
    - Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- Constructing Explanations and Designing Solutions
    - Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Developing and Using Models
    - Develop a model to describe unobservable mechanisms
    - Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
    - Develop a model to predict and/or describe phenomena
- Obtaining, Evaluating, and Communicating Information
    - Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
    - Weather and Atmosphere
- Grade 6, Unit 4
    - Interdependence
- Grade 7, Unit 1
    - Geology
- Grade 8, Unit 4
    - Humans and the Environment: Needs and Tradeoffs

How shall we evaluate our steward-shed proposals?
Part I: brainstorm
First of all, what do you think is most important thing to think about, when evaluating your proposal?

Now try to consider all the stakeholders in our steward-shed. Based on your research on stakeholders and their concerns, what do you think will be most important to the different people that your learned about? Start by considering the following methods:

Method 1: How can your proposal take into account the barriers to change?

There are many reasons why people do not choose sustainable behaviors.

- They might simply be unaware of the impact their behavior has on water quality.
- They might believe that doing the right thing is too expensive, takes too much time, is inconvenient, or is socially unacceptable.
- They might not believe that a change in the personal routines and habitats of just one person will make a difference.

These reasons are called barriers. Barriers prevent people from taking positive steps toward improving the environment. They can be:

- physical (such as the lack of facilities to collect household hazardous waste)
- economic (high cost)
- psychological (a perception that lush lawns are prized)
- knowledge-based (lack of understanding of how to conduct a soil test).

These obstacles must be minimized or removed so that the benefit outweighs the cost or effort of the action. To address these barriers, you need to think about why people have not adopted the environmentally friendly behavior.

For example, many people do not pick up after their pets. One common attitude is that pet waste is a part of nature and that it biodegrades quickly. Some even view it as fertilizer. They don't realize that dog droppings are one of the leading causes of pathogen contamination in streams; each gram of dog poop has more than 20 million E. coli bacteria colonies in it (not to mention the nitrogen and phosphorus). Others believe it is just too unpleasant to scoop.

Keep in mind that barriers (and benefits) are unique to each person and each behavior change.

Method 2: Possible Evaluation Criteria

Since you've researched your stakeholders, you should make up your own list of questions to consider. Here are a bunch of general examples, just to get your ideas flowing:

1. Which proposal will have the biggest impact on the water quality of the water that drains from our stewardshed?

2. Which proposal is cheapest?

3. Which proposal fits the best with the customs and cultures of our stakeholders?

4. Which proposal will have the longest-term positive effects?

5. Which proposal involves the most stakeholders in actively stewarding our steward-shed?

6. Which proposal is best for the health of our stakeholders?

7. Which proposal is best for the economy and jobs in our steward-shed?

8. Which proposal is best for affordable housing in our steward-shed?

9. Which proposal is best for transportation in our steward-shed?

10. Which proposal is the safest for our stakeholders?

11. Which proposal provides the best educational opportunities for our stakeholders?

12. Which proposal is best for __________________ people in our steward-shed? (You fill in the blank with groups that seem important to you, or to your stakeholders)

13. Which proposal has the fewest barriers? Or the easiest barriers to overcome?

15.

16.

Keep going on a separate piece of paper!

Part II:
Narrow down your list of criteria:

1. <u>Working alone</u> sort the criteria from most important to least important. Then fill in the table:

My three most important critera	
My three least important criteria	Why they are less important

2. <u>With your team</u>, compare your lists, discuss, persuade each other, and try to arrive at a consensus:

Our team's seven most important criteria	Why they are so important

How shall we gather information about our steward-shed stakeholders?

Part I: surveying a lot of people[1]

Method 1: Intercept Surveys

Intercept surveys are conducted by “intercepting” people as they walk around a shopping area, walk in the park, commute, or spend time in front of their homes and asking them to take part in a survey.

Intercept surveys are most effective when:

- respondents can see visuals related to what you are asking them about, thereby giving you credibility
- the questions are asked in the same order and same way for all respondents
- they are conducted in a high-traffic area frequented by many members of your watershed community
- the statistical validity of the survey data is not critical to your effort (i.e., when you are only interested in a quick overview of how people feel on the topic).

Method 2: Observation

This method helps you get a picture of what people actually do, as opposed to what they say they do. When asked, most people say that they care about water quality and believe that protecting it is important. When observed, however, those same people might be found dumping motor oil down storm drains or not picking up after their pets.

During the behavior, the observer makes notes about what triggered the behavior, how much effort the person exerted for the behavior, and what behaviors (e.g., facial expression, body language) accompanied the target behavior.

Observing how people behave in certain situations can be viewed as an invasion of privacy. Be sure that all observations are carried out in public locations. If the people you’re watching notice you, explain what you’re doing and why.

Often you might have to observe people for hours before you see them do something that is relevant to your investigation. So it’s hard to predict how much time you’ll need to gather information by observation alone.

[1] Adapted from the EPA’s publication, “A Guide for Conducting Watershed Outreach Campaigns” https://cfpub.epa.gov/npstbx/files/getnstepguide.pdf

Method 3: online chatter research

Several technologies allow you to get a real-time “read” on what people are currently writing online about your watershed issue. For example, you can set up a Google Alert to be notified by e-mail whenever new content is added online in blogs, websites, newsfeeds, or social networking sites about the topic you are interested in. You can also search the social networking site Twitter to see if subscribers are tweeting about your issue or organization. You can search by keyword or by using hash tags (words prefixed with #) to find posts grouped by topic. Keep in mind that new forums continue to pop up and others fall by the wayside. Ideally, you should monitor the forums that your stakeholders actually use, but it’s not always easy to figure out which ones those are.

Part II: targeting specific people

Method 4: Research local organizations

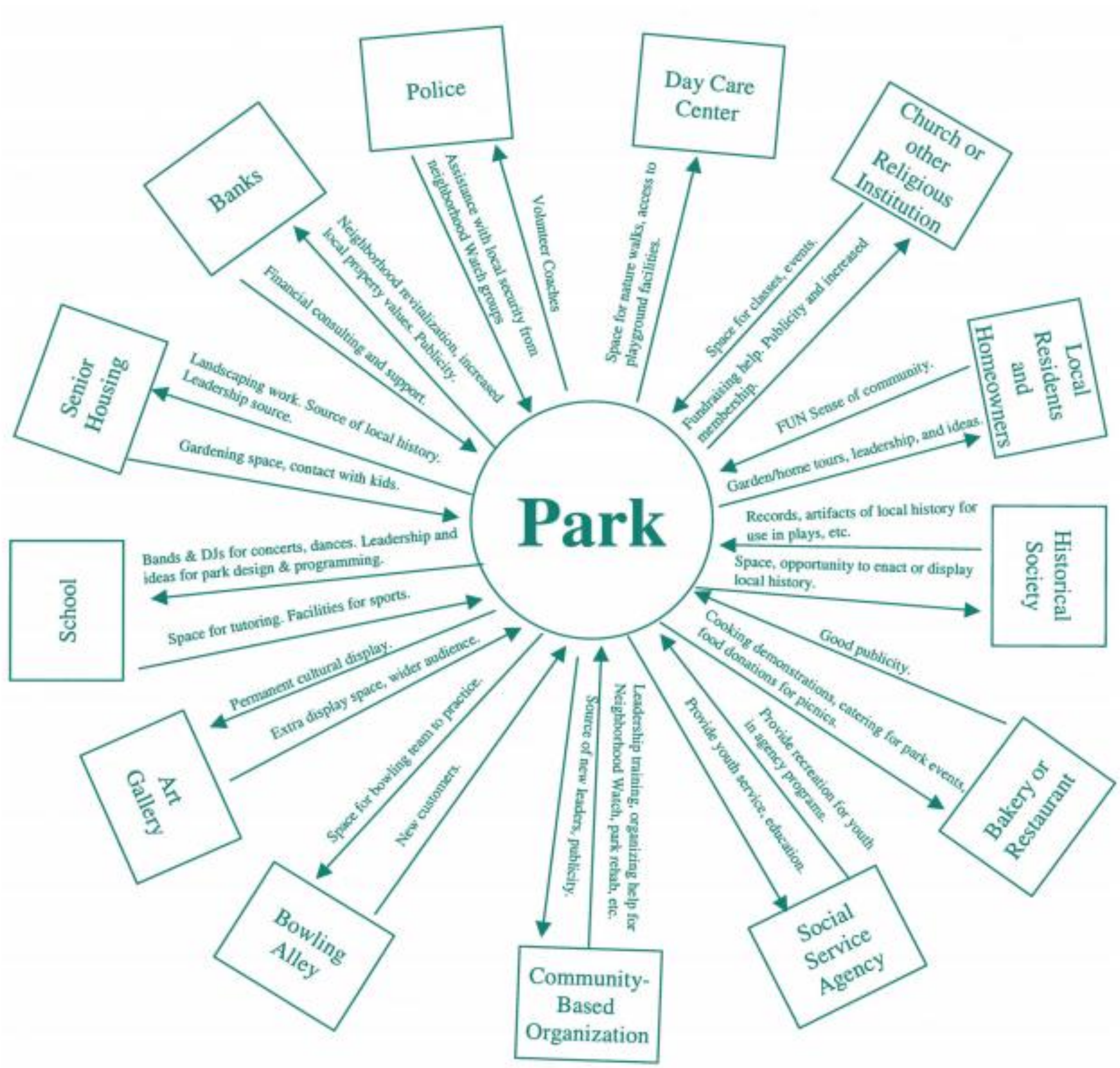
Key interest groups are not just power brokers like the mayor, the head of the Chamber of Commerce, or the president of the PTA. Remember that stakeholders are not only those who influence a decision but also those who are affected by it (positively or negatively) and those who can aid or prevent its implementation.

Here’s a general list of some possibilities, just to get you started:

- Religious organizations
- Labor unions
- Tenant associations
- Recreational organizations (e.g. birders, boaters, etc.)
- Athletic clubs
- Civic or political organizations (e.g., League of Women Voters)
- Historical or cultural associations
- Business organizations (e.g., Chamber of Commerce)
- Environmental organizations
- Parent-teacher associations
- And then remember to think about people who might not be formally connected to any local organizations. Do you know someone who is not a member of any of the above? What about youth? What about seniors? What about other stakeholders?

Method 5: Asset mapping

In this context, *asset* is a fancy way of saying a specific thing or place that people use or interact with, e.g. the railing at the water's edge by your ORS, or the park closest to your school. *Asset mapping* just means thinking about all the people, groups, and organizations that affect that asset, and all the ways that the asset might affect specific people, groups, and organizations. Here's a general example, based on a park:



https://www.epa.gov/sites/production/files/2015-09/documents/community_culture.pdf

Watersheds Part 1 - Where Does the Rain Go?

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 26, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	1	Field	Science

Summary

This lesson takes place in the field - ideally at your Oyster Restoration Station (ORS) site. This lesson would work well after you have completed the monitoring of your ORS. This lesson could also be done at any convenient location outside your classroom. Students will explore the area and make predictions about what happens to the water when it rains. Students will test their predictions with the actual pouring of water.

Objectives

- Observe carefully the slope and features of the surface of the ground
- Predict where water will flow along the surface of the ground
- Understand that slope and gravity affect water flow over the surface of the ground
- Design a way to reduce runoff at the site.

Materials and Resources

Supplies

- Clipboard for each student
- Water bottle full of water for each student
- Extra water

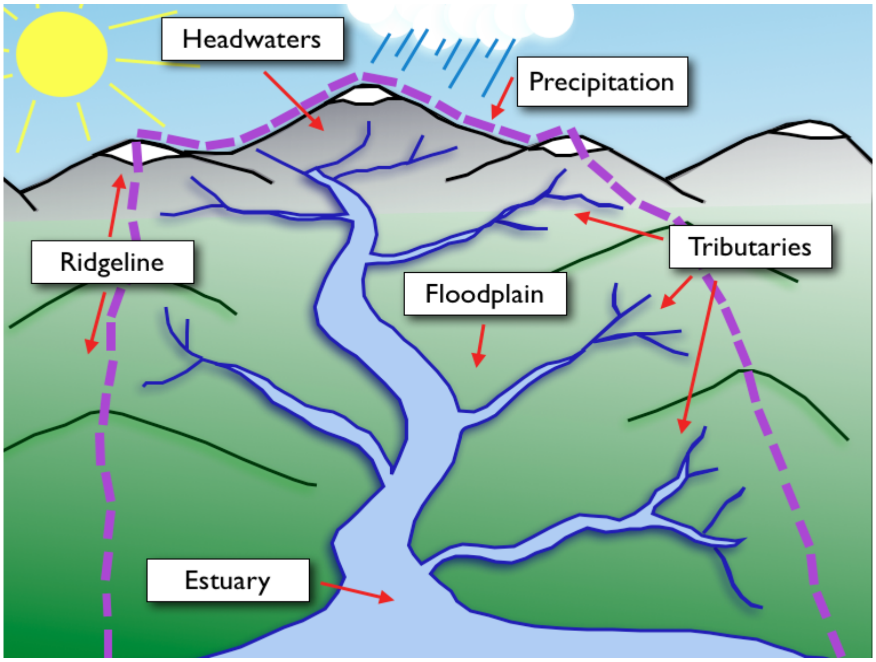
Before you get started

Tips for Teachers

Visit your field location before bringing your students, so you have an idea of what's there! Think about which features of the ground surface will be obvious to the students and which might be trickier for them to notice. Working outdoors or in the field goes more smoothly if every student has a clipboard! Trying to use folders, notebooks, or the backs of friends adds unnecessary distractions to an already distracting outdoor environment. You will need to bring extra water with you in the field, for use during the activity. It doesn't have to be potable water. Consider using buckets with line to get water from nearby waterbody, carrying a gallon jug of water, or buying a portable water sprayer ($15-$150 from Home Depot). Consider a visit to the Queens Museum! They have a specific NYC water supply watershed exhibit (a lovely scale model), which also has life-size photos of water tunnels, as well as the better-known NYC scale model. http://www.queensmuseum.org/2013/10/from-watersheds-to-faucets-the-marvel-of-new-york-citys-water-supply-system

Background

A watershed describes an area of land and how water flows in that area. A watershed is a basin-shaped area of land defined by high points (ridges) and low points (the receiving water-body). Imagine an umbrella turned upside down in the rain and how water would flow and collect in the center: the umbrella's inner surface is acting as the watershed for the little pond that is forming inside it. Since rain falls everywhere, all land is part of a watershed for some receiving body of water. Water "sheds" or flows off the ridges, down the slope and into the lowest lying body of water, which may be a lake, reservoir or river. As water flows downhill, it is also absorbed into the ground, lessening the amount that ends up directly running into the waterbody.



http://www.mobileranger.com/santacruz/san-lorenzo-river-whats-in-a-watershed-part-i/

Instruction Plan

Engage

1. In this activity, students observe the surface of the ground and predict where water will flow, where it will speed up and slow down, and what kinds of litter or pollutants they think it will pick up and/or drop in different places.
2. In the classroom, make sure each student has a clipboard and give each student a copy of the *Where does the rain go? Worksheet.*
3. Give the students a couple of minutes to look over the worksheet.
4. Take the class outside.
5. Ask: What happens to the rain that falls on this area?
    - Examples: Slopes, hills, drains, grates, holes, cracks, curbs, roofs, downspouts, gardens, tree beds, waterbodies,
6. Follow-up with probing questions, so students don't stop at their first thought.
    - Does that explain what happens to *all* of the rainwater?
    - How much of the rainwater would you guess goes to this place vs. that place?
    - What if it rains faster or slower? Thundershower vs. drizzle?
    - What if it rains every day or just once a month?
7. Ask: are there pollutants and litter in this area?
    - Where do you think flowing rainwater would pick up different pollutants and litter?
    - Where do you think flowing rainwater would drop different pollutants and litter?
8. Take note of information, misconceptions, questions, and dialogue among students.
9. Student complete questions #1 & 2 on their worksheet.

