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Teacher Resources

Gifts for Teachers

NorthBay's NEW Schoolyard Stormwater Lesson

NorthBay's Turbidity Tube Instructions

NorthBay's Schoolyard Stormwater Lesson

(v.3.1)

Overview

The first activity in this lesson engages students to see that they are part of and contributors to the water cycle. The next part of the lesson sends students out into their schoolyards to identify stormwater flow patterns and to calculate the ratio and percentages of pervious and impervious surfaces, and the impacts those surfaces have on waterflow. Students move out beyond the schoolyard, into the community, to follow the flow of stormwater in the third part of the lesson. For action, students identify one problem area in the schoolyard. Students will research solutions within their locus of control and develop a proposal to address the problem. Where feasible, students will implement their solutions. Teachers can choose to include or exclude sections of this lesson depending upon available time and learning goals.

What You'll Need

Clipboards (1 per student pair), schoolyard (and beyond) image from Google Maps (1 per student pair), pencils, colored pencils or markers (red, green, brown), rulers, Turbidity (Transparency) tube or Labquest turbidity probe, access to USGS water science school rainfall calculator, 100 ft measuring tapes (one per group).

Outcomes: Students will be able to describe what stormwater is, how it moves over the landscape and the impacts it can have. Students will be able to suggest solutions within the locus of their control.

Themes: Green infrastructure, Stormwater, Restoration, Education, Recreation, Water citizenship.

Character elements: Empowerment

Action: Develop a proposal for a small green infrastructure project (best management practice) and share it with stakeholders.

Suggestions for Student Inquiry: What impacts does the schoolyard runoff have on the surrounding community? What extent of impervious schoolyard surfaces could be remediated? Invite students to brainstorm additional ideas.

Standards Addressed

Common Core Middle School

6-8.WHST.7 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.

6.RP.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

7.RP.2 Recognize and represent proportional relationships between quantities.

NGSS Middle School

MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Common Core High School

9-12.WHST.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

NGSS High School

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Note: If students engage in a more extensive study of green infrastructure projects, these standards may also be met:

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural and environmental impacts.

Engage

"You IN the Water Cycle" activity. Modify the instructions as needed to fit into the time you have. This activity can be transformative as students realize they *are* participants the water cycle rather than external observers of the water cycle. This is a big shift in thinking for many! If students need a water cycle refresher, here are two helpful links: USGS Water Cycle for Younger Students , USGS Water Cycle for Advanced Students

Directions: Put students in groups and ask: "How are you part of the water cycle?" Direct students to create and share a short video, podcast, skit, cartoon, picture, anime, etc., that illustrates how they are part of the water cycle. Remind them to be sure to include all the water cycle processes in their portrayal. Ask them to be imaginative, resourceful, unconventional (and scientifically accurate) in your thinking and design.

Explore

Using a discussion routine from the BEETLES Project: http://beetlesproject.org/cms/wp-content/uploads/2015/12/Discussion-Routines.pdf, and effective questioning techniques http://beetlesproject.org/cms/wp-content/uploads/2015/12/Discussion-Leading-Tips-for-the-Instructor.pdf, invite students into a meaningful discussion about the water cycle based upon their water cycle presentations. Stitch in the challenges of stormwater runoff if students haven't gotten it into their water cycle presentations. Steer the conversation to reiterate that we are part of watersheds/watercycles, and that "our choices and actions matter." (The 'ol NorthBay motto).

Explain

Everyone is a citizen of a watershed and a participant in the water cycle. A **watershed** is the land area surrounding and draining into a specific body of water (stream, river, pond, lake). Water must flow downhill; bodies of water always lie in a low place in the land.

Stormwater is rain that falls to earth and moves. In the natural water cycle, water soaks down into the ground, becoming groundwater that supplies our wells and fills our streams, rivers and lakes. **Pervious surfaces** like wetlands, meadows, grasslands, and forests allow water to infiltrate. In our built environments, **impervious surfaces** like roads, sidewalks, driveways, parking lots and rooftops prevent rain water from penetrating the ground. In some instances, trails and lawns become so compacted by people walking over them that they, too, become impervious. When it rains, the stormwater washes over these impenetrable surfaces picking up sediment and liquids leaked from cars and trash. Sometimes the rushing water scours out adjacent areas, exacerbating erosion and sedimentation. This now polluted water flows into nearby storm sewers or directly into streams. During periods of high flow, eroding stream banks muddy the water, degrading habitat for plants and animals that depend on clear water. Sediment in the water clogs the gills of fish, blocks light needed for plants, and fills in the area around rocks where macroinvertebrates, snails, young fish, and crayfish live. The sediments also settle to fill in the channels of streams, lakes, and reservoirs.

On hot days, stormwater heats up as it flows over warm pavement and cement becoming **thermal pollution.** Warm runoff water is harmful for many of our cold-water species, such as trout, and makes it difficult for aquatic life to survive by decreasing the amount of dissolved oxygen. As more land is covered by impervious surfaces (e.g. stores, parking lots, roads, neighborhoods, etc.), more polluted runoff enters our rivers and streams.

Best management practices (BMP's) are installed in the built environment to mimic the flow of water in the natural water cycle. They are designed to slow water down, spread it out, and soak it up before it enters a local waterway. They include: Rain gardens, rain barrels, green roofs, permeable pavement, conservation plantings, bioretentions, submerged gravel wetlands, bioswales and more. Homeowner Guide to BMP's

Elaborate

When it comes to stormwater, there are multiple interdependent processes for students to understand: stormwater runoff, infiltration, erosion, turbidity, pervious and impervious surfaces. A good place to start is with an exploration of infiltration, which varies by surface and underlying substrate. NorthBay has an extension lesson where students design a model water table. You can find that in APPENDIX A.

Part 1. Stormwater Runoff in the Schoolyard

Step 1

Prepare students to investigate the schoolyard. Be playful with this, invite students to develop names for their stormwater sleuthing "job titles." If you are able, divide the class into 2 groups and divide the school property into two equal sections for the investigation. You can draw the dividing line across the map. Each group will complete just their section of the map.

Step 2

Hand out Google Map printouts of the school campus and areas beyond the school campus (you'll need this area for **Part 2**) to students (1 map per student pair). Point out to students the border of the school property and note safety concerns. Ask students to review the map, orient themselves, and identify key features (building, playground, athletic fields, basketball courts, gardens, etc). In their pairs, invite students make verbal predictions about the path of stormwater in their schoolyard. Students can lightly circle areas in the schoolyard where they think stormwater will flow or drain toward. Discuss students' responses and why they made those predictions.

Step 3

Review with students the terms **Impervious** and **Pervious**. Show them examples. Discuss how impervious and pervious surfaces can affect stormwater intensity (rate of flow), volume (total amount of water), and overall water quality of the local watershed (pollution potential). When students go outside, they will survey the school campus, using the map provided, to identify pervious/impervious surfaces and to calculate the area of different surfaces.

Step 4

When you first get outside, give each student a brightly colored ping pong ball. Walk to a high point on the campus. Invite students to release the ping pong balls, and then, to follow them, pausing and stopping where the balls stop. (The ping pong balls represent stormwater). Ask them what they notice about the ping pong ball movement. Coach students to go beyond immediate conclusions like "the water moves downhill." Have them really notice the "water"

movement in the landscape, and what litter gets carried along with it. Please make sure all ping pong balls are collected before moving to the next step.

Step 5

Next, using the *Student Stormwater Field Sheet*, students will identify the following items on their maps:

1. Locate highest and lowest points in your section. Mark with an “H” and a “L” on your map
2. Locate and outline impervious surfaces in Red. (use squares/rectangles to outline these areas, you will be calculating the area later). Measure the actual dimensions using the measuring tape.
3. Locate and outline pervious surfaces, including BMP’s, in Green. (use squares/rectangles to outline these areas, you will be calculating the area later) Measure the actual dimensions using the measuring tape.
4. Locate any places where water puddles and mark with a “W”
5. Locate any storm drains and mark with “SD”
6. Locate spots where water leaves the school property (in ditches, parking lots, etc). Mark the water exiting with an arrow pointing in the direction of water flowing.
7. Mark areas of erosion (vegetation missing) and evidence of deposition (piles of sand, pebbles, trash) with BROWN.