Explore

1. In this activity, students will think about how to change the direction of the water flow.
2. Engineering Challenge: What would we have to do in order to make rainwater flow a different way, right here on the ground in front of us?

3. Note: We are not yet concerned about how to decrease runoff, (although take note if students are thinking along those lines as this issue will be raised later in the lesson). In this activity we are trying to drive home the point about how slope and gravity affect water flow.
4. Students complete question #3 on their worksheet.

Explain

1. In this activity, students will think about how to change the direction of the water flow.
2. Engineering Challenge: What would we have to do in order to make rainwater flow a different way, right here on the ground in front of us?
3. Note: We are not yet concerned about how to decrease runoff, (although take note if students are thinking along those lines as this issue will be raised later in the lesson). In this activity we are trying to drive home the point about how slope and gravity affect water flow.
4. Students complete question #3 on their worksheet.

Elaborate

1. In this activity, students will be testing their predictions of where water will flow.
2. Explain: Now the students will be testing their predictions (inferences) of:
   1. where the water will flow
   2. Where the water will flow fastest and most slowly
   3. Where the water will pick up and drop different pollutants and litter
      Make sure students have made predictions before the water is poured.
3. Students get into small groups.
4. Students use their water bottles to pour water on the ground creating some flow. Students should test several locations to test their predictions from earlier.
5. Gather students back together.
6. Explain: if students have monitored their Oyster Restoration Station (ORS) you might want to ask them to think back to the Land Conditions data they collected for Protocol 1 - Site Conditions. See excerpt of data sheet below:

Land Conditions (Take a photograph of the water with your camera)

Shoreline type:

Bulkhead/wall | Fixed Pier | Floating Dock | Riprap/Rocky Shoreline | Dirt or Sand | Other

Estimate percent surface cover for the adjacent shoreline (about 100 x 100 feet)

______% Impervious Surface (concrete/asphalt paths, roads, buildings etc.)

______% Pervious Surface (dirt, gravel etc.)

______% Vegetated surface (grass, shrubs, trees)

=_____% Sum should equal 100%.

Garbage on the adjacent shoreline? Y / N

Extent/Type	Hard Plastic	Soft Plastic	Metal	Paper	Glass	Organic	Other
None							
Sporadic							
Common							
Extensive							

1. Explain: Students might want to look for places to pour the water that highlight the following features:
    - Sediment that will flow along with the water

      Litter or oil that will flow along with the water

    - Permeable or impermeable surfaces

1. Students complete question #4 on their worksheet and compare their results to their predictions.

Evaluate

1. In this activity, students will think about how and why they could change runoff patterns in this area.
2. Design Challenge: What could we change or build on the surrounding buildings or ground surface that would either:
    - Decrease the amount of runoff that ended up in the nearby water-body or storm sewers – in which case, where does the rainwater end up, and why is that better than runoff?
    - increase and direct runoff through a particular route – in which case, what route do you choose, and why?
    - Choose one of these goals, and design for that goal.
3. Encourage students to look back through their worksheets and to conduct some more water pouring experiments for design ideas.
4. Then discuss: which goal is most appropriate for this location? Why? Multiple right answers are possible!

Standards

CCLS - ELA Science & Technical Subjects

-
    - Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

NGSS - Cross-Cutting Concepts

- Cause and Effect
    - Cause and effect relationships may be used to predict phenomena in natural systems.
- Energy and Matter
    - Within a natural system, the transfer of energy drives the motion and/or cycling of matter.
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
    - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

NGSS - Disciplinary Core Ideas

- ESS2.A: Earth's Materials and Systems
    - All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- ESS2.C: The Roles of Water in Earth's Surface Processes
    - The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.
    - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
    - Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.

- ESS3.C: Human Impacts on Earth Systems
    - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- ETS1.B: Developing Possible Solutions
    - Models of all kinds are important for testing solutions.

NGSS - Science and Engineering Practices

- Asking Questions and Defining Problems
    - Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
- Constructing Explanations and Designing Solutions
    - Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.
    - Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.

NYC Science Scope & Sequence - Units

- Grade 6, Unit 2
    - Weather and Atmosphere

NYS Science Standards - Key Ideas

- LE Key Idea 7
    - Human decisions and activities have had a profound impact on the physical and living environment
- PS Key Idea 2
    - Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.
- PS Key Idea 3
    - Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity

NYS Science Standards - Major Understandings

-
    - The environment may contain dangerous levels of substances (pollutants) that are harmful to organisms. Therefore, the good health of environments and individuals requires the monitoring of soil, air, and water, and taking steps to keep them safe.
    - During a physical change a substance keeps its chemical composition and proper- ties. Examples of physical changes include freezing, melting, condensation, boiling, evaporation, tearing, and crushing.
    - The rock at Earth's surface forms a nearly continuous shell around Earth called the lithosphere.
    - The dynamic processes that wear away Earth's surface include weathering and erosion.
    - Water circulates through the atmosphere, lithosphere, and hydrosphere in what is known as the water cycle.

NYS Science Standards - MST

-
    - Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.
    - Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Where does the rain go? Worksheet

Directions: *Complete this worksheet while you are in the field with your class.*

1) Observations - Describe and/or sketch the different types of surfaces and ground features you see.	**Predictions (Inferences) -** For each observation describe how or where rainwater might flow over this area, and how the flowing water might carry or drop pollutants and litter in this area.

2) Draw a map of the area you are exploring. Use arrows to show which direction(s) you predict water will flow. Make wide arrows to show places you think the water will flow fastest, and skinny arrows to show where you think the water will flow most slowly. Include labels and text to explain your arrows.

3) Engineering Challenge - Describe what would we have to do in order to make the rainwater flow a different way, right here on the ground in front of us?

4) Results of Pouring Water - Look back at your observations and inferences. Make note of what happened when you poured water on the ground. Any surprises? How accurate were your predictions? What questions do you have now?

Watersheds Part 2 - Paper Watersheds

BOP Curriculum
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Sep 13, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	1	Classroom	

Summary

Students will make a two paper models of watersheds to highlight the way water flows through a watershed.

Objectives

- Identify and understand a ridge from a valley
- Understand and explain how water flows through a watershed
- Observe a topographic map
- Determine where the water flows on a topographic map

Materials and Resources

Supplies

- Paper (photocopy paper works well)
- Tape
- Washable markers
- Spray Bottles
- Water
- Eyedroppers

Before you get started

Tips for Teachers

You need to choose a topographic map for this lesson. Use the website ArcGIS USA Topo Maps. Ideally, choose the topographic map of you Oyster Restoration Station (ORS) site or the location you brought your class for the lessons "Watersheds Day 1 - How does water flow through the watershed?" Take the time to study your topographic map before you give it to your students!! Some parts of the topographic map are harder to read than others, depending on how clearly the contour lines stand out from the street map. You can make your own version by tracing the desired area onto a transparency. That can then be photocopied and/or laid over the ArcGIS map to make the contour lines stand out more clearly. If neither of the above locations have enough of slope to work well for the activity, consider using the topographic map of the Gowanus Canal, because it is an excellent example of a watershed within New York City.

Preparation

N/A

Background

N/A

Instruction Plan

Engage

1. Review vocabulary
2. Review student work from previous lesson, "Watersheds Day 1 - How does water flow through a watershed?"
3. Review "Land Conditions" data collected during previous expeditions to your Oyster Restoration Station (ORS).

Explore

1. In this activity, students make a simple watershed model out of paper and spray water on it.
2. Students get into small groups.
3. Each group gets a piece of paper, marker and tape.
4. Each group crumples up the paper.
5. Students open the paper on the desk so they have a hilly terrain (i.e. a watershed model).
6. Tape the edges of the paper to a solid surface, such a desk. The paper should be taped down so it is relatively flush to the surface.
7. Now introduce the vocabulary, and ask your students to identify what they think are the ridges, valleys, and the largest single watershed on their paper model.
    - Draw the ridgelines (high points) on the model to mark the watershed boundary using *washable* marker.
    -
    - Describe what the watershed model looks like. What features does it include?
    - What features are similar to something you know or have seen outdoors?
    - Sketch your watershed model. Add to your sketch throughout the activity.
    - What do you predict will happen when you spray water on your watershed model?
    - What happened when you sprayed water on your watershed model? Record your observations in words and/or diagrams.
    - Which direction did the water flow? Did it flow quickly, slowly, or some of each? What factors seem to influence the speed and direction of the water flow?
    - Where did the water collect? Did it collect all in one place, or in multiple places? Explain why you think it collected where it did.

Explain

1. In this activity, will learn/review the basics of a topographic map.
2. Each student gets a topographic map. (The example below is the Gowanus Canal)

Screen Shot 2016-09-13 at 12.04.55 AM.png

1. Explain or review topographic maps, contours and elevations.
2. Note: Consider showing an image like the one below to illustrate how a topographic map represents a 3-dimensional landscape.

    image019.png

    1. Note: Consider taking the time to supplement this activity with a lesson about constructing a 3D model of a topographic map.
    2. Draw the ridgeline on the topographic map. (Students may need more help with this step if the concept of topographic maps is new to them. Start by looking at the highest contour lines adjacent to the water body.)

Elaborate

1. In this activity, students will turn their flat, topographic map into a 3D watershed.
2. Carefully pinch and fold the map, so the ridgelines are the highest point and the Gowanus Canal and the Harbor are the lowest points.

3. Tape the edges of the paper to a solid surface, such a desk. The paper should be taped down so it is relatively flush to the surface.

IMG_0088.jpg

Standards

Watersheds Part 3 - Build a Watershed Model

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 15, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	1	Classroom	

Summary

Students will build a model of a watershed using a variety of materials in order to study the effects of runoff.

Objectives

- Observe how water flows over a watershed model with varied surfaces
- Determine the effect pollutants have on the local watershed

Materials and Resources

Supplies

- Large aluminum pan or paint tray
- Several pieces of paper (newspaper or scrap paper)
- Tape
- Aluminum foil, plastic wrap, butcher paper, and/or cloth
  Small model pieces to represent buildings, cars, trees, etc. (optional)
- Pieces of sponges
- Variety of colored powders or dyes (cocoa, fruit drinks, food coloring, etc.)
- Little pieces of plastic wrappers or similar plastic
- Spray Bottle
- Water

Before you get started

Tips for Teachers

You can get slightly different effects on your watershed model depending on which material you choose as the ground surface. The water will run more quickly down aluminum foil or plastic wrap and will absorb more into butcher paper or cloth. In this lesson students make their own watershed models. You can also buy watershed and sewershed models. Watershed models are expensive and bulky to store, but can last many years if well cared for. www.enviroscape.com Both homemade and purchased models work best with students in small groups. Consider having students stand, instead of sit, around the models so they can easily see all aspects of the model. If you use a model as a demo in front of the whole class take extra care to make sure all students can see the model.

Preparation

N/A

Background

N/A

Instruction Plan

Explore

1. Students get into small groups.
2. Each group gets aluminum/paint tray, paper, tape, aluminum foil/plastic wrap, sponge pieces and small model pieces.
3. Crumple several pieces of paper into balls and tape them down in the tray to create the foundation of a hilly topography.

newspaper_pan.jpg

1. Note: Consider mimicking one of the topographic maps you looked at in the previous lesson, “Watersheds Day 2 - Paper Watersheds.”

2. Cover the paper balls with more than one type of surface type (e.g. aluminum foil and cloth) and tape down.

spraying_water_watershed.jpg

1. Place and tape down a couple pieces of sponges throughout the watershed.

2. Tape small model pieces on the watershed if desired.

3. Explore the different parts of the model (e.g. hills, valley, river, estuary).

4. Spray the model with water using the spray bottle and discuss results. Ask students to share their predictions and the results they observed.

5. Name and then place different pollutants (i.e. powders, food coloring and plastics) on the model.

6. Think about which materials could represent which kinds of pollutants (i.e. oil, litter, dog poop, etc.)

7. Spray the now-polluted model with water and discuss results.

8. Use the following discussion questions throughout the activity or in a worksheet.

    - Describe what the watershed model looks like. What features does it include?
    - What features are similar to something you know or have seen in outdoors?
    - Sketch your watershed model. Add to your sketch throughout the activity.
    - What do you predict will happen when you spray water on your watershed model?
    - What happened when you sprayed water on your watershed model? Record your observations in words and/or diagrams.
    - Which direction did the water flow? What factors influence the direction of the water flow?
    - Where was the water absorbed? Explain why it was absorbed there.
    - Where did the water collect? Explain why it collected there.
    - Name some different types of pollutants you might find in the watershed? (Think about what you see on the street outside your school.)
    - What do you predict will happen when you spray water over the pollutants on your watershed model?
    - What happened to the pollutants when you sprayed water over them?
    - What specifically could YOU do to reduce the amount of pollutants in the watershed?
    - What are some larger scale actions that could reduce the amount of pollutants affecting the watershed?
    - What types of interventions could be designed and built that would help prevent pollutants in the watershed from entering the nearest waterbody?

Standards

Watersheds Part 4 - Sewersheds and CSOs

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 15, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
New York's Urban Ecosystem Lessons	6-8th	1	Classroom	Science

Summary

The class creates a model of a sewershed, and in the process reviews the concepts of sewersheds, combined sewers, and combined sewer overflows. CSOs are one of the most significant sources of pollution in New York City's waters.

Objectives

- Understand and explain how water flows through a sewershed
- Brainstorm and design a possible solution for combined sewage overflow during rain events.

Materials and Resources

Supplies

- Yogurt containers - 32oz. (enough to provide one to each small group of students)
- Knife
- Permanent marker
- Aluminum tray
- Small cup
- Large cup
- Coffee filter - large Rubber band
- Glitter

Before you get started

Tips for Teachers

- This model is a too small to build as a full-class demonstration, so we recommend that you let students make their own versions in small groups.
- The Handout: Instructions for making a sewershed model is written to support the full class discussing each stage of the model-making process. If you prefer, you might decide to modify the handout, so that students do most of their discussing within their small groups.
- A great sewershed model is called "Sewer in a Suitcase" and made by the Center for Urban Pedagogy (CUP). http://welcometocup.org/Projects/Workshops/SewerInASuitcase

Preparation

Prep the yogurt containers by carefully cutting two holes with an X-acto knife:

- a dime-sized hole in the bottom-center of the yogurt container
- a second, stamp-sized hole in the side of the yogurt container approximately a half-inch up from the bottom.

Instruction Plan

Engage

1. Students each get the handout Sanitary...Sewer?
2. Once students have completed it as best they can, lead a discussion about their responses.
3. Note: This is a great opportunity to engage in wordplay, a crucial part of vocabulary and literacy development. In particular, it can help students develop the powerful idea that words are related to each other through shared roots, both within English (e.g. sanitary and sanitation) and between languages (particularly important information for ELLs who speak languages related to English)It can also get at the irony of the term "sanitary sewer". (Historically, the name reflects the fact that the sanitary sewer is far cleaner and healthier for city dwellers than no sewer at all!)

Explore

1. Explain: We will now make a model of the most common type of sanitary sewer system in New York City.
2. Students get into pairs or small groups.
3. Pass out materials.
4. Show and explain what to do, and/or use Part I of the handout, Instructions for Making a Sewershed Model.
    - From underneath, wrap the coffee filter over the bottom of the yogurt container, and secure in place with rubber band. Trim the filter, or fold it under the rubber band so that the filter does NOT to cover the hole on the side of the container
    - Fill the small cup with water and mix in glitter.
5. Discuss what the mixture represents. Then write “Sanitary Sewer” on the small cup.
6. Show and explain what to do, and/or students continue on to Part II of the handout: Instructions for Making a Sewershed Model.
    - Hold yogurt container over the aluminum tray.
    - Pour “Sanitary Sewer” effluent into the yogurt container and discuss results.
    - The coffee filter should catch the glitter and the filtered water should pour out the hole in the bottom of the yogurt container.
7. Discuss what each part of the model represents. Then label the yogurt container “Sewershed,” the coffee filter “Sewage Treatment Plant,” and the aluminum tray “New York Harbor.”
8. Discuss your students’ questions. You might also ask things like:
    - What is a sanitary sewer? What does it connect to? What kinds of waste or pollutants might you find in a sanitary sewer?
    - What is a sewage treatment plant? What happens to the sewage there?
    - How could you reduce the pollutants in the sanitary sewer?

Explain

1. Explain: New York City also has a storm sewer system.
2. Now you will incorporate that into the model.
3. Discuss your students’ questions. You might also ask them:
    - What is a storm sewer?
    - What does it connect to?
    - What kinds of waste or pollutants might you find in a storm sewer?
    - How could you reduce the pollutants entering the storm sewer?
4. Show and explain what to do, and/or continue on to Part III of the handout, Instructions for Making a Sewershed Model.
5. Refill the small cup with water and mix in glitter.
6. Fill the large cup with water and mix in glitter.
7. Discuss what the mixtures represent, then write “Storm Sewer” on the large cup. Ask your students:
    - What do you predict will happen when you pour the combined sewer effluent into the sewershed model?
8. Show and explain what to do, and/or continue on to Part IV of the handout, Instructions for Making a Sewershed Model.
9. Quickly pour both the “Sanitary Sewer” and “Storm Sewer”” effluent into the yogurt container (i.e. create a rainstorm) and discuss the results. (The coffee filter should continue to catch some glitter, but some water and glitter should also flow out the hole in the side of the container.)
10. Ask your students:
    - What did happen?
    - What was the result?
    - What role did the hole in the side of the yogurt container play?

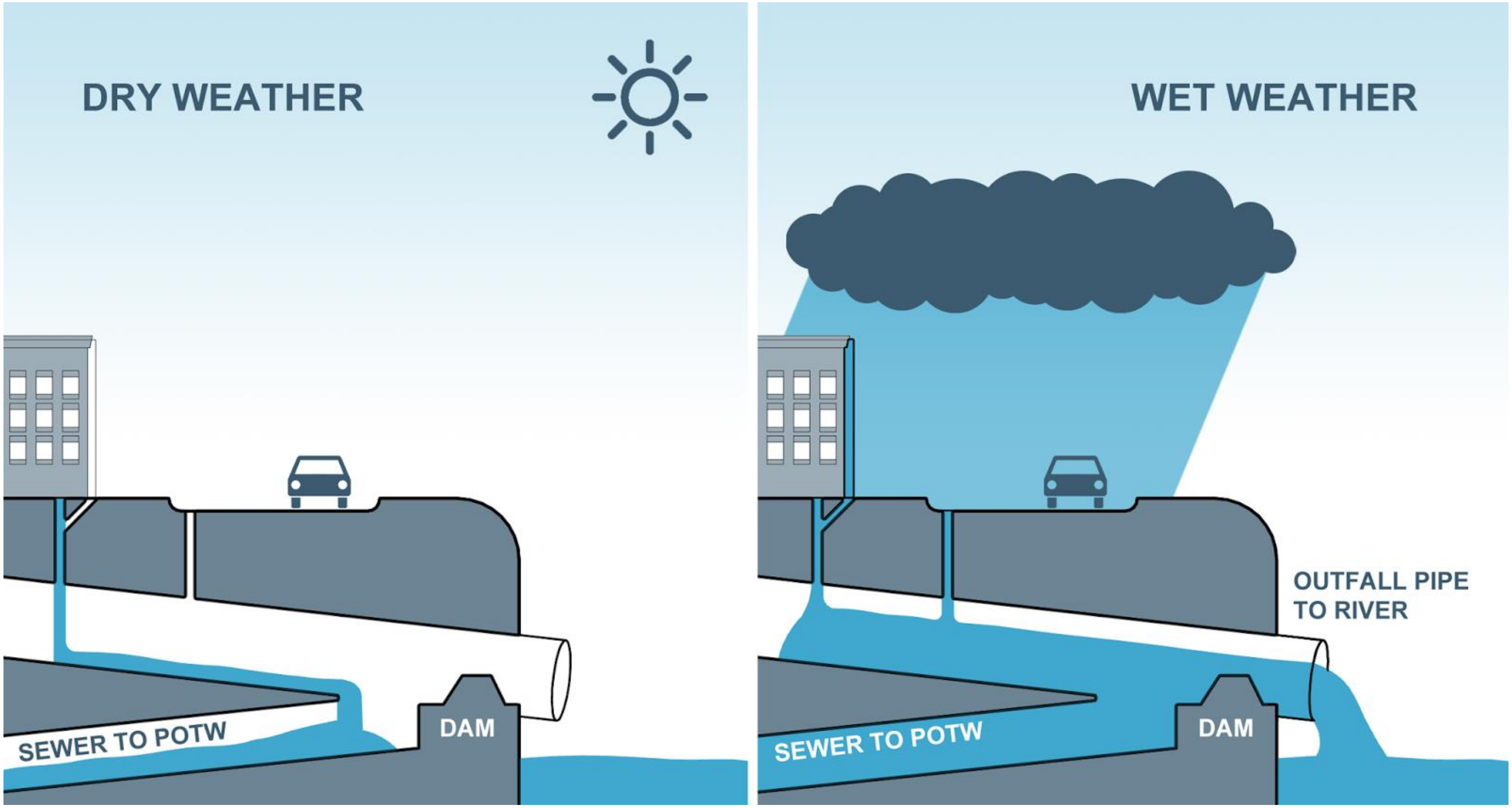
Elaborate

1. Explain: There are different ways to manage the sanitary sewer and the storm sewer. In most of New York City, the two are combined as modeled with our yogurt cups. When combined, the system is called a combined sewer.
2. Discuss what each part of the model represents. Then label the hole in the side of the container “Combined Sewer Outfall (CSO).”
3. Each student gets a CSO Diagram and uses it to compare and contrast with their model.
4. Discuss your students’ questions. You might also ask them things like:
    - What is a combined sewer?
    - What does it connect to?
    - What kinds of waste or pollutants might you find in a combined sewer?
    - What does CSO stand for?
    -

- What might be the pros and cons of combining the sanitary sewer with the storm sewer? Put another way: why on earth would anyone design a sewer system that dumps more poop in the harbor? And why don’t they just separate the two systems now?
- What are some larger scale actions that could reduce the amount of pollutants affecting your local sewershed?

- What types of interventions could be designed and built that would help prevent pollutants from entering New York City's waters?
- Describe the similarities and difference between the watershed and sewershed.

Standards


DRY WEATHER
SEWER TO POTW
DAM
WET WEATHER
OUTFALL PIPE
TO RIVER
SEWER TO POTW
DAM

Instructions for making a sewershed model

Materials

- Yogurt containers that have two holes cut in them: a dime-sized hole in the bottom-center of the yogurt container and a second, stamp-sized hole in the side of the yogurt container approximately a half-inch up from the bottom.
- Permanent marker
- Aluminum tray
- Small cup
- Large cup
- Coffee filter - large
- Rubber band
- Glitter

Part I:

A. From underneath, wrap the coffee filter over the bottom of the yogurt container, and secure in place with rubber band. Trim the filter, or fold it under the rubber band, so that the filter does NOT cover the hole on the side of the container.

B. Fill the small cup with water and mix in some of the glitter.

Then we will stop and discuss what we have so far.

Part II:

A. Hold yogurt container over the aluminum tray, pour “Sanitary Sewer” effluent into the yogurt container.

Stop again to discuss your results with the class.

Part III:

A. Refill the small cup with water and mix in glitter.

B. Fill the large cup with water and mix in glitter.

Pause here so we can discuss what we have so far.

Part IV:

A. Quickly pour both the “Sanitary Sewer” and “Storm Sewer”” effluent into the yogurt container (i.e. create a rainstorm).

Sanitary… sewer?

What does the New York City Department of Sanitation do?

Sanitary napkin -- what is it?

What would you think of, if you heard someone talking about an "unsanitary napkin"?

word that translates as "health"	language
salut	Catalan
santé	French
sante	Haitian Creole
salute	
salutem	Latin
Helse	Norwegian
saúde	Portuguese
sănătate	Romanian
salud	Spanish
hälsa	Swedish

Translations are from Google Translate.

Do you think all the above words for health come from the same roots? Why or why not? Do some of the words seem more closely connected than others?

In English, what do you think the word "<u>sanitary</u>" usually means? (Hint: it's not exactly the same thing as health)

Could it have something to do with <u>health</u>? Always? Sometimes? Never? Can you give an example?

What's a <u>sewer</u>?

What could possibly be the meaning of a "<u>sanitary sewer</u>"? Take your best guess!

What Do Oysters Need in Our Classroom Tank?

BOP Curriculum
bop-curriculum@nyharbor.org
Jan 17, 2017

Unit	Grade	Class Periods	Setting	Subject Areas
Oyster Tank Investigation	6-8th	2	Classroom	Science

Summary

Students observe the classroom tank and start poking around the Oyster Tank Topic Library in order to generate inferences and questions about what oysters need in the classroom tank. Then they identify parameters they can and can't (and sort of can) control for the oysters, and use that process to generate even more questions with a sense of which questions are most urgent. By the end of the lesson, the class has a good starting list of their own questions about what oysters need in the classroom tank.

Objectives

Gather information about what oyster need to survive in a classroom tank.

- Raise questions.

Materials and Resources

Supplies

- Functioning oyster tank
- Package information from all items that you added to your tank (e.g. tank conditioning drops)

Before you get started

Tips for Teachers

- This is a great lesson to use early in the year, around the first ORS (Oyster Restoration Station) visit.
- It's crucial that you hang onto your students' questions. You will definitely need them later, and they are impossible to recreate!

Preparation

You need to set up your classroom oyster tank with your students before doing this lesson.

Instruction Plan

Engage

1. In this activity, one group observes the oyster tanks while the other groups dive into the Oyster Tank Topic Library. Groups rotate until all groups have observed the tank.
2. Explain: Our goal today is to figure out what we need to know in order to take good care of our oysters. We're going to start by observing our oysters and reading about them.
3. Students get into groups of no more than four.
4. Each student gets an Oyster Tank Observation Inference handout and the Oyster Tank Topic Library.
5. One group at a time observes the classroom tank and each student in the group works on the Oyster Tank Observation/Inference handout.
6. Groups that are not observing the classroom tank work to get get familiar with the Oyster Tank Topic Library.
7. Consider wrapping up this activity with a class discussion:

Tank Observation Discussion Questions

- Look at your classroom oyster tank. How are the oysters doing? How could you tell?
- How about the water and any other things living in the tank? Can you observe clues about that?
- What questions do you have about your oysters and their tank?
- Brainstorm a list of as many observations, ideas, and questions as you can.

Topic Library Discussion Questions

- What's in it?
- What strikes you first?
- What different kinds of sources do you find there?
- Which source has the most appealing layout?
- Which source has the most appealing images?
- Which sources seem like they were written for adults, and might take some time to decode?