Step 6

After students finish all seven steps, they should complete their calculations. Students should calculate the overall area of both pervious and impervious sections of the school property by finding the dimensions of each section, multiplying them, and then adding them together to get a final value. Students can cross check their field measurements on the Google Maps website by right-clicking to use a measurement tool. (This last option will work if you have an ipad in the field).

Step 7

Next, students can calculate the ratio of pervious to impervious surfaces and determine the percentage of each surface type. Keep in mind that it takes only a small percentage, 7-10%

impervious surface, to change water flow/infiltration patterns (pers. comm. Watershed Stewards Academy, 2017).

Example: Impervious Areas:

Playground: 30 feet x 50 feet = 1,500 square feet

School building: 200 feet x 200 feet = 40,000 square feet

Athletic Shed: 5 feet x 10 feet = 50 square feet

Parking lot and sidewalk 100 feet x 50 feet = 5,000 square feet

Total Impervious Surface = 1,500 + 40,000 + 50 + 5,000 = 46,550 square feet

Once students have calculated their areas for their section, invite each group to share their results.

Step 8

Now that students know the amount of impervious surface in the schoolyard, they can calculate the volume of water running off these impervious surfaces during rainfalls of differing amounts: 0.25", 0.5", 1.0", 1.5" rainfall. There are two options for doing this below. It might be useful for students to complete both to see if they produce the same results. These are just options. How much of this information you use is determined by available time and learning goals.

Water Volume Calculation options:

The USGS Water Science School offers a water runoff calculator:
https://water.usgs.gov/edu/earthrain.html
Or, your students can do it the old fashioned way using this formula:
http://www.friendsoflittlehuntingcreek.org/description/roof.htm

Step 9 Discussion

Students share and explain their runoff maps. As part of their presentation, students should share their biggest "ah-ha!" moment—something they discovered as they learned about stormwater runoff that was significant and unexpected. To avoid too-lengthy responses, remind students to limit themselves to a less than two minute presentation.

Step 10 Action!

After students explore and add to their maps, invite them to share their observations and findings. Next, invite students to discuss actions. Now, knowing what they know about stormwater, and their schools' contribution to the problem, what would they like to do to reduce the stormwater running off the impervious surfaces in their own schoolyard? Ask students to determine and then share the following:

What action would you like to take?

What do you need to complete it?

Who will be impacted and how?

OPTIONAL Part 2. Runoff Beyond the Schoolyard

Runoff doesn't stop at schoolyard boundaries or those of any property. It crosses boundaries as it flows towards the lowest point and into a nearby waterway, which then feeds into a larger waterway, and so on, until it ends up in the ocean, where it circulates around the world. If you are able to take students off campus, take them to follow the path(s) of stormwater to the nearest waterway. (Before you leave the schoolyard students can investigate how the schoolyard is impacted by surrounding development and *how the schoolyard impacts the nearby landscape). Follow the stormwater trail as far as you can. As they are walking, students should be making and recording their observations. When you return to the classroom, ask students to add their findings to their maps. If you are unable to take students off campus, ask them to follow the paths of runoff when they are riding in cars or buses, or when walking on their off-school time.*

Extend

1. Invite students to research and then develop a concept and proposal to remediate an area of impervious surface in the schoolyard. They will need to learn about BMP's, first. Best management practices (BMP's) are installed in the built environment to mimic the flow of water in the natural water cycle. They are designed to slow water down, spread it out, and soak it up before it enters a local waterway. They include: Rain gardens, rain barrels, green roofs, permeable pavement, conservation plantings, bioretentions, submerged gravel wetlands, bioswales and more. They range from relatively simple to complex. Students may need to consult with Environmental Services or Public Works departments for technical assistance, should they choose to install a BMP.

2. See APPENDIX A for suggestions about making a stormwater model.

Evaluation Suggestions:

1. Check student calculations for accuracy.
2. Check student understanding of the stormwater terms, and their impacts: stormwater, runoff, turbidity, impervious surfaces, pervious surfaces, erosion, infiltration.

References:

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Lake Dance: Science, Art, Pedagogy. Chicago, Illinois. http://www.lakedance.org/pipes-and-precipitation.html

Lower Columbia Estuary Partnership. Portland, Oregon. http://www.estuarypartnership.org/sites/default/files/Schoolyard%20Impervious%20Surface%20Lesson.pdf

Student Stormwater Field Data Sheet

Team Member Names: _____

Before you begin, check to see that you have: Clipboards (1 per student pair), schoolyard image from Google Maps (1 per student pair), pencils, colored pencils or markers (red, green, brown), rulers, measuring tape, OR know your pace.

Schoolyard Map Directions:

1. Locate highest and lowest points in your section. Mark with an “H” and a “L” on your map. Stand in each one, if you can safely.
2. Locate and outline impervious surfaces in RED. (use squares/rectangles to outline these areas, you will be calculating the area later). Measure and record the actual dimensions using the measuring tape or known pace.
3. Locate and outline pervious surfaces, including BMP’s, in GREEN.(use squares/rectangles to outline these areas, you will be calculating the area later) Measure and record the actual dimensions using the measuring tape or known pace.

4. Locate any places where water puddles and mark with a “W”

5. Locate any storm drains and mark with “SD”

6. Locate spots where water leaves the school property (in ditches, parking lots, etc). Mark the water exiting with an arrow pointing in the direction of water flowing.

7. Mark areas of erosion (vegetation missing) and evidence of deposition (piles of sand, pebbles, trash) with BROWN.

List Impervious surfaces	Area	List of Pervious Surfaces	Area

After your outside investigation:

Calculate the overall area of both pervious and impervious sections of the school property. Cross-check field measurements using the online measuring tool on Google maps, which you can access by right-clicking.

Example: Impervious Areas:

Playground: 30 feet x 50 feet = 1,500 square feet

School building: 200 feet x 200 feet = 40,000 square feet

Athletic Shed: 5 feet x 10 feet = 50 square feet

Parking lot and sidewalk: 100 feet x 50 feet = 5,000 square feet

Total Impervious Surface = 1,500 + 40,000 + 50 + 5,000 = 46,550 square feet

	Group 1	Group 2	TOTAL
Total Impervious Surfaces:	_____square feet	_____square feet	_____square feet
Total Pervious Surfaces:	_____square feet	_____square feet	_____square feet

What is the ratio of pervious to impervious surfaces?_____

What is the percentage of pervious surfaces? _____ Impervious surfaces?_____

Calculate the amount of stormwater that will flow off the **impervious** schoolyard surfaces during a 1.0" rain. _____

Need help? Here is what to do:

1. Convert square feet into square inches. Using the earlier example, if you have a school building that is 200 ft x 200 ft it becomes 2,400 in x 2,400 in = 5,760,000 sq inches.
2. Multiply the number of square inches by the amount of rain that has fallen: 5,760,000 sq in x 1.0 in rainfall = 5,760,000 cubic inches!
3. To turn this into gallons, a more commonly used unit, divide by 231 cubic inches (the volume of one gallon). This puts the number in an everyday context. 5,760,000/231 = 24,935 gallons of water.

This is how much water will flow off impervious surfaces in a 1.0 " rainfall. This is a lot of water that needs to go somewhere! It will travel, sometimes with significant velocity, until it reaches a place where it can infiltrate. Oftentimes, the water flows downhill and enters a stormwater pipe and then ends up in the nearest waterway rather than going to a wastewater treatment plant first. The water carries with it everything off the surfaces it crosses: litter, sediments,

contaminants from vehicles, sand, salt, fertilizers, pesticides, etc. **What do you think about this?** Share your thoughts with a classmate.

Action Planning

Given what you have learned from your study of the schoolyard, talk with your classmates and teacher. Compare your results. Consider what you will do to reduce the impacts of stormwater runoff. What action would you like to take? What do you need to complete it? Who will be impacted and how? Write answers below to share in a discussion with your classmates and teacher.