  Which title is the most confusing?
- Can you tell which sources were written by experts in their field? If so, how can you tell?
- After you've observed the oyster tank and you have some observation and questions - which source would you read first? Why?
- In order to keep your oysters alive, which source would read first? Why?

Explore

1. In this activity, students begin to synthesize what they've learned so far as they've set up their tank, observed it and read about it.
2. Each student gets a What Can We Control? handout.
3. Students complete the handout individually and then share their work with their small groups. Students ask each other questions and offer ideas to one another.
4. Debrief with the whole class to review and check for understanding.   After one or two groups share their ideas, get the discussion going with questions like:
   - What do people think of that list?
   - Do some of you disagree with any items on that list?
   - How is your list different from this group's list?
   - What do you suppose might be the thinking behind this item on this list?

Elaborate

1. In this activity, students take their thinking and learning and raise questions about their oysters and oyster tank.
2. Remind students: Our goal today is to figure out what we need to know in order to take good care of our oysters.
3. Students work in their small groups to compile a list of at least ten questions about their oysters, the oyster tank or how to take care of their oysters. Students refer to the Oyster Tank Observation Inference and What Can We Control? Handouts.
4. Lead a class discussion, solicit questions from the students and write the questions where they can be seen by the whole class.
5. Students should ask each other clarifying questions about their questions.

Evaluate

1. Allow groups a moment to re-word questions that could be clearer, in response to their classmates' confusion. Maybe one question could be rewritten as two different questions.
2. Lead a discussion from these starting points:
   - Which questions seem most urgent – things we have to know right away? Why?

- Which questions seem most exciting – things we are really interested in knowing more about? Why?

3. Title this list, “Student Questions as of (today’s date).”
4. POST IT PROMINENTLY, NEAR THE OYSTER TANK!

Standards

Oyster Tank Observation Inference

Observation • Use your senses. What do you see, hear, smell, taste, feel?	**Inference / Prediction** • What do you think it means? Why do you think it is this way?	**Questions** • What questions does this raise for you?

Notes/Results/Sketch/Questions/Connections

1. Look at your classroom oyster tank. How are the oysters doing? How could you tell?

2. How about the water and any other things living in the tank? Can you observe clues about that?

3. What questions do you have about your oysters and their tank?

4. Brainstorm a list of as many observations, ideas, and questions as you can.

Oyster Tank Topic Library

Consider as you read:
When you set up an oyster tank, should you try to imitate the conditions in the estuary?

1) Oyster Recovery Partnership “Kids Zone” -- a few good sentences about how oysters live.

2) Ecosystem stressors to oysters -- a diagram that shows some problems oysters can have.

3) Crunchy on the Outside, Soft and Squishy on the Inside -- about oyster shells and oyster predators.

4) Brackish aquarium setup -- one person’s opinion about setting up a brackish tank.

5) Creating A Brackish Habitat Fish Aquarium -- a second person’s opinion about setting up a brackish tank.

6) Estuarine Aquarium Keeping for Beginners -- a third person’s opinion about setting up a brackish tank.

7) Creating Oyster Habitat- What Makes a Good Site? -- about setting up oyster reefs in an estuary.

8) Environmental factors affecting oyster populations -- a list of things that affect oysters in an estuary.

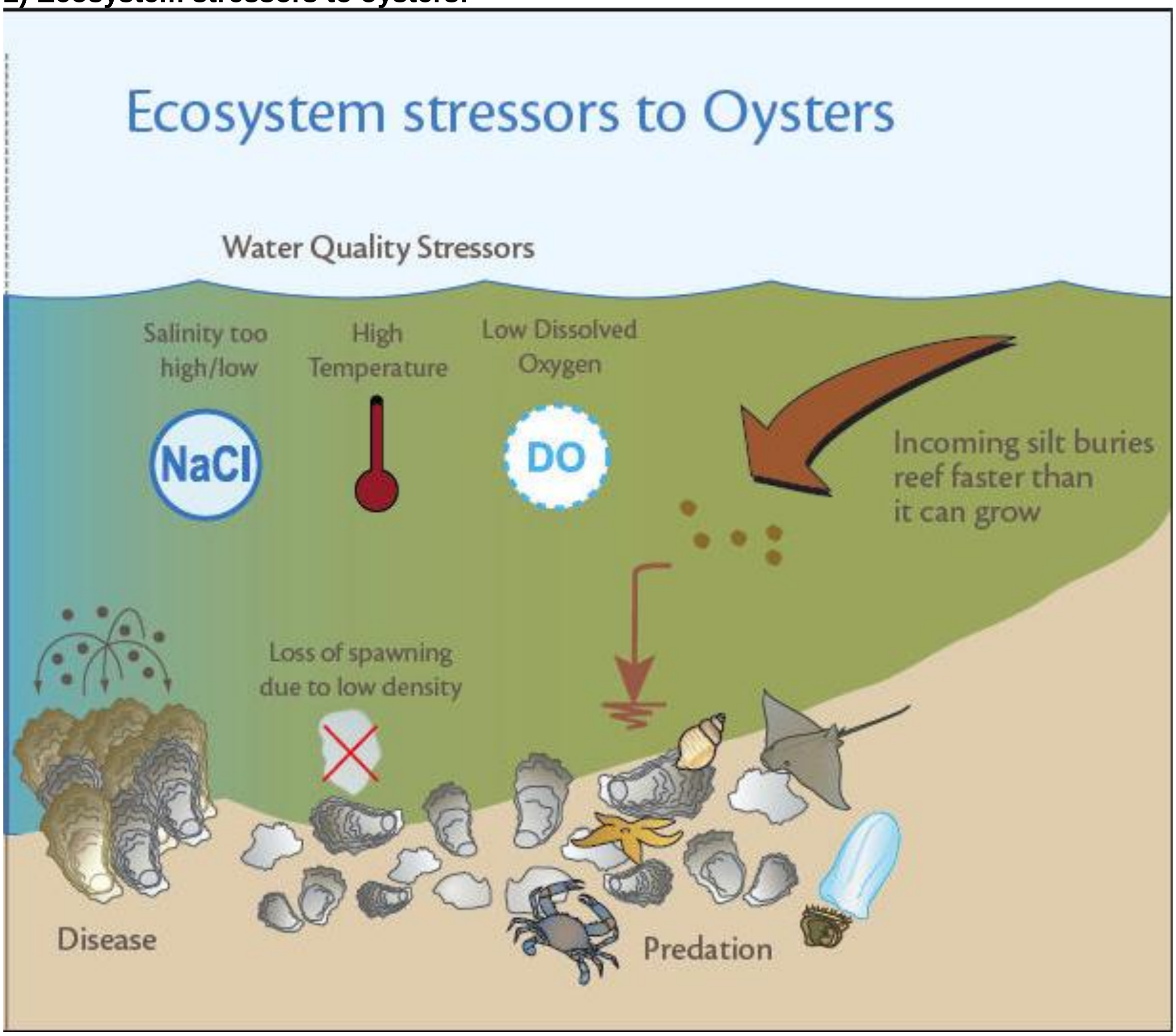
9) Problems with low dissolved oxygen in the East River -- some of the specific pros and cons of life in the East River, especially for oysters.

10) NY/NJ Harbor Estuary Map from Stevens Institute of Technology shows parameters like surface and bottom salinity, surface currents, surface air temperature, etc. -- You’ll need to access the internet for this. Once you figure out how to use this website, you can find a ton of information about your ORS site! You can find data from different times, and from different places around the city.

1) Oyster Recovery Partnership "Kids Zone"
"Oysters are pretty cool creatures. They live most of their lives in a shell at the bottom of rivers or bays….Oysters eat by sucking water through their bodies, pulling out the nutrients they need to grow."

From Oyster Recovery Partnership: http://oysterrecovery.org/oysters-101/kids-corner/

2) Ecosystem stressors to oysters:



https://chesapeakebay.noaa.gov/oysters/oyster-reefs

3) Crunchy on the Outside, Soft and Squishy on the Inside
"Oyster predators can easily locate oyster prey and since oysters are not mobile. Once found, they have no means for escape. However, the oyster's thick shell presents a significant deterrent to oyster predators as they must first penetrate the shell before consuming the tissue.

Successful oyster predators possess specialized adaptations that help them crush, drill, or open the shell exposing the meat within. Common oyster predators include snails, crabs, starfish, flatworms, and fish (such as cownose rays, oyster toadfish, flounder, drumfish)."

From Project Ports Guide 3: https://www.billionoysterproject.org/wp-content/uploads/2013/06/curriculum_guide_3-1.pdf

4) Brackish Aquarium Setup
"Brackish water is somewhere between "pure" freshwater and "high salinity" ocean water....

Brackish species are very adaptable.... As long as waste products (ammonia, nitrite, and nitrate) are at safe levels, the animals will do fine, even if there is a gradual change in pH, hardness, or salinity. Because these animals naturally live in an environment where water parameters may change from one spot to the next, a super-stable environment is not quite as important for brackish species."

From Fishlore.com http://www.fishlore.com/aquariummagazine/feb08/brackish-fish-tank-setup.htm

5) Creating A Brackish Habitat Fish Aquarium
What is "Brackish?"

It's not quite saltwater, but it's definitely not freshwater. Brackish waters occur all over the world where inland freshwater streams and springs meet the ocean, creating estuaries. The lower part of the Hudson River that separates New York and New Jersey, for example, is a giant brackish estuary….

The Salinity of Brackish Water
The world's marine waters have a salinity between 32 and 35 parts per thousand. Brackish water, by definition, must be lower than that...

Calculating the salinity of water is done by measuring specific gravity (SG) with a hydrometer….For practical purposes, brackish aquarium water should range between 1.002 to 1.022 SG at a temperature of 77 degrees Fahrenheit. Most brackish aquarium animals can tolerate this range. A 50/50 mix of fresh and marine water would provide a salinity of 1.012 SG – a happy medium for a general brackish aquarium...

If you want to provide the best care for your brackish animals, however, I recommend matching the salinity level to the type of brackish habitat you are trying to re-create or the type of brackish animals you want to maintain."

From Petcha.com: http://www.petcha.com/creating-a-brackish-habitat-fish-aquarium/

6) Estuarine Aquarium Keeping for Beginners

"Temperature

and this can 4 be a *major* factor in regards to which species will thrive. Water temperatures can easily climb into the 80 degrees Fahrenheit in a school hallway, or during the weekend if they turn the air conditioning off...

Ammonia becomes more toxic with higher aquarium temperatures and the nitrifying bacteria that comprise the biological filter will likely die if water temperatures rise above 95 degrees F.

You do not have to be concerned about cold-water periods. As the water temperature in your aquarium decreases, the critters will simply slow down and may stop eating entirely. It should not be a problem if your water temps decrease to 50°F, or even colder during school vacations."

"Oxygen

….Water can hold less dissolved oxygen (DO) as it gets warmer and saltier. Estuarine water usually holds between 5 and 8 parts per million (ppm) oxygen...Fish will begin to get stressed in DO levels of 3 and 5 ppm and will get very stressed in water below 3 ppm. All tanks should have several sources of oxygen…

Animals use more oxygen when they are active and also after eating, while they digest food. Active animals (such as fish that don't stop swimming around the tank) use more oxygen than more sedentary species. Animal metabolisms increase with rising water temperatures, so animals also use more oxygen as the temperature increases. It is important to remember that the bacteria in the biological filter… also use oxygen.

Dead animals and uneaten food left in the tank are decomposed by huge numbers of bacteria, which use oxygen. These bacteria can cause the oxygen in your tank to decrease to a harmful level for your animals. Therefore you should not have uneaten food or dead animals present in your aquarium."

"Tank Size

The volume of water in the tank, the surface area of the water/air interface and the surface area of the substrate are all very important.... Most estuarine animals stay close to the bottom of the tank, so you should try to maximize the bottom surface area of an estuarine aquarium. For instance it is better to purchase a 20-gallon long aquarium instead of a 20-gallon tall model. The long model has more bottom surface area than the 20-gallon tall aquarium model. The surface area of a tank is important in gas exchange (namely oxygen)...

The surface area of the substrate, or bottom of the tank, is also very important. Bacteria grow on the surface of aquarium substrate. These bacteria are part of the biological filter.... A larger bottom area will give you more substrate surface area for the bacteria to grow, which increases your biological filter. This is a good thing. Crushed coral and gravel have a lot more surface area for bacteria growth than sand, because sand is made of such small grains that they pack closely together, leaving few nooks and crannies."

"Aging The Aquarium or Cycling the Biological Filter

One of the most critical steps in starting up an aquarium is giving the aquarium enough time for the biological filter bacteria population to build up or "cycle." Animals excrete ammonia waste (NH3), which is toxic. Animal feces, uneaten food and dead animals will also add ammonia during decomposition. This ammonia will build up unless you frequently change a lot of water (impractical), or your biological filter converts it first to nitrite (also toxic) and then to nitrate (not toxic) through the nitrogen cycle. It takes time for your nitrifying bacteria population to build up, and this process is called aging or cycling. The nitrobacter and nitrosomonas bacteria, which do

this important job, are found in all aquatic environments, and they are in the river or bay water that you fill your tank with."

From the Chesapeake Bay National Estuarine Research Reserve in Virginia. http://www.vims.edu/cbnerr/_docs/education_docs/EstAquKeepwriteup.pdf

7) Creating Oyster Habitat- What Makes a Good Site?
By Don Meritt, Sea Grant Shellfish Specialist

….This article will address some of the basic issues that need to be considered in choosing sites for oyster restoration.

Salinity
Perhaps the most important factor for oysters is salinity. Oysters can survive in salinities from under 5 ppt to full strength ocean water and more (ocean water is around 35 ppt). These low or high salinity levels can cause of physiological stress. Unless your site is in a fresh water or ocean region, salinity will vary from season to season and year to year... A good indicator of a site's suitability is live oysters nearby….

Dissolved Oxygen
It's important that oysters have enough oxygen. The absence of oxygen, or anoxia, can especially occur in summer months when bacteria… use up dissolved oxygen in the water. Winds, currents and plant activity (photosynthesis) as well as direct transfer from the air to the water all contribute to adding oxygen to the water. Locating oyster reefs in areas with good circulation, where the water is well mixed from top to bottom, should help….

Disease
Oysters in many prime growing regions are under attack by… MSX disease… and Dermo disease (but these oyster diseases do not harm people). The microorganisms that infect oysters are also influenced by salinity. MSX is only found in areas where salinities are moderately high, above 14 to 16 ppt. Dermo disease is better able to survive in lower salinity waters.

Predation
While the oyster is wonderfully adapted for thriving in a wide range of conditions, it is still vulnerable to attack by predators such as oyster drills, boring sponges, and blue crabs. Consider predators and parasites that may invade the oyster reef you are planning to construct. In other words, try to locate reefs at sites where predatory organisms are less common.

Bottom Characteristics
Oysters grow best on hard substrates. Think of an oyster reef as the foundation of a house: no one would build a house directly on top of mud – it would sink until it encountered a bottom solid enough to hold up the rest of the structure. The foundation of a reef must be strong enough to keep the oysters from sinking into the ground and strong enough to withstand storms and other forces – particularly waves and heavy current surges – that could tear it apart.

Heavy wave action, for example, can actually lift oysters and shells and transport them to locations far from where they were originally placed. This is especially true in shallow water areas. Any reefs in water less than six to twelve feet deep should not be located in areas where severe winds will cause heavy wave action. Even if the force of the waves does not move the oysters, it may stir up sediments, and that could bury the oysters. Exposure to runoff that carries toxic substances should also be avoided.
From Maryland Aquafarmer Spring 2001

8) Environmental Factors Affecting Oyster Populations
The list below is the table of contents from a chapter entitled, "Environmental Factors Affecting Oyster Populations" from a 1964 scientific publication from NOAA about the American oyster.

As you read the list, what do you recognize? What would you like to know more about?

A couple fun terms:

- Gastropods are snails. Gastro = gut, and pod = foot. Does it make sense to you somehow that "gut-foot" = snail?

- Commensals are different species that live together. One of the species benefits from the relationship, and the other species is unaffacted. "Com" = sharing, and "mensal" = a table. Does it make sense to you somehow that "sharing-a-table" = commensal?

Excerpted from "The American Oyster, *Crassostrea virginica* Gmelin," from the NOAA Northeast Fisheries Science Center's (NEFSC) "Classic Publications" page, which includes NEFSC literature "from pre-computer days." The excerpt is here.

9) Problems with low dissolved oxygen in the East River:

Although the East River's water quality has steadily improved, it still has problems with eutrophication, turbidity, and low levels of dissolved oxygen. As suspension filter feeders, oysters have a great capacity for water filtration. On a per-area basis, oyster reefs are estimated to remove 25 times more nitrogen than salt marshes do (Waldman 1999). Oysters remove phytoplankton, particulate organic carbon, sediments, pollutants, and microorganisms from the water and they use most of the organic matter that they filter (Tolley et al.).

Oysters are generally hardy creatures (Waldman 1999) but... their development and mortality are influenced by salinity, current velocity, and dissolved oxygen levels. Oysters generally tolerate salinity levels between 15-25 ppt….Current velocity can affect oyster growth because currents bring food and oxygenated water to the reefs (Brumbaugh et al. 2006).

Generally, dissolved oxygen levels should consistently be above 5.0 mg/l or above. In its current state, the Lower East River barely meets this requirement during the summer and the Upper East River has dipped below this threshold (NYCDEP 2004); this affects the timing and location of oyster restoration.

Adapted from: http://www.columbia.edu/itc/cerc/danoff-burg/RestoringNYC/RestoringNYC_EastRiver.html

10) NY/NJ Harbor Estuary Map from Stevens Institute of Technology shows parameters like surface and bottom salinity, surface currents, surface air temperature, etc. Via: http://hudson.dl.stevens-tech.edu/maritimeforecast/maincontrol.shtml

What Can We Control?

Hint: *If you're having trouble getting started on the questions below, draw a diagram of our oyster tank and the different things we put into it when we set it up.*

1. What are the easiest things to control in our oyster tank? (You should check your notes from the day we set up the tank to help you remember a few details.)

2. What are the things we can influence but not completely control? (This one is tricky; see what you can come up with!)

3. What are the things that we can’t influence or control?

4. Do you think some of these things might be a problem for our oysters? If so, which ones, and why?

What is Density?

BOP Curriculum
bop-curriculum@nyharbor.org
Sep 8, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	3	Classroom	Math

Summary

Students will compare various substances and discuss the difference between mass and volume. This will lead them to a discussion of density. The class will then jigsaw and each group will find the density of one substance. Then, the teacher will do a demo in which she creates a density column, and the class can see how liquids of different densities behave.

Objectives

- What is density?
- How can the same 'amount' (volume) of a substance feel heavier?

Materials and Resources

Supplies

- 1 large graduated cylinder (100 mL) (for the class)
- 5 10 mL graduated cylinder
- ethanol dishwashing detergent (any brand, but should be colored, e.g. Dawn lemon)
- Dark corn syrup
- vegetable oil
- water
- 4 50 mL cylinders, two full of molasses and two full of alcohol (enough for the whole class to pass around, so you might want to make 3 of each)

Before you get started

Tips for Teachers

Note for vocabulary: It is worth discussing with your students the difference between precise scientific terms and imprecise vernacular terms when discussing quantity. In particular contexts, think about: what do you mean when you say "amount" or "quantity"? Are you actually thinking of number? Volume? Mass? Something else? This lesson is structured as a jigsaw. Each group will compute the density of one substance and then the teacher will create the density column for the whole class. The reason for this is that it is very difficult for students to create a density column. If you get any materials on the side of the cylinder, the column will not look good. Make sure to practice the density column in advance. It helps to use a funnel to pour the substances in. Make sure the water is colored so that you can see that it is a different substance. For example, if your dish detergent is yellow, use blue for the water. In this lesson, we use the ideas of weight and mass interchangeably. Make sure students are clear on the difference before plunging in.

Preparation

N/A

Background

This lab introduces them to the idea that certain substances are denser than others. Density is a characteristic property of a substance. The density of a substance is the relationship between the mass of the substance and how much space it takes up (volume). The mass of atoms, their size, and how they are arranged determine the density of a substance. The concept of density is essential to understanding how oysters filter. This lesson introduces density.

Instruction Plan

Engage

Pass out graduated cylinders that hold 50 mL of molasses and 50 mL of alcohol. The graduated cylinders must be the same size. First, ask what they know about molasses and alcohol? Ask if they're each some kind of water and/or contain water?

Now, Ask students to make observations about the two liquids.

Explore

Divide your class into five groups. Give each group 10 mL of one of the following substances and a scale.

1. ethanol
2. dishwashing detergent
3. dark corn syrup
4. vegetable oil
5. Water (colored blue)

Make sure to write the mass of the graduated cylinder on the board so that the students can subtract that from their total mass.

Explain

Introduce the formula for density. Explain that density is mass over volume (or how “heavy” something is divided by the space it takes up. In other words, how compact a substance is). This is a good time to give different examples of the uses of "amount" "more" and "less". Ask students how two objects that are more dense and less dense would feel. What is the difference?

Also, be sure to distinguish between volume and mass/weight!

Use the density calculation handout to have each group find the density of their substance.

Elaborate

Before beginning this section, have a discussion with students. Ask them to describe things that they think are very dense, and things they think are very rarified (opposite of dense). Then they can make hypotheses about the given substances. Write the name of every substance on the board. Ask for student hypotheses about the density rankings. Once students have proposed different hypotheses and explained their thought processes, rank the substances by the actual densities calculated by the students. Then, collect the samples and pour them into a large graduated cylinder with the most dense on the bottom (see picture on the next page). Now have a discussion about what they see, how it compares to their prediction, and what new insights and questions have come up.

Standards

CCLS - ELA Science & Technical Subjects

- - Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

CCLS - Mathematics

- -

- Patterns
  - Graphs, charts, and images can be used to identify patterns in data.
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
  - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

NGSS - Disciplinary Core Ideas

- PS1.A: Structure and Properties of Matter
  - Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

NGSS - Science and Engineering Practices

- Analyzing and Interpreting Data
  - Analyze and interpret data to provide evidence for phenomena.
- Constructing Explanations and Designing Solutions
  - Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.

NYC Science Scope & Sequence - Units

- Grade 7, Unit 2
  - Energy and Matter

NYS Science Standards - Key Ideas

- PS Key Idea 3
  - Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity

NYS Science Standards - Major Understandings

- - Substances have characteristic properties. Some of these properties include color, odor, phase at room temperature, density, solubility, heat and electrical conductivity, hardness, and boiling and freezing points.
  - Density can be described as the amount of matter that is in a given amount of space. If two objects have equal volume, but one has more mass, the one with more mass is denser.

NYS Science Standards - MST

- - Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.
  - Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.
  - Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science

1)What substance do you have?

____

2) What is its mass?

____

3) How much does the graduated cylinder weigh?_______________________

Total mass - Graduated Cylinder mass = mass of Substance

_________ - _______________________ = ________________

4) What is the volume of your substance?

____

Mass ÷ Volume = Density

_____ ÷ _______ = _____

5) Compare the 5 substances that your class is exploring. Make a hypothesis. Which do you think will be the most dense and which do you think will be the least dense? Rank the substances from most dense (1) to least dense (5)

_____ethanol
_____dishwashing detergent
_____dark corn syrup

_____water

In the table below, make as many observations about each liquid as you can. What words can you use to describe each substance?

Molasses	Alcohol

What is Paerdegat Basin Designed For?

BOP Curriculum
bop-curriculum@nyharbor.org
May 9, 2018

Unit	Grade	Class Periods	Setting	Subject Areas
What's Your Stake in Paerdegat Basin?	6-8th	2-5	Classroom	Science Social Studies

Summary

Students use several maps to begin their research on people's relationships with the land- and water-forms around Paerdegat Basin (and the creek that used to exist where the basin is now). Based on the evidence they collect, they develop a provisional answer to the question: what is Paerdegat Basin designed for?

Objectives

- recognize major local geographic features on maps: Jamaica Bay, Canarsie, Paerdegat Basin, Fresh Creek.
- use 'warp' and 'transparency' functions on NYPL digital maps to compare past and present maps.
- think critically about the land and water forms around them, alert to the possibilities of past and present human interventions.
- close-read a map as a primary source, considering its author/cartographer, audience, and purpose.

Materials and Resources

Supplies

- Each student needs a computer with internet access
-
- Tracing paper (optional)

Before you get started

Preparation

- Consult Lesson Library of Maps of Paerdegat Basin, to learn about the maps and choose which ones you want to use with your students.
- If you like, examine Extended Library of Maps of Paerdegat Basin. It provides a dozen or so additional geographic images of Canarsie and Paerdegat Basin. Depending on the questions your students come up with, you might choose to introduce some of this material for them to continue their research.

Background

Paerdegat 'Basin', a human invention, was built around the mouth of Paerdegat Creek (aka Bedford Creek), which once originated at a freshwater spring that was near today's Newkirk Avenue 2/5 subway station. For years, the Town of Flatbush got its drinking water from a water works at that spring. In the period under study in this lesson, 1890-the present, real estate developers and city planners transformed this creek and its surrounding marshlands into the paved, sewered, linear and angular landscape and waterscape we recognize today.

Since the 1990s, environmental regulators, local residents and their civic associations and politicians, and nonprofits like Sebago Canoe Club and Billion Oyster Project have proposed, debated, and in some cases enacted changes to Paerdegat Basin and the way people can use it.

The change continues to this day, as, for example, you and your students help steward the oyster reef at Sebago Canoe Club, and as sea level rise changes the boundaries between land and water.

By witnessing some key moments in this story of change via maps, and by close-reading historical and contemporary maps of the area, students can begin to develop informed answers to the question: what is Paerdegat Basin designed for?

Especially in concert with other lessons from the unit, your students' inquiry-driven research can help them identify their personal stake in Paerdegat Basin.

In chronological order, the maps in this lesson are:

1. Robinson's 1890 Map of King's County, which New York Public Library has digitally 'warped' (overlaid) onto a contemporary map.

2. one of two Plans for a Jamaica Bay Port (see Lesson Library of Paerdegat Basin Maps for more on the two versions).
   Some powerful New Yorkers pushed this plan from about 1905 through the 1930s, and then gave up on the idea.

3. Parkway Map from 1938
   Robert Moses built the Belt Parkway, which traverses Paerdegat Basin. In the process, he also changed land use surrounding the highway.

4. Sewershed Map from the 2006 Paerdegat Basin Combined Sewer Oveflow (CSO) Long-Term Control Plan, published by NYC Department of Environmental Protection, shows which parts of Brooklyn direct raw sewage toward Paerdegat Basin.
   Much of this raw sewage can go straight into the basin, untreated, whenever rain overwhelms the area's combined sewer system. That happens much less often since 2014, when DEP started operating a 50 million-gallon holding tank to store the sewage until the rain stops, . In dry weather, the Owl's Head and Coney Island sewage treatment plants can then receive and treat it the stored sewage.

5. Riparian Improvements Map from the 2006 Paerdegat Basin Combined Sewer Oveflow (CSO) Long-Term Control Plan shows DEP's plans for Paerdegat Basin Park. The park runs along the two long sides of the basin.
   The land at the head of the basin is not parkland. It consists of a DEP facility, most of which consists of that holding tank, and a Department of Transportation (DOT) facility. According to city planning records from 1997, DOT was supposed to move that facility and leave that stretch of waterfront for parks. So far none of that has happened.

6. Satellite Image of Paerdegat Basin from June 2018 (or the latest Google Satellite image, but you won't know the date of the image, and it may be older than June 2018).

7. Sea Level Rise Viewer from National Oceanic and Atmospheric Administration (NOAA).

Instruction Plan

Engage

1. Project the 1890 Robinson's Map of King's County warp view, and set the transparency at 0. (This makes the 1890 map completely transparent, so you are looking at the contemporary map behind it.) Choose a view that you think your students can recognize. Ask: "What do you recognize on this map?"