Describe action:

Describe what you need to complete it:

Describe who will be impacted, and how:

After you have a chance to see the impacts of schoolyard runoff on the surrounding community, briefly write about something you weren't expecting to find. What surprised you?

_____

_____

Lastly, choose someone outside of your class to teach about stormwater runoff. Many people don't realize that stormwater is a problem, therefore, teaching them fills an important need.

APPENDIX 1

Stormwater Runoff Model (*From "The City" Lesson in UPRIVER: A Story Map Curriculum for Exploring Watershed Citizenship*)

When it comes to stormwater, there are multiple interdependent processes for students to understand: stormwater runoff, infiltration, erosion, turbidity, pervious and impervious surfaces. A good place to start is with an exploration of infiltration, which varies by surface and underlying substrate. Here is a fun way to begin: Cue up *A Watershed Story*. https://vimeo.com/264540625 and watch to the end of *Try it*! 07:49 min. Then, invite students to develop a way to model water

infiltration rates of different substrates. There are multiple ways to facilitate this depending on learning needs and the age of your students. Here are some options:

Option 1: Split students into four groups so the class creates its own set of models. Each group will create one. They can make temporary ones like in the *Try it!* clip. A useful addition to the one shown in *Try it!* would be to create a 4th container to represent an agriculture field or construction site. (Thus the need for four student groups). The teacher can have basic supplies on hand and have students create them in the class or at home. Teachers can add to the challenge by telling students they may only use recycled or repurposed materials.

Once students have created their demonstration stormwater model, they can vary and calculate the slope to see how slope impacts erosion, runoff volume, infiltration rates and runoff turbidity.

Sample Data Table

	Substrate 1		Substrate 2		Substrate 3		Substrate 4		
	___%Slope	___%Slope	___%Slope	___%Slope	___%Slope	___%Slope	___%Slope	___%Slope	
Runoff Volume (ml)									
Infiltration (Initial volume – runoff) (ml)									
Turbidity (NTU's)									
Time (sec)									

Option 2: Ask students to design and make a permanent structure to be used by their class and by future classes. Designing and building a permanent table would lead to a variety of engineering outcomes.

Option 3: Take students outside. Ask students to identify pervious and impervious surfaces in the schoolyard and create a way to measure infiltration on each surface.

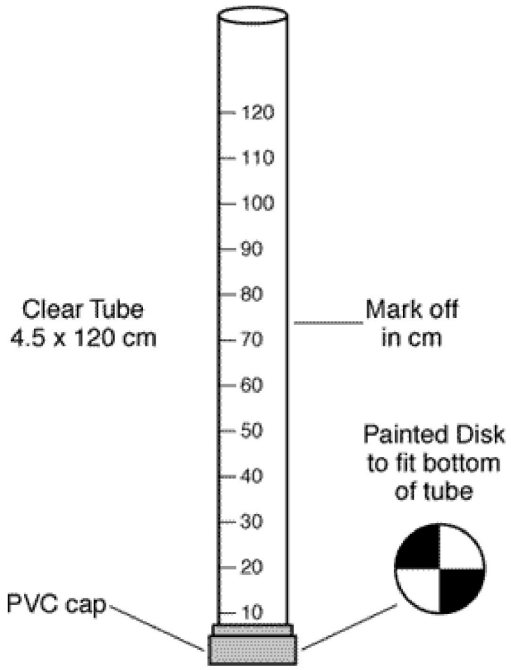
Regardless of the option you choose, turn this into a real inquiry, where students are predicting outcomes, gathering and recording data, analyzing it, and developing and sharing well-reasoned conclusions.
When students are finished, invite them to watch the rest of the clip *A Watershed Story* to consider impacts runoff can have on aquatic wildlife. https://vimeo.com/264540625. *Be sure to watch it all the way to the end. The very end. Beyond the credits.*

NorthBay's Turbidity Tube Directions

How to build a Turbidity Tube Video: https://vimeo.com/311988074

Materials Needed:

- One T-12 Tube Guard (fluorescent light tube plastic protective sleeve)
- One 1 ¼" PVC End Cap Tube Guard end cap (1 per each tube)
- Clear silicone caulk with caulk gun
- Secchi disk sheet
- Laminator with plastic sheets
- Scissors
- Cloth tape measure
- Rubber band
- Permanent marker

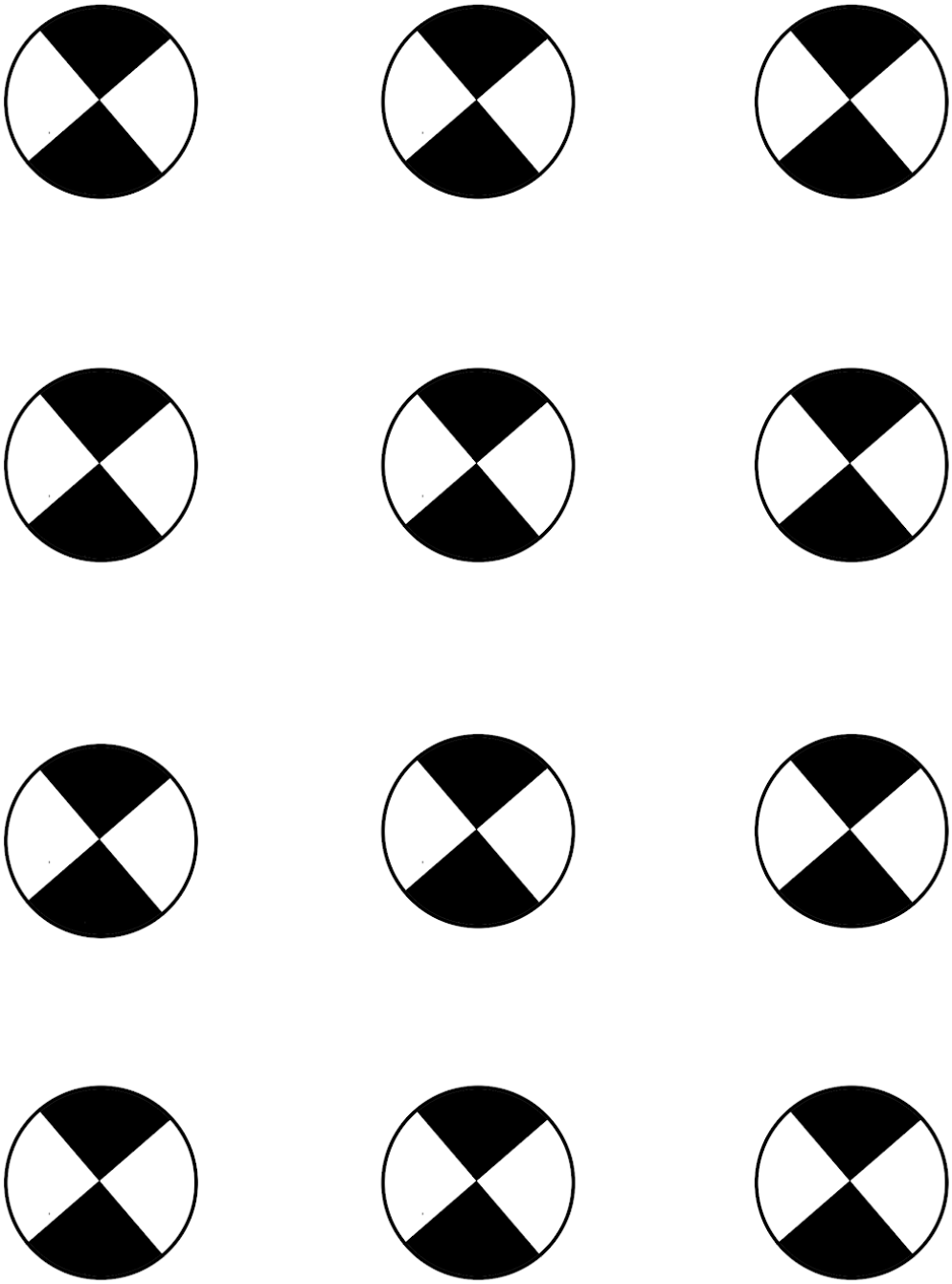


Directions:

1. Laminate sheet with secchi disk design
2. Cut out disks post-lamination
3. Re-laminate disks and cut out
4. Remove black end caps from T-12 tube guard
5. Turn one T-12 tube guard black end cap solid end up (rather than "cup" end)
6. Use clear silicone caulk, fasten secchi disk onto flat end of cap. Let dry at least 1/2 hour.
7. Apply silicone caulk to outer edge of black cap and insert into one end of plastic tube with secchi disk inside plastic tube. Let dry at least 1/2 hour
8. Apply silicone caulk to inside wall of white PVC plastic end cap and slide onto end of tube over black cap. Let dry at least 1/2 hour
9. Apply bead of silicone caulk around top edge of white PVC cap, smooth with finger to ensure water-tight seal

10. Using cloth tape measure, place beginning of tape at top of white PVC (where it meets the clear tube). Use the rubber band at the top end of the tube to secure the measure against the clear tube.