2. Zoom in on Paerdegat Basin. Once students are oriented, ask: "What do you think this place looked like in 1890?"

3. Introduce the 1890 map by raising the transparency setting to 100. (This makes the 1890 map completely opaque, so you can't see the contemporary map behind it.) Play with the transparency so that students can understand that they are seeing an old map overlaid onto a contemporary map. Ask: "According to these two maps, what are some of the things that have changed since 1890? What are some of the things that have stayed the same?"
   - Solicit observations, inferences, and questions.
   - Distribute one copy of Observation / Inference / Questions for Maps to each student.
   - Students write down their initial notes.

4. Distribute Key to Robinson's 1890 Map of King's County and Title Page from Robinson's 1890 Atlas of King's County
   - Discuss the Key and Title Page.
   - Students write additional notes.

Explore

Provide digital access to the maps you have chosen for your class from Lesson Library of Maps of Paerdegat Basin. Students manipulate the 1890 Robinson map in warp view, and complete their note-taking on it.

Explain

Students first write their responses, and then discuss as a class:

- Based on the evidence you have gathered so far, what do you think Paerdegat Basin was designed for? What is your evidence?
- What additional information would you need, in order to better answer the question?

- {for students who write more quickly, while others are still answering the other questions} Does it seem accurate to say that Paerdegat Basin was or is 'designed'? Why or why not? What's your evidence? It's an unusual way to describe a body of water connected to the ocean.

Elaborate

Introduce other maps you have chosen from Lesson Library of Maps of Paerdegat Basin, and distribute a copy of Observation / Inference / Questions for Maps to each student for each map. Students continue their note-taking in search of better answers to the question: what is Paerdegat Basin designed for?

Evaluate

Based on the new evidence they have collected, students revise their written responses, and then discuss as a class:

- Based on the evidence you have gathered so far, what do you think Paerdegat Basin was designed for? What is your evidence?
- What additional information would you need, in order to better answer the question?
- {for students who write more quickly, while others are still answering the other questions} Who do you think designed Paerdegat Basin? What's your evidence? Where could you look for more evidence?

Extend

1. Students choose two of the maps from the lesson, and compare and contrast the purposes of the different map-makers.
    - What information about the map-maker's purpose is available on the map or with the map?
    - What can you infer by examining what is emphasized in and what is left out of each map?
2. Another extension (could be homework): using tracing paper and today's map, students create a plan that shows something they wish existed, but doesn't. Everything else on the plan should be accurately traced.

Standards

CCLS - ELA Science & Technical Subjects

-
    - Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
    - Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

NGSS - Cross-Cutting Concepts

- Influence of Engineering, Technology, and Science on Society and the Natural World
    - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

NGSS - Disciplinary Core Ideas

- ESS3.C: Human Impacts on Earth Systems
    - Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

NGSS - Science and Engineering Practices

- Obtaining, Evaluating, and Communicating Information
    - Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.

NYC Science Scope & Sequence - Units

- Grade 8, Unit 4
    - Humans and the Environment: Needs and Tradeoffs

NYS Science Standards - Key Ideas

- LE Key Idea 7
    - Human decisions and activities have had a profound impact on the physical and living environment

NYS Science Standards - Major Understandings

-
    - Overpopulation by any species impacts the environment due to the increased use of resources. Human activities can bring about environmental degradation through resource acquisition, urban growth, land-use decisions, waste disposal, etc.

- Since the Industrial Revolution, human activities have resulted in major pollution of air, water, and soil. Pollution has cumulative ecological effects such as acid rain, global warming, or ozone depletion. The survival of living things on our planet depends on the conservation and protection of Earth’s resources.

NYS Science Standards - MST

- - Students will access, generate, process, and transfer information using appropriate technologies.

Where is my Oyster Research Station Site?

BOP Curriculum
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Sep 16, 2016

Unit	Grade	Class Periods	Setting	Subject Areas
Oysters & Organisms Lessons	6-8th	1	Classroom	

Summary

Students will study a variety of maps and other resources so that they may begin to understand the features of their Oyster Restoration Station (ORS) site.

Objectives

- Locate their ORS site relative to their school location
-
- Ask at least three question about the ORS site

Materials and Resources

Supplies

Choose from "Where is my ORS Site?" Library of Resources

Before you get started

Tips for Teachers

There are a lot of resources available for this lesson. It is important for you to take the time to familiarize yourself with the history and current conditions of your ORS site, so that you may choose what resources will be most valuable for your students. The more you left students discover facts about their sight, the better. Resist the impulse to tell them the "answers." The books would need to be purchased and relevant sections photocopied in advance of the lesson.

Instruction Plan

Engage

1. Give students a map that includes both your school and the ORS site on it.
2. Don't just tell students where the ORS site is!
3. Give landmarks, coordinates or some sort of scavenger hunt, so that students have to look carefully at a few elements of the map in order to find the ORS site.
4. Students put an "x" on the site.
5. Go through the same process for finding the school.
6. Discuss with the students how you will be getting from the school to the ORS site. You might want to tell them, or you might want them to figure it out. Pass out a subway or other map if needed to describe the route.
7. Tell students the date of their first trip to the ORS.

Explore

1. Students get into small groups.

2. Each group is provided with resources from the *"Where is my ORS Site?" Library of Resources*.
3. At this point, give a pep talk. Remind students that this is a lot of information to digest and that they should look at it one piece at a time and not worry about covering it all.
4. The resources can be presented in several different ways:
    - Give each group the same set of resources.
    - Give each group a somewhat different or completely different set of resources.
    - Have many resources (with multiple copies) available around the classroom and allow students to choose resources.
    - Some combination of the above suggestions.
5. Each student gets a *Source-Quotation-Response Worksheet.* Students may need multiple of these worksheets, depending on how many resources they are looking at.
6. Students make observations based on the resources provided and come up with inferences about the state of their ORS site (either on land or in the water).

Elaborate

1. Each group shares out 1-2 observations and inferences.
2. Record these where the whole class can see.
3. Offer some probing questions, so students don't stop at their first thought. For example:
    - How can we paint a fuller picture of what our ORS site looks like, with this list of observations?
    - Are there any observations up here that are related to each other?
    - Which of these observations surprise you?
    - Listed on the board are only some of your observations. Let's hear a different observation that either adds to or contradicts one of the observations on the board.
    - Has anyone been to this site before? What do you know about the site from your experience?
4. Students write a paragraph summarizing what they've learned about their ORS site thus far.
5. Students generate a list of questions they still have about their ORS site.

Evaluate

1. Each group looks over the list of questions from the group and chooses one they want to try to answer during their first ORS expedition.
2. Post all the students' questions in the room.
3. After the students return from the first ORS expedition, they revisit the one questions their group chose and take the time to answer it.

Standards

Source-Quotation-Response Worksheet

Source • What source are you using? Why did you choose it? What is useful about it? What's not so useful?	**Quotation** (Objective) • Quote or paraphrase from your source. What words do you read? What images do you see?	**Response** (Subjective) • What do you think it means? Why do you think it is this way? What questions does it raise?

Notes/Results/Sketch/Follow-up Questions/Connections

Will Our Oysters Do Better in the Classroom Tank or the ORS?

BOP Curriculum

Science

Summary

Students review the BOP ORS Field Manual and the Oyster Tank Guide, and use that information to make predictions about how their oysters will fare in the tank vs. in the ORS (Oyster Research Station). Predictions are powerful motivators, because students often want to find out if they were right!

Objectives

- Consider similarities and differences between tank ecosystem and harbor ecosystem.
- Predict that their oysters will 'do better' in the classroom tank or the ORS.
- Consider how to establish that one group of oysters is 'doing better' than another.

Materials and Resources

Supplies

- It's helpful to have available all the equipment you use at your ORS.
- It's also helpful to have your oyster tank, and all the bottles of things that go into it.

Before you get started

Tips for Teachers

It's crucial that you hang onto your students' predictions. You will definitely want them later, and they are impossible to recreate!

Preparation

- Ideally, provide your own typed-up notes of curiosity, excitement or interest from the students' field expedition and the students' experience setting up their classroom tank, perhaps with photographs.
- If possible, list quotes of particular things students said on the above days.

Instruction Plan

Engage

1. Explain: We've been talking about what we can and cannot control in the classroom. Now let's think about how the tank compares to the ORS in the harbor.
2. Debrief with the class, to make sure people remember most of the key things that oysters need.
    - You might ask your students: When we talk about "things oysters need" what are the things we do for the oysters' health vs. what are the things we do mainly because we want to have information about the oysters and their environment?
3. Ask your students: Is there anything we do to "take care of" our oysters in the ORS?
4. If students get stuck on yes/no answer follow us with further questions: What happens to cages that are abandoned?
    - Would they grow at all without us?
    - Would they do better without us?
    - Would this be true for the tank?
    - Why do you have to take care of the tank in ways you can't even take care of the ORS?

- Is the goal of the tank to replicate the ORS exactly or as closely as possible or is it to do something a little different?

Explore

1. Each student gets a Will Our Oyster do Better in the Classroom Tank or in the ORS? handout.
2. Students complete first section individually.
3. Think about life from the oyster's point of view. Imagine you are living inside one of those shells, filtering the water and going about your business. What are all the similarities and differences you can think of for the oysters between life in the tank and life in the ORS?

Elaborate

1. Distribute the following handouts:
   - BOP ORS Field Manual
   - Oyster Tank Guide
   - Typed-up teacher notes (see "Preparation" above)
2. Students will work with these handouts before tackling the second page of Will Our Oyster do Better in the Classroom Tank or in the ORS?
3. Explain: Give your students a pep-talk about using these long documents!
   - They've got this. It's just describing things they've done before with their own hands!
   -
   - How will you be able to tell?
   - What data will you need to take in order to convince other people that your conclusion is accurate?
2. Post the classroom tally, possibly with students' names. Later in the year, you'll want to check back and remember what people are predicting now.
3. If there is any disagreement about where the oyster will do better, this is a wonderful opportunity for a thoughtful discussion! Some clarifying questions might include:
   - What do you mean by "doing better," and is that the same thing that other people are thinking?
   - Which parameters do you think are most important, and why? Is that the same thing that other people are thinking?
   - We all have our predictions: are you very confident in your prediction? If so, why? If not, do you feel that there are many uncertainties in this situation? Can you articulate some of those as questions?

Standards

Oyster Tank Topic Library

Consider as you read:
When you set up an oyster tank, should you try to imitate the conditions in the estuary?

1) Oyster Recovery Partnership “Kids Zone” -- a few good sentences about how oysters live.

2) Ecosystem stressors to oysters -- a diagram that shows some problems oysters can have.

3) Crunchy on the Outside, Soft and Squishy on the Inside -- about oyster shells and oyster predators.

4) Brackish aquarium setup -- one person’s opinion about setting up a brackish tank.

5) Creating A Brackish Habitat Fish Aquarium -- a second person’s opinion about setting up a brackish tank.

6) Estuarine Aquarium Keeping for Beginners -- a third person’s opinion about setting up a brackish tank.

7) Creating Oyster Habitat- What Makes a Good Site? -- about setting up oyster reefs in an estuary.

8) Environmental factors affecting oyster populations -- a list of things that affect oysters in an estuary.

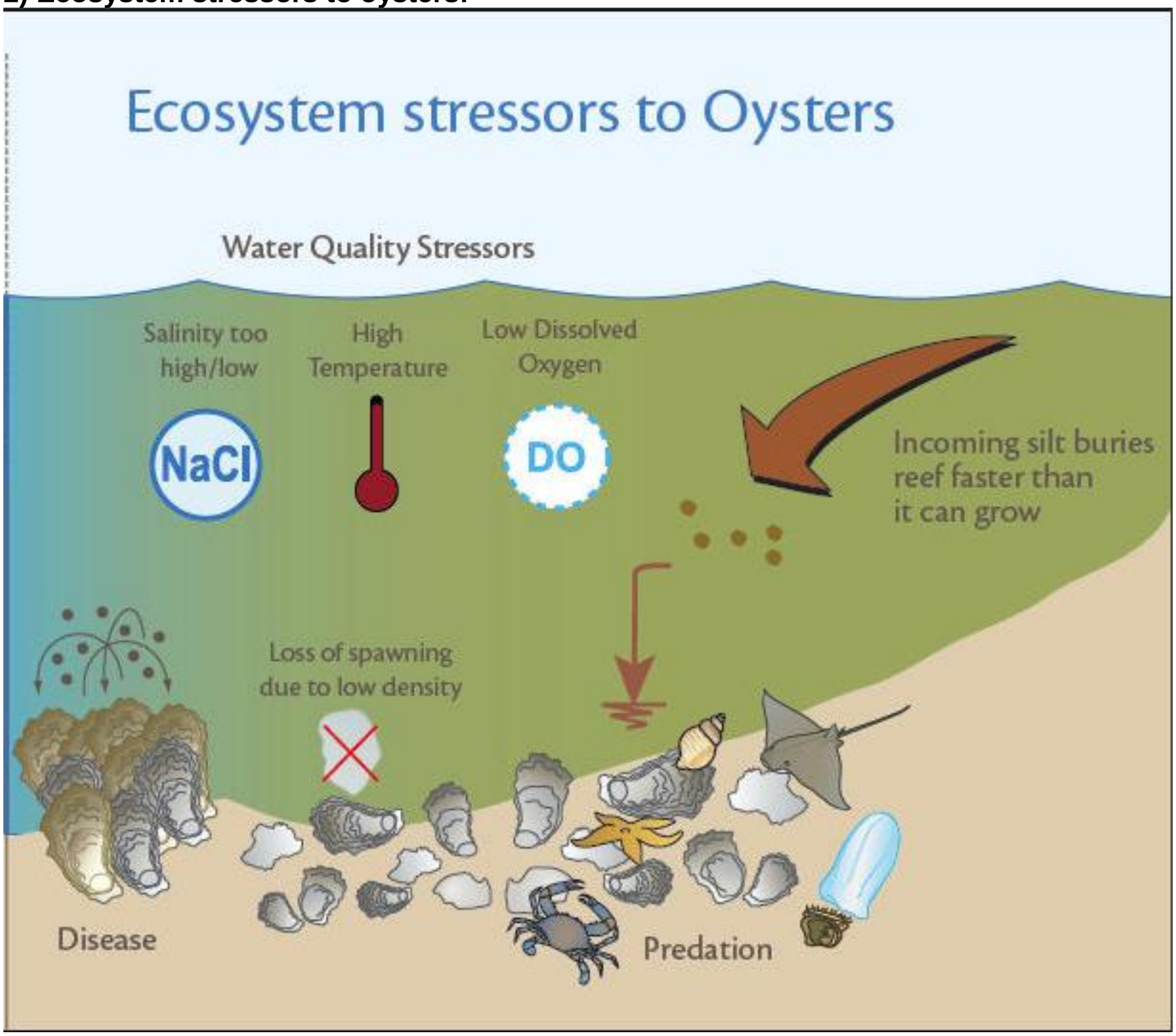
9) Problems with low dissolved oxygen in the East River -- some of the specific pros and cons of life in the East River, especially for oysters.

10) NY/NJ Harbor Estuary Map from Stevens Institute of Technology shows parameters like surface and bottom salinity, surface currents, surface air temperature, etc. -- You’ll need to access the internet for this. Once you figure out how to use this website, you can find a ton of information about your ORS site! You can find data from different times, and from different places around the city.

1) Oyster Recovery Partnership "Kids Zone"
"Oysters are pretty cool creatures. They live most of their lives in a shell at the bottom of rivers or bays….Oysters eat by sucking water through their bodies, pulling out the nutrients they need to grow."

From Oyster Recovery Partnership: http://oysterrecovery.org/oysters-101/kids-corner/

2) Ecosystem stressors to oysters:



https://chesapeakebay.noaa.gov/oysters/oyster-reefs

3) Crunchy on the Outside, Soft and Squishy on the Inside
"Oyster predators can easily locate oyster prey and since oysters are not mobile. Once found, they have no means for escape. However, the oyster's thick shell presents a significant deterrent to oyster predators as they must first penetrate the shell before consuming the tissue.

Successful oyster predators possess specialized adaptations that help them crush, drill, or open the shell exposing the meat within. Common oyster predators include snails, crabs, starfish, flatworms, and fish (such as cownose rays, oyster toadfish, flounder, drumfish)."

From Project Ports Guide 3: https://www.billionoysterproject.org/wp-content/uploads/2013/06/curriculum_guide_3-1.pdf

4) Brackish Aquarium Setup
"Brackish water is somewhere between "pure" freshwater and "high salinity" ocean water....

Brackish species are very adaptable.... As long as waste products (ammonia, nitrite, and nitrate) are at safe levels, the animals will do fine, even if there is a gradual change in pH, hardness, or salinity. Because these animals naturally live in an environment where water parameters may change from one spot to the next, a super-stable environment is not quite as important for brackish species."

From Fishlore.com http://www.fishlore.com/aquariummagazine/feb08/brackish-fish-tank-setup.htm

5) Creating A Brackish Habitat Fish Aquarium
What is "Brackish?"

It's not quite saltwater, but it's definitely not freshwater. Brackish waters occur all over the world where inland freshwater streams and springs meet the ocean, creating estuaries. The lower part of the Hudson River that separates New York and New Jersey, for example, is a giant brackish estuary….

The Salinity of Brackish Water
The world's marine waters have a salinity between 32 and 35 parts per thousand. Brackish water, by definition, must be lower than that...

Calculating the salinity of water is done by measuring specific gravity (SG) with a hydrometer….For practical purposes, brackish aquarium water should range between 1.002 to 1.022 SG at a temperature of 77 degrees Fahrenheit. Most brackish aquarium animals can tolerate this range. A 50/50 mix of fresh and marine water would provide a salinity of 1.012 SG – a happy medium for a general brackish aquarium...

If you want to provide the best care for your brackish animals, however, I recommend matching the salinity level to the type of brackish habitat you are trying to re-create or the type of brackish animals you want to maintain."

From Petcha.com: http://www.petcha.com/creating-a-brackish-habitat-fish-aquarium/

6) Estuarine Aquarium Keeping for Beginners

"Temperature

All aquatic animals have a range of temperatures in which they can live, and they do best when temperatures are close to the middle of that range. School classrooms are notoriously warm,

and this can 4 be a *major* factor in regards to which species will thrive. Water temperatures can easily climb into the 80 degrees Fahrenheit in a school hallway, or during the weekend if they turn the air conditioning off...

Ammonia becomes more toxic with higher aquarium temperatures and the nitrifying bacteria that comprise the biological filter will likely die if water temperatures rise above 95 degrees F.

You do not have to be concerned about cold-water periods. As the water temperature in your aquarium decreases, the critters will simply slow down and may stop eating entirely. It should not be a problem if your water temps decrease to 50°F, or even colder during school vacations."

"Oxygen

….Water can hold less dissolved oxygen (DO) as it gets warmer and saltier. Estuarine water usually holds between 5 and 8 parts per million (ppm) oxygen...Fish will begin to get stressed in DO levels of 3 and 5 ppm and will get very stressed in water below 3 ppm. All tanks should have several sources of oxygen…

Animals use more oxygen when they are active and also after eating, while they digest food. Active animals (such as fish that don't stop swimming around the tank) use more oxygen than more sedentary species. Animal metabolisms increase with rising water temperatures, so animals also use more oxygen as the temperature increases. It is important to remember that the bacteria in the biological filter… also use oxygen.

Dead animals and uneaten food left in the tank are decomposed by huge numbers of bacteria, which use oxygen. These bacteria can cause the oxygen in your tank to decrease to a harmful level for your animals. Therefore you should not have uneaten food or dead animals present in your aquarium."

"Tank Size

The volume of water in the tank, the surface area of the water/air interface and the surface area of the substrate are all very important.... Most estuarine animals stay close to the bottom of the tank, so you should try to maximize the bottom surface area of an estuarine aquarium. For instance it is better to purchase a 20-gallon long aquarium instead of a 20-gallon tall model. The long model has more bottom surface area than the 20-gallon tall aquarium model. The surface area of a tank is important in gas exchange (namely oxygen)...

The surface area of the substrate, or bottom of the tank, is also very important. Bacteria grow on the surface of aquarium substrate. These bacteria are part of the biological filter.... A larger bottom area will give you more substrate surface area for the bacteria to grow, which increases your biological filter. This is a good thing. Crushed coral and gravel have a lot more surface area for bacteria growth than sand, because sand is made of such small grains that they pack closely together, leaving few nooks and crannies."

"Aging The Aquarium or Cycling the Biological Filter

One of the most critical steps in starting up an aquarium is giving the aquarium enough time for the biological filter bacteria population to build up or "cycle." Animals excrete ammonia waste (NH_3), which is toxic. Animal feces, uneaten food and dead animals will also add ammonia during decomposition. This ammonia will build up unless you frequently change a lot of water (impractical), or your biological filter converts it first to nitrite (also toxic) and then to nitrate (not toxic) through the nitrogen cycle. It takes time for your nitrifying bacteria population to build up, and this process is called aging or cycling. The nitrobacter and nitrosomonas bacteria, which do

this important job, are found in all aquatic environments, and they are in the river or bay water that you fill your tank with."

From the Chesapeake Bay National Estuarine Research Reserve in Virginia. http://www.vims.edu/cbnerr/_docs/education_docs/EstAquKeepwriteup.pdf

7) Creating Oyster Habitat- What Makes a Good Site?
By Don Meritt, Sea Grant Shellfish Specialist

….This article will address some of the basic issues that need to be considered in choosing sites for oyster restoration.

Salinity
Perhaps the most important factor for oysters is salinity. Oysters can survive in salinities from under 5 ppt to full strength ocean water and more (ocean water is around 35 ppt). These low or high salinity levels can cause of physiological stress. Unless your site is in a fresh water or ocean region, salinity will vary from season to season and year to year... A good indicator of a site's suitability is live oysters nearby….

Dissolved Oxygen
It's important that oysters have enough oxygen. The absence of oxygen, or anoxia, can especially occur in summer months when bacteria… use up dissolved oxygen in the water. Winds, currents and plant activity (photosynthesis) as well as direct transfer from the air to the water all contribute to adding oxygen to the water. Locating oyster reefs in areas with good circulation, where the water is well mixed from top to bottom, should help….

Disease
Oysters in many prime growing regions are under attack by… MSX disease… and Dermo disease (but these oyster diseases do not harm people). The microorganisms that infect oysters are also influenced by salinity. MSX is only found in areas where salinities are moderately high, above 14 to 16 ppt. Dermo disease is better able to survive in lower salinity waters.

Predation
While the oyster is wonderfully adapted for thriving in a wide range of conditions, it is still vulnerable to attack by predators such as oyster drills, boring sponges, and blue crabs. Consider predators and parasites that may invade the oyster reef you are planning to construct. In other words, try to locate reefs at sites where predatory organisms are less common.

Bottom Characteristics
Oysters grow best on hard substrates. Think of an oyster reef as the foundation of a house: no one would build a house directly on top of mud – it would sink until it encountered a bottom solid enough to hold up the rest of the structure. The foundation of a reef must be strong enough to keep the oysters from sinking into the ground and strong enough to withstand storms and other forces – particularly waves and heavy current surges – that could tear it apart.

Exposure: Physical and Human

Heavy wave action, for example, can actually lift oysters and shells and transport them to locations far from where they were originally placed. This is especially true in shallow water areas. Any reefs in water less than six to twelve feet deep should not be located in areas where severe winds will cause heavy wave action. Even if the force of the waves does not move the oysters, it may stir up sediments, and that could bury the oysters. Exposure to runoff that carries toxic substances should also be avoided.

From Maryland Aquafarmer Spring 2001

8) Environmental Factors Affecting Oyster Populations

The list below is the table of contents from a chapter entitled, "Environmental Factors Affecting Oyster Populations" from a 1964 scientific publication from NOAA about the American oyster.

As you read the list, what do you recognize? What would you like to know more about?

A couple fun terms:

- Gastropods are snails. Gastro = gut, and pod = foot. Does it make sense to you somehow that "gut-foot" = snail?

- Commensals are different species that live together. One of the species benefits from the relationship, and the other species is unaffacted. "Com" = sharing, and "mensal" = a table. Does it make sense to you somehow that "sharing-a-table" = commensal?

Excerpted from "The American Oyster, *Crassostrea virginica* Gmelin," from the NOAA Northeast Fisheries Science Center's (NEFSC) "Classic Publications" page, which includes NEFSC literature "from pre-computer days." The excerpt is here.

9) Problems with low dissolved oxygen in the East River:

Although the East River's water quality has steadily improved, it still has problems with eutrophication, turbidity, and low levels of dissolved oxygen. As suspension filter feeders, oysters have a great capacity for water filtration. On a per-area basis, oyster reefs are estimated to remove 25 times more nitrogen than salt marshes do (Waldman 1999). Oysters remove phytoplankton, particulate organic carbon, sediments, pollutants, and microorganisms from the water and they use most of the organic matter that they filter (Tolley et al.).

Oysters are generally hardy creatures (Waldman 1999) but... their development and mortality are influenced by salinity, current velocity, and dissolved oxygen levels. Oysters generally tolerate salinity levels between 15-25 ppt….Current velocity can affect oyster growth because currents bring food and oxygenated water to the reefs (Brumbaugh et al. 2006).

Generally, dissolved oxygen levels should consistently be above 5.0 mg/l or above. In its current state, the Lower East River barely meets this requirement during the summer and the Upper East River has dipped below this threshold (NYCDEP 2004); this affects the timing and location of oyster restoration.

Adapted from: http://www.columbia.edu/itc/cerc/danoff-burg/RestoringNYC/RestoringNYC_EastRiver.html

10) NY/NJ Harbor Estuary Map from Stevens Institute of Technology shows parameters like surface and bottom salinity, surface currents, surface air temperature, etc. Via: http://hudson.dl.stevens-tech.edu/maritimeforecast/maincontrol.shtml

Will Our Oyster do Better in the Classroom Tank or in the ORS?

Imagine you are an oyster! Living inside one of those shells, filtering the water and going about your business...

*What are all the similarities and differences you can think of **for the oysters** between life in the tank and life in the ORS?*

Similarities	Differences

After doing a bit of reading, what are some additional similarities and differences you can think of?

Additional Similarities	**Additional Differences**

Now get together with a small group of classmates and choose what you think will be the two biggest differences between the tank and the ORS. Explain your reasoning.

1.

2.

Now go back to working on your own.

1. Where do you think the oysters will do better, in the classroom or in the ORS? Why?

2. How will you be able to tell if that prediction turns out to be accurate?

3. What data will you need to collect in order to convince other people that your conclusion is accurate?

Oyster Tank Guide

TABLE OF CONTENTS

INTRODUCTION

The goal of this oyster tank is to bring oysters and your monitoring work into the classroom! We hope that you can get out to monitor your Oyster Restoration Station (ORS) more than four times a year, but understand that it can be difficult to get out of the classroom. We hope that you use the oyster tank as a platform for regular study, data collection and research with your students. The oyster tank also provides an excellent opportunity for your students to practice the monitoring skills that they will need in the field in order to monitor their ORS.

TANK SETUP & MAINTENANCE

<u>Supplies for Tank Setup</u> (purchase at Petland Discounts or Petco unless noted otherwise)

- 10 gallon tank
- Cold tap water
- Tap Water Conditioner (de-chlorination of tank water)
- Instant Ocean Aquarium Salt (15 lbs bag)
- Aerator and air stone

- Plastic bottle with wide mouth (for DIY filter)

- Stress Zyme (optional for adding more bacteria to your tank)
- Shellfish Diet 1800 phytoplankton concentrate (1 quart)
    - o purchase http://reedmariculture.com/product_instant_algae_shellfish_diet_1800.php
- Recycled oyster shells for substrate
    - o obtain directly from BOP by contacting the Hatchery Manager at Billion Oyster Project
- Live spat-on-shell oysters
    - o obtain directly from BOP by contacting the Hatchery Manager at Billion Oyster Project
- Associated organisms collected from NY Harbor
    - o collect from your from your ORS mobile trap
- Algae discs (optional for occasionally feeding the associated organisms)

Directions for Tank Setup

1. Add tap water to tank.
2. Add water conditioning drops (follow instructions included with drops).
3. Add Instant Ocean Aquarium Salt (follow the product guidelines to obtain an optimal salinity of 15ppt).
4. Use hydrometer to test salinity.
5. Set up DIY filter with aerator and air stone. Turn on the aerator and let run for a few minutes.
6. Add recycle oyster shells.
7. Add spat-on-shell.
8. Feed oysters with phytoplankton concentrate.