11. Mark off by cm (very near end of plastic tube).



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Stakeholder Perspectives

Stakeholder	Position (For, Neutral, Against)	Supporting Statements	Underlying Value	Level of Influence
Ex. Mayor Sandy Estrella	For	Our town needs this reservoir to increase tourist visitation	Economic	High

Completed Stakeholder Perspective Charts

Dredging: Article 1

Will Dredging Alleviate the Conowingo Dam Sediment Issue? The Washington Post.

https://www.washingtonpost.com/national/health-science/will-dredging-alleviate-the-conowingo-dam-sediment-issue/2015/04/05/fec9cb0e-c025-11e4-9271-610273846239_story.html

Stakeholders	Positions	Statements	Values	Level of Influence
Larry Hogan, Maryland's Governor	For, the sediment should be removed by Exelon	"The dam's sediment problem has been 'ignored for eight years'." "The dredging operation costing up to $250 million might be the answer to the bay's pollution problem, and the dam's owner, Exelon Corp., should pay most of that cost."	Political Economic	High
Exelon Corporation Executives, Owner of Conowingo Dam	Against, the sediment should not be removed	"Dredging isn't the answer" "Nutrients from phosphorus and nitrogen that run off farms and municipal sewer overflows are far more harmful to the Chesapeake" (based on a study by Army Corps of Engineers) "Less than a fifth of all sediments in the bay came from behind the Conowingo between 2008 and 2011" (based off a study by Army Corps of Engineers)	Economic	High
John Seebach, Senior Director of Federal River Management American Rivers	For, the sediment should be removed by Exelon	"They're going to get a 40-to-50 year license. The only time we can get [Exelon] to do something about these things is right now"	Environmental	Moderate to High
Dan Bierly, Chief of Civil Project Development Branch Army Corps	Against, the sediment should not be removed by Exelon	"The research brought together the foremost experts in this field" and "used the best and most trusted mathematical models" to arrive at the conclusion that "sediment itself doesn't really pose a major threat to the bay" "Nutrient pollution, not sediment, is what causes disease and oxygen-depleted dead zones that kill fish in the bay" "Dredging the dam would remove sediment, but the natural flow of the Susquehanna would replace it, forcing digging every year at a cost of hundreds of millions of dollars."	Scientific Environmental	Moderate to High
Chris Meekins, Spokesman for Rep. Andy Harris	Against, the sediment should not be removed by Exelon	"We need to consider all viable options to improve the health of the bay; whether or not dredging behind the Conowingo Dam is fiscally viable is yet to be seen."	Political Economic	Moderate
Beth McGee, Senior Water-Quality Specialist Chesapeake Bay Foundation	Against, the sediment should not be removed by Exelon	"Honestly, if it were as simple as saying we just need to dredge behind the dam, though it would be expensive, it would be one thing we could do. We could have pulled state and federal resources to go after dredging, but it's not a silver bullet."	Scientific Environmental	Moderate

Dredging: Article 2

Dredging Conowingo Little Help to Bay

http://www.baltimoresun.com/features/green/blog/bs-md-conowingo-bay-study-20141112-story.html

Stakeholders	Positions	Statements	Values	Level of Influence
Anna Compton, Biologist Army Corps of Engineers, Baltimore District	Against, the sediment should not be removed by Exelon	"We get very minor, temporary improvements to water quality in the Chesapeake Bay from these large amounts of sediment being removed"	Scientific Environmental	Moderate
Bruce Michael, Director of Resource Assessment Maryland Department of Natural Resources	Neutral, a watershed-wide cleanup needs to occur	"With the exception of the northern end of the bay, most of the Chesapeake's rivers aren't heavily affected by sediment or nutrient pollution from the Susquehanna. So to clean up the rest of the bay and its tributaries, communities across the state need to continue to upgrade sewage plants and reduce polluted runoff from cities, suburbs, and farms."	Environmental	High
Larry Hogan, Maryland's Republican governor (during his campaign)	For, the sediment should be removed by Exelon	"Oppose granting the company a long-term renewal of its license until it agrees to help remove the sediment."	Political	High
Alison Prost, Maryland Executive Director of the Chesapeake Bay Foundation	Neutral, a watershed-wide cleanup needs to occur	"The dam is one of many sources of pollution throughout the bay's drainage area." "To clean up the bay, we must clean up our local stream, creeks and rivers that feed it." "Exelon should be held responsible for its share of the problem...but the most cost-effective means of cleaning the bay is reducing pollution at its source."	Environmental	Moderate to High

Migratory Fish Article 1

Judge to Hear Arguments over Fish Passage at Conowingo Dam. Exelon Challenges Biologists' Recommendations For Upgrades and Offers An Alternate Plan
http://www.bayjournal.com/article/judge_to_hear_arguments_over_fish_passage_at_conowingo_dam1

Stakeholders	Positions	Statements	Values	Level of Influence
Exelon Corporation	Against, Exelon contends that upgrading the existing fish ladder and restoring an old program where the fish are trapped below the dam and then transported upstream past all four Susquehanna dams would improve fish passage and be less costly.	Upgrades too costly and are unlikely to achieve fish passage goals of 5 million shad and 12 million River Herring.. The fish are in decline up and down the east coast from multiple factors, such as bycatch and predation.	Economic Environmental	High
Dept of Interior	For, Exelon needs to invest and build new fish lifts to encourage higher passage rates	The dams are the reason the migratory fish populations are declining, since the population of shad in the Potomac river is increasing, and it is an undammed river. Since Exelon seeks a 46 year license, the Dept of Interior needs to be sure best practices are in place to support the fish populations in the long term.	Environmental Scientific Legal	Moderate to High
River Herring	Natural. No Dam	??	Ecological	Low
American Shad	Natural. No Dam	??	Ecological	Low
American Eel	Natural. No Dam	??	Ecological	Low

Migratory Fish Article 2

Scientists Find Shockingly Good News About Eels in PA river. Not Only Were Stocked Eels Faring Well in Buffalo Creek, But There Is Hope For Restoration of Eastern Elliptio Mussel Population.

http://www.bayjournal.com/article/scientists_find_shockingly_good_news_about_eels_in_pa_river

Stakeholders	Positions	Statements	Values	Level of Influence
Joshua Newhard, a fisheries biologist with the U.S. Fish and Wildlife Service Maryland Fisheries Resource Office	For, re-stocking rivers with eels whose migration routes were blocked by dams.	"We're not going five or 10 feet without catching an eel now." (The stocking efforts appear to be working).	Scientific Environmental	High
Steve Minkkinen, head of USFWS Maryland Fisheries Resource Office	For, restoring eels to historic upstream habitat. For, restoring mussels, who depend on eels to transport their young to the upper reaches of the drainage area.	Restocked eels expected to grow quickly as they take up residence in their former habitat. The mussels need the eels to transport them, and humans and other species need the mussels to clean the water.	Scientific/ Environmental	High
Exelon Corporation	For, a new license. Company may have to negotiate eel restocking to gain new operating license.	Transporting eels will add additional costs to operating budget. (This is implied, not explicit in the article)	Economic Legal	High
Biologists	For, a restored ecosystem	Want to know how eels and mussels will fare in the creek, which has changed a lot since eels were last abundant	Ecological Scientific	Moderate
Migratory Fish	Impacted by dams, overfishing, habitat loss and modification, invasive species	??	Ecological	Low