Directions for DIY Filter

1. Poke or drill about 6 holes in the side of the plastic bottle about ½ inch up from the bottom. Make sure holes are about the same diameter as the aerator tube.
2. Take the air stone off the aerator tube.
3. Feed the aerator tube into the plastic bottle through one of the holes in the side.
4. Carefully feed the aerator tube out of the top of the bottle.
5. Put the air stone on the aerator tube.
6. Carefully pull the aerator tube down so the air stone rests on the bottom-inside of the plastic bottle.
7. Fill the plastic bottle with aquarium gravel.

Notes on Tank Setup & Maintenance

Tank Size - You need *at least* a 10-gallon tank, however a larger tank will make for happier oysters. You do not want to overcrowd your tank. The volume of water in the tank and the surface area of the water/air interface are important components to keep in mind when thinking about creating the best habitat for your oysters. For instance it is better to purchase a 20-gallon long aquarium instead of a 20-gallon tall model. The long model has more bottom surface area than the 20-gallon tall aquarium model.

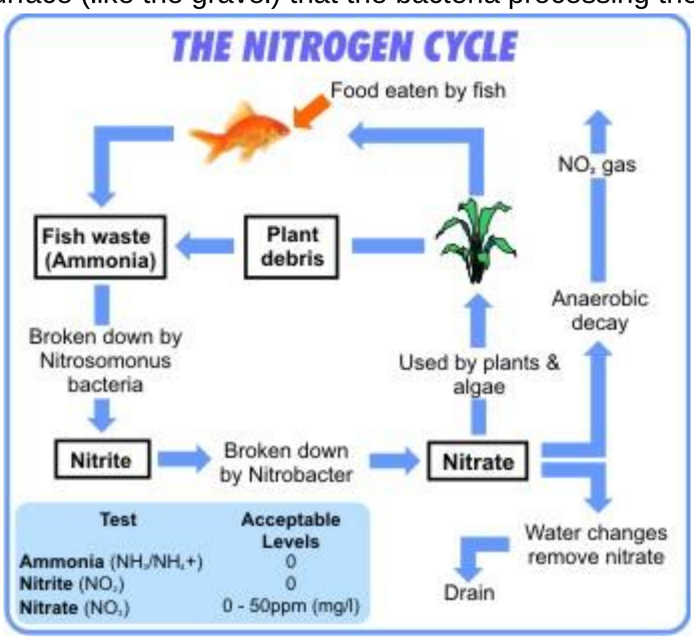
Temperature - School classrooms are notoriously warm, and this can be a major factor in regards to the survival of your oysters. Water temperature in your tank can easily climb into the 80’s at school or during the weekend if there’s no air conditioning. The oysters will be much easier to care for if you have cooler water. Ideally keep your tank in an air conditioned room. If this is not possible, be sure to keep the tank out of the direct sunlight. You do not have to be concerned about cold-water periods. As the water temperature in your aquarium decreases, the oysters will simply slow down and may stop eating entirely. It should not be a problem if your water temps decrease to 50°F, or even colder during school vacations.

Aerator - Tanks must be kept aerated at all times to ensure adequate levels of oxygen and regulate bacteria. Never turn off your aerator or allow the hose to become blocked.

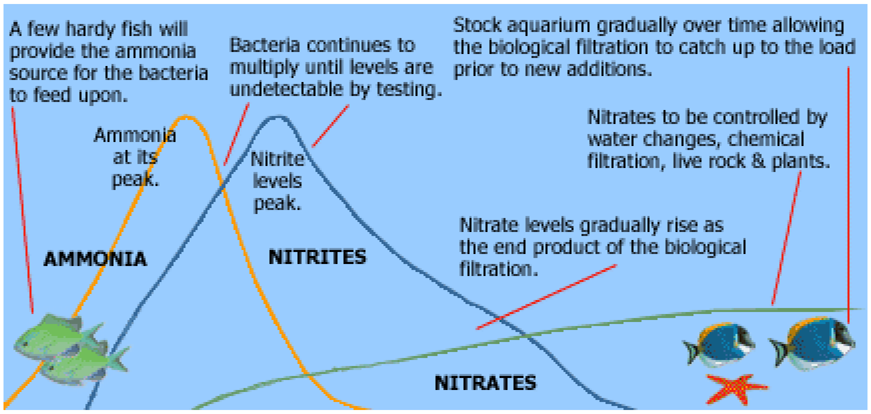
Ammonia - Any ammonia above 0.5ppm should be considered too high. Check ammonia daily at first. Do a water change any time the ammonia readings are too high. Change no more than 50% of the water as this will keep more of the helpful bacteria in the tank.

Bacteria - You need bacteria in the tank to deal with the ammonia that builds up from keeping animals in the enclosed space. This bacteria can take weeks to develop, and if you let the ammonia build up, that is more than enough time to kill all your oysters. Using harbor water to start adds a wide variety of bacteria. You can add them with a product called “Stress Zyme.” Be prepared to do water changes very frequently for the first few weeks.

DIY Filter - Your plastic bottle full of gravel is a biological filter that involves bacteria and other microorganisms converting your oysters’ waste into less toxic substances. Your oysters excrete waste into their aquarium water constantly as they process their food. This waste, if not removed, will become toxic to the oysters. A biological filter will convert toxic ammonia (from your oysters’ waste, excess food, decaying or dying plant matter, and dead organisms) into Nitrite. Then it will convert toxic Nitrite into Nitrate. Nitrate is much less harmless, although it does have to be removed from the tank through regular water changes. Nitrate will also contribute to algae growth. Biological filtration occurs as the water passes over any surface (like the gravel) that the bacteria processing the waste can grow on.



http://koiorganisationinternational.org/?q=blog&sort_by=created&sort_order=DESC&page=4



http://www.peteducation.com/article.cfm?c=16+2154&aid=2657

Water change - The recommended frequency for changing the water in your tank is between once per week and once per month. The exact frequency is up to you and some experimental designs may call for changing water more or less frequently than the recommended range. Always keep the water at a constant level, adding tap water with added Instant Ocean Aquarium Salt to account for evaporation.

Oyster Feeding - Oysters must be fed a steady diet of phytoplankton (single and multi celled algae). In nature phytoplankton is abundant; however in a tank environment a concentrated solution must be added. The best option is Shellfish Diet 1800, a commercially produced mixture of six different species. The recommended ration is as follows

- For <10 gallon tanks containing less than 100 oysters: 2.5ml-5ml diluted in 100ml of cold tap water 3-5 times per week
- For >10 containing more than 100 oysters: 5ml-10ml diluted in 200ml of cold tap water 3-5 times per week
- A one-quart bottle will last about two months for a 2.5-10 gallon tank of up to 100 oysters.

Associated Oyster Reef Organisms - Don't overfeed the other species. Doing so will create toxic levels of ammonia and a smelly tank. You also want the crabs and other scavengers to eat as much as detritus as they can from around the tank, which they will only do when they are hungry. But once in a while you may want to feed them too. Try breaking the algae discs into tiny pieces and dropping them on the crabs or oyster toad fish. It's lots of fun for students to do this. They seem to mainly go for the food if it's moving (while it's sinking). If it settles on the bottom it will probably stay there and turn to mush.

Watch, watch, watch! A close eye on your oyster tank, during feeding and at different times during the day will give you invaluable information as to how everything is working.

(Note: some of this information comes from "Estuarine Aquarium Keeping for Beginners**,"** a guide written by the Chesapeake Bay National Estuarine Research Reserve in Virginia, a protected estuary area that is jointly managed by the National Oceanic and Atmospheric Administration (NOAA) and the College of William and Mary Virginia Institute of Marine Science. You can check out the whole guide here: http://www.vims.edu/cbnerr/_docs/education_docs/EstAquKeepwriteup.pdf)

TANK MONITORING

Supplies for Tank Monitoring

Note: Use the equipment from the *BOP ORS Supply List*

- Thermometer
- Dissolved oxygen kit
- Hydrometer
- pH meter
- ammonia test strips
- Nitrate test strips
- phosphate test strips
- turbidity tube
- Shallow pan (to catch water from turbidity tube)
- calipers

Directions for Tank Monitoring

Note: Hands must be clean and without residue of soap or hand sanitizer before putting hands in tank.

Water quality

1. Using a standard sampling cup (100ml) remove a water sample from the control tank. Use this sample to conduct all water quality measurements except temperature and turbidity.
2. Take the temperature reading directly in the tank.
3. Use a clean cup to fill up the tube. Use a shallow pan to catch water released from the bottom of the tube.
4. Conduct water quality tests in the following order: temperature, dissolved oxygen, nitrate/ammonia/phosphate, pH, salinity, turbidity.
5. Record results.
6. Discard sample water (do not return to tank).

Oyster Measurements

1. Remove all spat-on-shell from the tank.
2. Take pictures of both sides of each shell.
3. Count total live oysters on each shell and record results.
4. Measure all LIVE oysters on each shell and record results.
5. Return oysters to the tank.

EXPERIMENTAL TANK

1. The only things that must be placed in this second, experimental tank are
    - Water (with some amount of salt)
    - Oysters
    - The aerator
    - Some amount of food
2. Other than that, what is put in the second tank is based on the experimental question the class decided upon.

3. Possibilities for variables include:
    - The amount of salinity
    - The kind of water (Instant Ocean or NY Harbor)
    - Substrate (sand, oyster shells, concrete, etc.)
    - Number of oysters
    - Volume of water
    - Conditioning drops
    - Other organisms

CYCLING A NEW TANK

Introduction

Animals in a new aquarium will quickly suffer and die of exposure to the ammonia and nitrites that result from their own excretions. Unlike in a new tank, in nature and in more established aquaria, communities of "nitrifying bacteria" form. These bacteria are found almost everywhere, especially in water and soil that have not been disinfected or sterilized. Once the nitrifying bacterial community is established in a tank, it can quickly convert ammonia to nitrites and nitrites to nitrates. In general, animals tolerate dissolved nitrates much better than they tolerate dissolved ammonia, giving you more time to change the water before the level of nitrates becomes toxic. One way to establish a nitrifying bacterial community is sometimes called 'fishless cycling"--really animal-less cycling--where you add dissolved ammonia to initiate the process.

Supplies for Cycling a Tank

- 10 gallon tank
- Tap Water Conditioner (de-chlorination of tank water)
- Instant Ocean Aquarium Salt (15 lbs bag)
- Aerator and air stone
- Aquarium gravel (for DIY filter)
- Plastic bottle with wide mouth (for DIY filter)
- Stress Zyme (optional for adding more bacteria to your tank)
- Ammonium chloride
    - purchase at pentairaes.com

Directions for Cycling a Tank

The point here is to establish a new tank without any animals and focus on making sure the water quality is stable before adding animals.

Setup Day 1

1. Add water to tank. Options include:
    - Harbor water
        - Advantage is that you will probably have a population of nitrifying bacteria already in the water
        - Disadvantage is carrying 10 gallons of water from the harbor to your school
    - Tap water
        - Add water conditioning drops

        - Add Instant Ocean Aquarium Salt and follow the product guidelines to obtain an optimal salinity of 15ppt
        - Add Stresszyme (optional)
    - Mixture of tap and harbor water
        - Dechlorinate your tap water by letting it sit for 24 hours (because the chlorine in the tap water will kill the bacteria in your harbor water)
        - Add harbor water
        - Add salt if necessary (Decide if you want your final mixture of water to have a salinity of 15ppt or to match the salinity of the harbor water you collected)
2. Set up aerator and air stone. You may want to create more surface area for nitrifying bacteria to colonize. Options include:
    - Using the DIY filter (see directions above)
    - Adding gravel to bottom of tank
    - Other commercially available filters
3. Let water sit for at least 24 hours.

Setup Day 2

1. Monitor pH for baseline data
2. Monitor ammonia, nitrites and nitrates for baseline data

Setup Day 3

1. Monitor pH to make sure that it is stable. If the pH is not stable, wait another 24 hours and try again. (Nitrifying bacteria are sensitive to sudden changes in pH.)
2. Monitor ammonia, nitrites and nitrates in order to continue to collect data
3. Manipulate the tank's nitrogen cycle by dissolving ammonium chloride salt in tank water. You want to have an initial ammonia concentration of 2 to 3 mg/L (ppm). Do not go above 5 mg/L. The bottom row of this page helps with the calculation of the amount of ammonia: http://www.fishforums.net/aquarium-calculator.htm
4. The nitrogen cycle in your tank could be influenced by the following:
    - If you have plants in your tank they can remove ammonia and nitrites from the water and store the nitrogen in their tissues.
    - If you have dead organic matter in the tank, then the ammonia and nitrites will go back into the water through decomposition.

Setup Day 4

5. Monitor and record ammonia, nitrites, nitrates and pH daily.
6. The nitrifying bacteria are particularly sensitive to sudden changes in pH, so if you have a sudden change in pH, you'll lose a lot of your nitrifying bacteria and the process will have to start over to some extent. You need to track pH so you can try to identify anything that might have caused a sudden change in pH, and avoid that problem in the future. Common pH-related mistakes include:
    - Adding a lot of new water to the tank without comparing its pH with that of the water already in the tank.
    - Adding water mixed with Instant Ocean or other synthetic salt, without letting the mixture sit for at least 24 hours first.

***Monitor your tank for at least two weeks before adding animals. When ammonia and nitrites are at 0, and nitrates are present, you can start adding animals.**

<u>Directions for Adding Animals</u>

Add your animals, one species and a few individuals at a time. Add a new species every 3-5 days. Most importantly, continue to monitor your tank daily and make sure water quality is stable before adding the next set of animals. Consider gathering all the animals you need from your ORS during a single visit and have a second tank with harbor water and an aerator in which to keep them alive while you wait to add them to your conditioned tank.

1. Add mud snails (be sure they are mud snails and not oyster drills, unless you don't want to keep your oysters alive for very long -- although it might be interesting for students to watch how oyster drills prey on oysters.
2. A couple days later add shrimp (grass shrimp, shore shrimp, sand shrimp, etc.)
3. A few days later add crabs (mud crabs are easier to deal with than blue crabs, because the blue crabs can swim, eat everything else, and fight -- although that might make them especially interesting to watch)
4. Finally, add 10 spat-on-shell substrate oysters