Links to Lists of Fish in Mid-Atlantic and Pacific Northwest States

MD
Maryland Fish (Freshwater and Saltwater)

NY
Small Prey fish
Common Minnows

OR
Oregon Native Freshwater Fish Species

PA
Pennsylvania Fish

VA
Virginia Fish

WA
Washington Department of Fish & Wildlife Freshwater Fish

WV
West Virginia Fish

Maryland Department of Natural Resources (MDNR)

This is a very useful collection of excellent stream-related resources for teachers
http://dnr.maryland.gov/streams/Pages/streamhealth/Teacher-Resources.aspx

National Geographic

Your students might be interested in participating in one of these National Geographic conservation missions as a way of highlighting and sharing their work in local streams/rivers.

https://www.nationalgeographic.org/projects/photo-ark/education/challenge/

NOAA

NOAA provides many valuable resources for educators, notably climate change resources.
http://oceanservice.noaa.gov/education/

Selected Study Protocols

Large Woody Material Measurement Protocols

This measure is important to include in a stream assessment because the amount of woody material in a stream influences stream "velocity, depth, and cover." (EPA Rapid Bioassessment Protocols, p. 5-5).

1. Only count and measure woody material (logs/limbs/root-wads) which are in contact with stream water.
2. "Each woody material formation with a surface area in the plane of the water surface >0.25 m^2 is recorded." (p. 5-4)
3. Record the estimated length and width of each formation. "Recorded length is maximum width in the direction perpendicular to the length. Maximum actual length and width of a limb, log, or accumulation are not considered." (p. 5-4).
4. Multiply the length and width of each large woody material formation, and add the products to give the aquatic habitat area directly influenced.
5. "This area is then divided by the water surface area (km^2) within the sampled reach (obtained by multiplying the average water surface width by reach length) to determine LWD [Large woody debris] density . . . .This density is not an expression of the volume of LWD, but rather a measure of LWD influence on velocity, depth, and cover" (p. 5-5).
6. Please contact NorthBay if you need support with this protocol.

Adapted from *EPA Rapid Bioassessment Protocols. Chapter 5: Habitat Assessment and Physiochemical Parameters* pp. 5-4 to 5-5.

Population Studies

Mark-recapture studies are commonly used to estimate population size, and to track movements of individuals within animal populations. Special scientific collection permits are required for this work. Animal use permits may also be required. Contact your state department of natural resources or fish and game agency to find out what is needed. Employees at these agencies are knowledgeable in their fields and can be helpful when you are designing a study. Moreover, they are often interested in the data your students may generate.

Before we share the procedures for population studies, we would like to present some thoughts about sample size for these experiments. Ideally, sample size is calculated based on a known or assumed variance in the population. However, the reality is that the sample size is usually defined by what you are able to catch in the amount of time allowed for the study. Expert advice can help define the ideal sample size, which is often a starting point for permitting purposes.

For crayfish studies, 10 individuals should be a decent starting point. Reality may be fewer, however. Clams and mussels will vary based on local conditions and species. Asian clams can have extremely high densities, so sample sizes of one hundred or more may be possible.

We will share three model study protocols in this section. The first is a bivalve population lesson that we conduct at NorthBay. The bivalves are not marked for this study. In addition to showing technique, the lesson shows how to integrate life lessons into a population study. The second study protocol we include here is drawn from our experiences. It is an example of a mark-recapture study. While the procedure is specifically designed to estimate populations, we propose that students adapt it further

to study movement. Methods for movement within a population study, the third protocol, are presented after the marking study protocol.

In the final section we will briefly visit plant surveys. As with all the methods we share, we recommend consulting in-depth methods sources for more detailed explanations and procedures, especially if you and your students intend to publish your work. We include a few suggestions in the resources section. Lastly, the USGS, EPA, USFWS, state Departments of Natural Resources, and scientific journals accessible on library databases are all useful and valuable sources of background knowledge and techniques developed over time.

Population Estimates for Bivalves Without Mark-Recapture - NorthBay's Lesson for Bivalves in the Chesapeake Bay

TIME NEEDED: 2.0 hours

Objectives

- Students will use background knowledge and investigative strategies in order to determine the function and importance of bivalves in the Chesapeake Bay.
- Students will use mathematical strategies to quantify the local populations of diverse species of bivalves.

Equipment needed:

- Weighted ¼ meter quadrats with a float attached. One per group.
- Small Buckets. One per group.
- PFDs for work in the water. All students must be in life jackets.

Vocabulary

· Filter · Diversity · Habitat · Abiotic · Biotic
· Exotic · Invasive species · Niche · Bivalve · Native

INVITATION

Take students to the beach. Orient them to where they are. (Upper Chesapeake Bay where the mighty Susquehanna fills the upper bay with freshwater etc.) Then set boundaries, and ask, “Who lives here?” “How do we know?”

EXPLORATION.

After this very brief introduction, send the students off to find “evidence,” which in this case are objects that capture their attention. An alternative would be to take students to the beach, set boundaries, and send them on a biotic/abiotic scavenger hunt, where students are asked to find a predetermined number of biotic and abiotic objects. After students explore and collect, have them gather together to share their finds. This could be in a circle with toes touching and the objects in the middle; or a “pair-and-share” (one-on-one arrangement) with a partner; or you can lay out objects on the beach for everyone to see. Whatever method you use, when students are gathered together, please ask intentional questions such as:

How are the objects the same?

How are they different?

What do you notice?

What do you wonder?

What does your object/subject remind you of?

If it makes sense for your students, ask them to draw what they find in their journals before you ask the questions.

CONCEPT INVENTION

Background

Bivalves play an important role in the ecology of the Chesapeake Bay. One of the most difficult problems that face the bay is erosion and subsequent sedimentation. This is the

process of soil washing off of the land and becoming suspended in the water column. Bivalves serve to improve the water clarity in the bay and allow fish to breathe freely in the waters. This is possible because just under a clam's shells are the mantles, which secrete the shells. Under the mantles are the gills. Like the gills in fish, these serve to extract dissolved oxygen from the water -- but they also serve other functions. The gills are covered with mucous and thousands of tiny finger-like structures called cilia. When water passes over the gills, the mucous traps small particles and then the cilia, in a waving motion, pass them toward the clam's mouth, where food is separated from sediment. This feeding activity plays an important role in keeping water clear.

Bivalves and other mollusks also are important as food for other organisms, like waterfowl. With the loss of much of the eelgrass in the bay, the canvasback ducks switched their diet to primarily small clams. Many of the smaller species are eaten by fish. And, it is not unusual to see an otter, mink, or raccoon having clams for lunch.

There are three predominant species of bivalves in the shallows of NorthBay, but we find as many as six. They include freshwater mussels that leave trails on the muddy bottom as they extend their foot. Once, freshwater mussels were manufactured into buttons. With the plastics industry, came the elimination of mussels for that purpose. Today, the Japanese pearl industry uses freshwater mussel nacre (the inner layer of the shell) for seeds to make pearls in Japanese oysters.

Clams and other bivalves are benthic macroinvertebrates known as biological indicators because they are sensitive and reliable indicators of habitat quality. Since they are not particularly mobile, they cannot escape environmental problems. Their population will be diminished or absent in polluted areas. Freshwater mussels are the only bivalves found at NorthBay that are native to the Chesapeake Bay. At this time, their population is low compared to other bivalves in the bay. The loss of mussels has a large impact on the variety of animals that use them for food. Brackish water clams were introduced into the Chesapeake Bay around the 1960's. They are an exotic species, thought to have arrived in the bay by way of ballast water collected in ports from the mid-Atlantic south to the Gulf of Mexico. Asian clams, the most populous here, are from Southeast Asia.

How they got into U.S. waters is unknown, although it is suspected they were brought over for food and released into the water. They can attach themselves to pipes of power plants and hydroelectric facilities and cause expensive fouling problems. They have the potential to outcompete native clams for food and space.

The most recent nonnative bivalve showing up in the bay is the Zebra mussel. According to USGS (http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=5), the zebra mussel is a small shellfish named for the striped pattern of its shell. Color patterns can vary to the point of having only dark or light colored shells with stripes absent. It is typically found attached to objects, surfaces, or other mussels by the byssal threads it creates in a gland. Zebra mussels are filter feeders having both inhalant and exhalant siphons. They are capable of filtering about one liter of water per day while feeding primarily on algae.

Native to the Black, Caspian, and Azov Seas, they have proven to be an invasive species in the United States. They clog intake pipes, outcompete native bivalve populations, and disrupt the food chain. They have been especially disruptive in the Great Lakes ecosystems. People inadvertently transport these small bivalves that attach to boats and trailers and enter ballast water.

At NorthBay, we find the following bivalve species:

Asian Clam (*Corbicula fluminea*)
Brackish Water Clam (*Rangia cuneata)*
Tidewater Mucket (*Leptodea ochracea)*
Alewife Floater (*Anodonta implicata)*
Eastern Elliptio (*Elliptio complanata*) and possibly another elliptio species
Zebra Mussel *(Dreissena polymorpha*)

Events/Phenomena

Nonnative species have moved into the Chesapeake Bay.

NorthBay built breakwaters to slow down the water approaching the dock and beach.

The conversion of land from forests to agriculture and buildings and roads has increased surface runoff into the bay.

Problems

Nonnative species have unknown impacts on native species.

The breakwaters changed the wave energy and impacted sand movement up and down the beach.

The breakwaters likely have an impact on local animal populations by changing the local habitat.

The extensive forests in this region once buffered the bay, now agricultural and urbanizing landscapes in the region surrounding the upper bay sends more sediments and pollutants to the bay.

Issues

1. Exotic clam species have moved into the bay. They filter the water, thus improving water clarity. Because they are exotic, however, they may have negative impacts on native species and on public works projects.
2. Pollution from land use practices has a negative impact on bivalves and other bay biota.
3. NorthBay built breakwaters to reduce beach erosion. The breakwaters most likely impact bay species. We are trying to determine what those impacts are.
4. The breakwaters might provide habitat for nonnative species, such as Zebra mussels.

PLAY the game Sediment – Sediment to model the effects of pollution on the bay and how pollution has contributed to bivalves not being able to keep the bay as clean as in years past. This active game should set students up to learn more about the role of bivalves in the Chesapeake Bay watershed, and also to introduce them to the ideas that what happens on land impacts the bay.

HOW TO PLAY Sediment-Sediment: Define for the students what sediment is. Have entire class stand shoulder to shoulder in a line on one end of a field. Choose one student to be the “Tree Planter”. Once this student says “Sediment, sediment, roll down my hill!” all students (or “sediment”) run to the other side of the field. The tree planter’s job is to try to tag students as they run past. Once a student is tagged he or she is then “planted” by the tree planter and become a tree. The “trees” may pivot and move their arms, but are otherwise stationary. Their job is to catch the “sediment” as they run to the other side. Once all sediment is tagged, the game is over. Debrief the game by explaining the importance of trees in preventing erosion, and keeping sediments out of the bay. While bivalves are powerful filters, their diminished numbers coupled with the increase in sediments and nutrient pollution flowing into the bay mean the bay is not as clean as it once was and could be. The bay’s health is impacted by the surrounding land use.

Integrate new knowledge created/discovered by students during their explorations and the game with the four points that follow, and weave in event-problem-issues and vocabulary words as you can:

1. Discuss invasive species, exotic species, introduced species. Are all exotic species invasive? What makes something invasive? Use the Beetles discussion technique suggestion: “Thought Swap”
http://beetlesproject.org/cms/wp-content/uploads/2015/12/Discussion-Routines.pdf

2. Discuss biotic and abiotic. Make sure students have a solid grasp of the dependency of biotic on the abiotic ecosystem elements if not covered earlier in the week. If discussed earlier, briefly revisit.

3. Make sure students have a solid grasp on the concepts of diversity, filters, and invasive species (specifically noting the difference between invasive and exotic spp).

4. Discuss pollution and the role native and nonnative bivalves play in water clarity and quality.

APPLICATION

Study Design

Through discussion that follows from exploration and concept invention, guide students to formulate their research question for the class. Here are a few to help guide you.

Research Questions

Does the breakwater at NorthBay affect the diversity and abundance of bivalves?
Are exotic species of clams abundant at NorthBay?
Is there mortality in Asian clams at NorthBay?
Develop your own question.

Data Collection

After students copy the research question in their journals, they can copy the chart below.

Table 1. Table for Bivalve lesson from the dock or in the bay.

Bivalve Species	**# alive**	**# dead**
Asian clam (Nonnative)		
Tidewater Mucket (freshwater mussel)		
Eastern Elliptio (freshwater mussel)		
Alewife Floater (freshwater mussel)		
Brackish Water Clam (Nonnative)		
Zebra mussel (Nonnative)		
Total		

Ask students for ideas about how the group can sample the clams. Take a few minutes to discuss sampling. Ask, “Can we sample the whole bay?” We cannot. Therefore, we survey a subset of the bay, a representative sample. For this study we use ¼ meter quadrats. Oftentimes meter quadrats are used in ecological sampling. When we use a measuring instrument of a known size, we can estimate the area we are sampling. Ask, “Why do you think it is important to know the size of the area sampled?” If your group is receptive, discuss types of samples. *Convenience* sampling is performed as a matter of convenience to the scientist and provides the least representative results. An example of this would be collecting and identifying bivalve shells washed up on the beach. *Systematic sampling* occurs when the samples are acquired using a system, such as placing a quadrat down every 10 meters along a transect line and counting the bivalves within it, and yields more representative results. *Random sampling* is a technique where all members of a population have an equal chance of being represented; it is the most accurate. Using numbers generated from a random number table to represent coordinates, students would place the grids within a designated area and count and

identify bivalves. Have students decide which type of sampling they will use in this study.

Clearly explain sampling directions:

- Assign each group a location.
- Set clear boundaries and go over safety instructions (life jackets on snugly and zipped up, group stays together)
- Drop quadrat onto bay bottom a predetermined number of times in a predetermined pattern. Keep track of where it is at all times!
- Assign tasks to each student (recorder, sampler, quadrat carrier, etc.).
- Have students one at a time pick up bivalves found within the quadrat and gently place in bucket.

Guide each small group to their location and review the directions and goals. Make sure each group knows the number of times they are to move the quadrat to determine the total number of samples.

Move between small groups helping with identification, keeping them on task, answering any questions they may have.

After 20 to 30 minutes have each group sort and count their bivalves, and record their numbers, then return the bivalves to where they found them (Best method is to count bivalves in the water and record numbers back on dry land. If animals are taken back to beach/dock, one group member needs to get back in the water to return them).

Regroup your class, have all groups return buckets and quadrats.

Ask the recorder for each group to add their data to the group chart on the whiteboard.

Data Evaluation

Reassemble the entire class and have them report out each group's results. They should share not only numbers, but also observations. For example, was there baygrass where they dropped their quadrats? Was the water calm/rough? Were they inside/outside breakwater? Was the water really deep or shallow? How might any of these conditions have impacted what they found?

Use the entire class's data to construct a bar graph. If you have time, determine ratios and percentages of different species found. Reflect on what the numbers may indicate.

Discuss how your study design could be improved.

Ask, "Do your results beg to answer a new question?" If so, what would a new study you design look like?

REFLECTION

Conclusion and Recommended Actions

- Have students develop and write a conclusion using the Claim, Evidence, Reasoning model.
- Discuss how they came to this conclusion. Ask them to consider recommendations for future research; for example, what might they do differently if they were to repeat this study.
- Discuss: "What factors might have a negative effect on bivalves?" "Why is it important for us to know about bivalves in the bay?"

"What action will you take to protect the bay?"

An idea for lesson wrap up is: With a dramatic flourish, erase all data on whiteboard and ask, " What do these results have to do with us humans, meaning, why should we

care?”

Character Connections

Bivalves fill a significant niche in the bay. They filter sediments as well as excess nutrients and pollutants from the water. People can have filters to help reduce the toxins in their lives. Have students identify the people who act as filters in their own lives. Parents, teachers, friends, older siblings, grandparents, aunts and uncles, mentors.

When land is developed and all trees are removed, the land becomes degraded for all wildlife, and the impacts extend into other ecosystems, like streams, rivers, and the bay. Increased runoff from developed impervious surfaces brings more sediments into the tributaries that lead to the bay, making life more difficult for the wildlife that live there. This is called a degraded condition. Have students identify a degraded condition in their lives.

Degraded conditions can be improved. NorthBay has upgraded the condition of the land after development through tree planting initiatives, removal of invasive species, and meadow restoration projects. How can you have a positive impact on the degraded condition in your life? Picking up litter, helping with chores, staying out of trouble, tutoring a friend, finding great filters, giving your best effort to your schoolwork.

Discuss diversity and how it relates to their lives; lead them to understand that the world is made up of all sorts of people, just like the bay is made up of all sorts of organisms. Explain that it is important to accept all aspects of diversity in life. In ecosystems and in human communities, diversity leads to resilience and strength.

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Marking Protocols

Here is how to conduct a mark-recapture study for bivalves or crayfish.

1. Randomly place in a representative section of a waterway a weighted ½ or ¼ meter quadrat a predetermined number of times. Collect all the bivalves in the sample. Mark them all. To mark the shell of an organism, place a dot of nail polish on the shell. Allow it to dry. Place organism back in the specific locations where they were captured.
2. Mark sample areas with flags. After a predetermined amount of time, return to the site and collect all animals within the sample area. Then determine the population using the following equation. N = Mn/R

Where:

N = Population size

M = Marked animals

R = Recaptured animals

n = Second population sample

(Brower, Zar, von Ende, 1998, p. 124).

3. For crayfish that are being hand caught, use this equation to estimate populations:

N = M(n + 1)/R + 1

Where:

N = Population size

M = Marked animals

R = Recaptured animals

n = Second population sample

(1998, p. 125).

Studies using Mark-recapture methodology to understand movement over time:

For studying the movement of bivalves, mark every animal within a ½ or ¼ meter square quadrat and return them to that same quadrat. Outline the quadrat with flags or something else that will not float away in the stream and become debris, so the site can easily be found again in the next day or so. Remove the quadrat. During the second visit, place ½ meter quadrats near the original site to see if the animals have moved or not. Measure distance, direction of movement and take extensive notes that describe everything in the habitat you observe. One never knows what detail may lead to a whole new way of looking at an organism or a habitat.

For studying the movement of crayfish, carefully hand catch animals, or catch them with a seine net. Mark each animal, and return to the location where it was captured. Come back next day to see if they have moved. Consider the following questions: Have they moved to a similar habitat? A different habitat? Is a riffle area a barrier to their movement or have they moved from one pool to another one? Are there other observations worth noting?

Plant Sampling

Studying plants along stream and riverbanks reveal even more of a stream's story. Worth exploring are populations of certain species; density, diversity---relative frequency--differences in buffer width and their impacts on stream conditions; relationships between plants on the banks and aquatic organisms in the adjacent waters. Plants can be measured using plot sampling methods or transect sampling methods. Plant identification can be somewhat intimidating, but don't let that stop you. Plants can be identified using keys, by using online plant guides, or depending on learning goals, they can simply be labeled as species 1, species 2, etc.

In addition to studying the richness (variety) and abundance of plants in a particular area, there exist also community vegetation study protocols that look at plant forms, structures and roles in the landscapes. (See Brower, Zar, von Ende, 1998, Chapter 5a, for example.)

Plant guides

[Native Plants for Wildlife Habitat and Conservation Landscaping Chesapeake Bay Watershed]

[Plants of the Chesapeake Bay: Lady Bird Johnson Wildflower Center]

Mobile plant ID apps exist but we have not found one that is particularly accurate. If you know of one that is, please share it with us!

Regardless of what you and your students choose to study, let your learning goals dictate choices, and high quality thinking dictate methods.

Seine Net Fishing in Coastal Streams* Throughout the Chesapeake Bay Watershed

Seine nets are a great way to engage multiple students in a sampling procedure. When the first net-full of fish is pulled up, student engagement and excitement increase exponentially. Here is how to seine.

Extend the net, held up by two or three people, across the width of the waterway. The bottom of each pole at either end of the net should be held forward of the top of each pole. This ensures that fish that are captured stay in the net. Next, have a group of students travel a specified distance upstream along the streambanks. Once they reach the designated point, they should step into the water. Then standing shoulder to shoulder, preferably spanning the width of the stream, these students should walk slowly and deliberately towards the seine net, which is downstream. This should move the stream organisms towards the net. Upon arriving at the seine net, they should lift up their side of the net, making a hammock with it. Other students should take the fish and other animals out of the net, place them in buckets of cool stream water to maintain

oxygen levels, and once all the fish are gently removed from the net, identify them. Afterwards, the fish should be released gently back into the stream where they were captured.

This YouTube video from Powhatan school in the Chesapeake Bay watershed, shows how to use a seine net in a stream: How to use a seine net in a stream

List of Materials

A reference for fish studies
Seine Nets (2)- Check regulations for each state below
Dish tubs or 3 to 5 Gallon Buckets
5 Scoop Nets (small)- optional

*Nets get caught on rocks in upland/Piedmont streams.

SPECIAL State Regulations (Licenses and Seine Net Sizes)

MD

Seine net Regulations for non tidal areas are:

- Must have mesh no greater than ¼ inch
- Must not exceed 6 feet in width and 4 feet in height
- Must only be used to catch minnows and baitfish
- May not be used within 50 feet of a dam or the mouth of any river or tributary

NY

Seine Net Regulations: 518-402-8845,
Licenses: Adults- If possess NY driver's license-$25, if not $50 per year

PA

Seine Net Regulations:

- Must not exceed 4 feet in any direction

Licenses:

- 1 person must possess a PA Fishing license, apply for FREE Educational permit

VA- National Park Shenandoah County, George Washington National Forest

Call: 540-265-5100

WV

Seine Net Regulations:

- No longer than 6 feet, no deeper than 4 feet.

Licenses:
· Scientific Collecting Permit $25
http://www.wvdnr.gov/wildlife/scollectpermit.shtm
Contact: Barbara Sargeant (304) 637-0245

Speakers Who will Visit Classrooms

Speakers Link

Standards Met

Standards addressed in the course *Tributaries for Life: A Watershed Inquiry*

Maryland Environmental Literacy Standards

STANDARD 1 ENVIRONMENTAL ISSUES

The student will investigate and analyze environmental issues ranging from local to global perspectives and develop and implement a local action project that protects, sustains, or enhances the natural environment.

Topic A: Environmental Issue Investigation

Indicator 1: Identify an environmental issue
Indicator 2: Develop and write research questions related to an environmental issue
Indicator 3: Given a specific issue, communicate the issue, the stakeholders involved and the stakeholders' beliefs and values.
Indicator 4: Design and conduct research
Indicator 5: Use data and references to interpret findings to form conclusions

Topic B: Action Component

Indicator 1: Use recommendation(s) to develop and implement an environmental action plan.
Indicator 2: Communicate, evaluate and justify personal views on environmental issue and alternate ways to address them.

Indicator 3: Analyze the effectiveness of the action plan in terms of achieving the desired outcomes.

How this standard is met: This standard is met in its entirety in our course. We ask teachers to learn and practice inquiry and upon completing this professional development course, guide their students through the same process.

STANDARD 4 POPULATIONS, COMMUNITIES AND ECOSYSTEMS

The student will use physical, chemical, biological, and ecological concepts to analyze and explain the interdependence of humans and organisms in populations, communities and ecosystems.

Topic A: Cycling of Matter and Energy

Indicator 1: Explain how organisms are linked by the transfer and transformation of matter and energy at the ecosystem level.

Topic C: Community and Ecosystem Dynamics

Indicator 1: Explain how the interrelationships and interdependencies of organisms and populations contribute to the dynamics of communities and ecosystems.

How this standard is met: Topics A and C are met in the section of the course on stream ecology where teachers, and later, their students, learn about the cycling of nutrients between a stream/river ecosystem and the surrounding riparian forest.

STANDARD 5 HUMANS AND NATURAL RESOURCES

Topic A: Human Impact on Natural Processes

Indicator 1: Analyze the effects of human activities on earth's natural processes
Indicator 2: Analyze the effects of human activities that deliberately or inadvertently alter the equilibrium of natural processes.

How the standard is met: Topic A is addressed when teachers, and later, their students, make a model of a local watershed and design an experiment to demonstrate the effect of land use on runoff quantity and quality.

STANDARD 7 ENVIRONMENT & SOCIETY

The student will analyze how the interactions of heredity, experience, learning and culture influence social decisions and social change.

Topic A: Environmental Quality

Indicator 1: Investigate factors that influence environmental quality.

Topic B: Individual and Group Actions and the Environment

Indicator 1: Examine the influence of individual and group actions on the environment and explain how groups and individuals can work to promote and balance interests through:

Topic C: Cultural Perspectives and the Environment

Indicator 1: Investigate cultural perspectives and dynamics . . ..

*For this standard, Indicator 1 is met for Topic A and Topic B.

How this standard is met: Topic A is met when teachers, and later, their students, complete a Stream Corridor Problem Assessment to look for readily apparent problems such as a pipe discharging effluent, and then later in course, when they complete the comprehensive Stream Health Assessment. After the assessments are completed the teachers and their students will trace backwards from the findings to uncover the possible sources of environmental contaminants.
Topic B and Topic C are partially addressed in an assignment whereby we ask teachers who later, ask their students, to investigate migratory fish that live/have lived nearby and report on their current status, efforts to restore them and cultural significance.

Next Generation Science Standards

LS2-7 Ecosystems: Interactions, Energy and Dynamics for Middle and High School students.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations**.**

How this standard is met: This standard is met when learners perform stream assessments and compare their findings to established standards.

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

How this standard is met:
This standard is met when learners develop an action plan based upon their research findings.

Science and Engineering Practices for Middle School

- Analyze and interpret data to provide evidence for phenomena
- Construct and explanation that includes qualitative or quantitative relationships between variables that predict phenomena.
- 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

Science and engineering practices are met when learners complete a research project that leads to action.

Disciplinary Core Ideas met for Middle & High School

LS2: Interactions, Energy, and Dynamics Relationships in Ecosystems (MS); Ecosystems: Interactions, Energy, and Dynamics (HS).

LS2.A: Interdependent Relationships in Ecosystems.

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems.

LS2.C: Ecosystem Dynamics Functioning and Resilience

LS4.D: Biodiversity and Humans

ETS1.B: Developing Possible Solutions

How the Disciplinary Core Ideas are addressed: Students learn about Interdependent Relationships in Ecosystems and the next disciplinary core idea, Cycles of Matter and Energy Transfer in Ecosystems when they learn about the cycling of nutrients between a stream/river ecosystem and the surrounding riparian forest. Moreover, they deepen understanding of human interdependence with riparian systems when they consider how human-caused issues impact interconnected waterways and the biota that inhabit them. Rigorously evaluating stream health using standardized protocols illuminates the functioning or dysfunctioning of the stream system under study and addresses the third disciplinary core idea in this strand: Ecosystem Dynamics Functioning and Resilience. The fourth disciplinary core idea, Biodiversity and Humans, is addressed when learners consider the effects of human caused pollution on biodiversity in light of our dependence on biodiversity to maintain health. The final disciplinary core idea in this group, Developing Possible Solutions, is addressed when students systematically evaluate potential solutions to the problems their investigations uncover.

Crosscutting concepts addressed for Middle and/or High School

Patterns (Middle School)

Cause and Effect (Middle and High School)

Energy and Matter (Middle and High School)

Stability and Change (Middle and High School)

How the Crosscutting Concepts are addressed: Students explore all four cross-cutting concepts when they look for patterns in the data they collect and consider the possible causes that led to their research findings. They learn about the flow of energy and matter as they consider the relationships and interactions between a stream, a stream's inhabitants and the soils and inhabitants of the neighboring riparian forest. After collecting a variety of data, students consider how a stream is impacted by human activities. Lastly, students consider the cumulative impacts of local stream health on the Chesapeake Bay.

Common Core Standards for ELA/Literacy (College and Career-Ready Standards)

Middle School Statistics and Probability Standards

CCSS.MATH.CONTENT.6.SP.A.1

Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.

How the standard is met: This standard is met when students develop study designs that incorporate statistical methods to answer their research question.

CCSS.MATH.CONTENT.6.SP.B.5.B

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

How the standard is met: This standard is met when students develop study designs that incorporate statistical methods to answer their research question.

Middle School Writing Standards

CCSS.ELA-Literacy.W.6.1

Write arguments to support claims with clear reasons and relevant evidence.

CCSS.ELA-Literacy.W.6.1.A

Introduce claim(s) and organize the reasons and evidence clearly.

CCSS.ELA-Literacy.W.6.1.B

Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.

CCSS.ELA-Literacy.W.6.1.C

Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons

CCSS.ELA-Literacy.W.6.1.E

Provide a concluding statement or section that follows from the argument presented.

How the standard is met: These standards are met when students summarize research project findings.

High School Science & Technical Subjects Standards for 9 – 10th grade

Integration of Knowledge and Ideas

CCSS.ELA-Literacy.RST.9.10.7

Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

How the standard is met: These standards are met when students present research data from their studies.

High School Writing Standards for 9 – 10th grade

Research to Build and Present Knowledge.

CCSS.ELA-Literacy.WHST.9-10.7

Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

How the standard is met: This standard is met when students develop and conduct their own research based on field observations and background research.

High School Science & Technical Subjects Standards for 11th-12th grade

Research to Build and Present Knowledge.

CCSS.ELA-Literacy.WHST.11-12.7

Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

How the standard is met: This standard is met when students develop and conduct their own research based on field observations and background research.

Integration of Knowledge and Ideas.

CCSS.ELA-Literacy.RST.11-12.9

Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

How the standard is met: This standard is met when students write a report based upon their own research, but informed by prior background research.

High School Writing Standards for 11th – 12th grade

Text Types.

CCSS.ELA-Literacy.WHST.11-12.2.a

Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

How the standard is met: This standard is met when students write their research report, beginning with the research question and including the study design, findings, analysis, conclusion, and lastly, a plan for action.

Stream Problem Assessment from MDNR

Stream Corridor Assessment Appendix C

Stream Health Assessments from MDNR

High-gradient stream

Low-gradient stream

Useful References for Fish Sampling Methods

Bonar, S., A., Hubert, W. A. Willis, D. W., Eds. (2009). *Standard methods for sampling North American freshwater fishes*. Bethesda, MD: American Fisheries Society.

Brower, J. E., Zar, J. H., & von Ende, C. N. (1998). *Field and laboratory methods for general ecology*. Boston: McGraw-Hill.

Useful References for Stream Ecology Sampling Methods

Hauer, F. R., Lamberti, G. A., Eds. (2007). *Methods in stream ecology*, 2nd Edition. Elsevier: London.

Izaak Walton League. *Key to stream macroinvertebrates*. Retrieved October 2015 from http://www.creekfreaks.net/sites/default/files/attachments/key%20to%20stream%20macroinvertebrates.pdf

Mitchell, M. K., Stapp, W. B., & Beebe, A. (1986 or 1994). *Field manual for water quality monitoring: An environmental education program for schools*.

Plafkin, J. L., Barbour, M. T., Porter, K. D., Gross, S. K., & Hughes, R. M. (1989). *Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish* (EPA/440/4-89/001). Washington D.C: EPA.

Yetman, K. (2001, September). *Stream corridor assessment survey: Survey protocols*. Annapolis, MD: Watershed Restoration Division Chesapeake & Coastal Watershed Services Maryland Department of Natural Resources.