Monitoring Water Quality in the Charles River

Grade: Grade 9
Place of Focus: Stream(s) in town listed as part of priorities from the Municipal Vulnerability Plan (MVP)
Citizen Science Protocol:

- Stream Selfie
- Assessment of Stream from Charles River Watershed Association Biological Monitoring Training
  - Form A2 Habitat Assessment Reference Guide
  - From A2 EPA Habitat Assessment Form
- Earth Force Stream Monitoring (Stream Ecology testing kit)

Massachusetts Curriculum Framework for Science and Technology/Engineering Standards

- **HS.LS.2.2.** Use mathematical representations to support explanations that biotic and abiotic factors affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem.
- **HS-LS2-7.** Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.

Learning Objectives

By the end of the field lesson, students will:

- Assess a stream habitat's condition using a modified rubric from the Charles River Watershed Association
- Run tests in situ to determine the abiotic water quality parameters
- Collect and identify benthic macroinvertebrates to assess biodiversity
- Utilize bioindicators of stream health by calculating the Pollution Tolerance Index Score

Pre-Visit Learning

Prior to the site trip, students should understand:

- What a Habitat Assessment is and some of the features that will be looked at:
  - Habitat Assessment Factsheet on Water Quality Parameters
  - Charles River Watershed Association Biological Monitoring Training
  - Video with examples of each parameter: "Become a Biological Monitor!"
- What macroinvertebrates are and have practiced identifying them using Macroinvertebrates.org
- How to use the macroinvertebrate data to calculate Pollution Tolerance Index Score - see leaf-pack-network-biotic-index-sheet (1).pdf

Essential Questions

Is this stream considered an optimal ecosystem or a poor one?

Guiding Questions

1. What is the habitat condition of this stream?
2. Are there acceptable abiotic conditions for dissolved oxygen, nitrate, phosphate, pH, turbidity & temperature present?
3. Is there a high biochemical oxygen demand or coliform bacteria amount?
4. What is the ratio of organisms that indicate high vs. low pollution in our stream?

Field Visit Preparations

Time

1.5 - 3 hours

Materials and Supplies

- Phone or camera for taking a picture of the stream to upload to Stream Selfie
- (x1) Carolina Dichotomous Identification Key to Freshwater Macroinvertebrates, Pack of 6, Item #: 652007 $50
- (x1) Carolina Earth Force® Standard Water Monitoring Kit, Item #: 652568 $329.00
- (x1) United Scientific Prism Microscope, 40X, Mfr # MCRPR1, Zoro # G6162406 $65.19
- (x2) Coopay 20 Pieces Bug Viewer Critter Insect Cage Magnifying Insect Box Bug Magnifier Container Bug Catcher Cage, Science Nature Exploration Tools $13.99
- (x2) FISHINGSIR Fishing Waders for Men with Boots Womens Chest Waders 2-Ply Nylon/PVC Waterproof for Hunting with Boot Hanger, Size M05/W07, $39.99

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Materials and Supplies (cont.)

- (x2) FISHINGSIR Fishing Waders for Men with Boots Womens Chest Waders 2-Ply Nylon/PVC Waterproof for Hunting with Boot Hanger, Size M10/W12, $39.99
- (x2) FISHINGSIR Fishing Waders for Men with Boots Womens Chest Waders 2-Ply Nylon/PVC Waterproof for Hunting with Boot Hanger, Size M13, $39.99
- (x1) Carolina Kick Net, 1 x 1-m, 500-µm. $167.50
- (x1) ePackageSupply 5 Gallon White Bucket & Lid, Made in The USA, Durable 90 Mil All Purpose Pail, Food Grade, Contains No BPA Plastic, Premium HPDE, 3 Pack $18.99
- (x3) Mason Jars 32 Oz Glass Extra Wide Mouth Quart Storage Jars 32 oz with Lids - BPA Free Plastic Storage Lids - Made in USA - Quart Glass Jars 32 oz with Lids (Set of 2) $18.95

Logistics

- If we are taking a bus to a site not within walking distance, an effort should be made to find a space with parking. Rosemary Lake is close by and has public restrooms.
- We need to find a stream access that is close enough to public restrooms for any emergencies, but students should go to the bathroom before leaving school and upon return.
- We will set up a muster site where all equipment is brought and sorted at least 15 feet from the bank of the stream.
- A 50-100m stretch of stream will be marked off and all groups will have spots within that range.

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Logistics

- Students will be placed into their lab groups and special jobs will be designated:
  - **Water Collector.** Member will don the waterproof gear and be responsible for wading to collect the water for water quality tests, and later working the kick net. (May be useful to make lab groups with one person who fits the equipment and is willing to wade as the first consideration.)
  - **Equipment Collector.** Member will inventory and ensure proper equipment and instructions for each test or task.
  - **Equipment Returner.** Member is responsible for tidying/cleaning the equipment after each test and for returning equipment to the muster site, waste to appropriate containers, and organisms to stream at the end of the trip.
  - **Data Checker.** Member is responsible for making sure that every member has their data written in their notebooks/worksheets before moving on to the next test/task.
- All students will be working on Stream Selfie and Habitat Assessment first. We will muster and distribute the chemical test equipment and a rotating schedule.
- After all groups have conducted chemical tests we will muster and distribute macroinvertebrate sampling equipment.
- The teacher will walk with the kick net starting downstream and each Water Collector will kick at their group's location until the end of the sampling run. The Kick Net contents will be dumped into a collection vessel and each group will take a container sample to conduct their macroinvertebrate identifications.
- As groups finish they will come back for more samples until the collection vessel is empty.
- Once groups are done, the Equipment Returner of each group will bring back the equipment to the muster point where we will gather and groups will tally and reflect.

Scientific Protocol

We will participate in taking a picture of the stream for Stream Selfie. Student phones and/or digital cameras will be used. Location will be noted for later data input.

We will rate the habitat using a rubric from the Charles River Watershed Association Biological Monitoring Training and Habitat Assessment Form Form A2: EPA Habitat Rapid Bioassessment Protocols.

- Habitat Assessment Reference for Form A2: Form A2 Reference Guide

We will use the Earth Force Stream Monitoring (Stream Ecology testing kit) to conduct tests on Biochemical Oxygen Demand, Coliform Bacteria, Dissolved Oxygen, Nitrate, pH, Phosphate, Turbidity, Temperature.

- Test protocols found in the Manual. 5848 Water Monitoring Kit Manual.pdf

We will collect macroinvertebrates using the same Charles River Watershed Association Biological Monitoring Training.

- Helpful explanation from the EPA

We will use the Pocket Macros app/Dichotomous Macroinvertebrates Key to identify and collect data in the Biotic Index Data Sheet: leaf-pack-network-biotic-index-sheet (1).pdf to be able to calculate Pollution Tolerance Index Score.

Field Visit Outline

Introduction

Students will be in groups of four to conduct tests to measure the abiotic parameters of the water in addition to assessing the habitat and species diversity within the stream they are investigating. They will be working with their lab partner groups the entire time.

SAFETY

- Stay with your class and lab partners for the duration of the field investigation. Do not wander off.
- Do not touch, smell, or taste any chemicals or specimens unless specifically instructed to do so.
- Do not enter any body of water unless for data collection, only at dedicated times, and with a buddy.
- The First Aid kit is with the teacher, make sure to monitor yourself (wear a hat and minimize skin exposure to prevent burns, bug bites, and allergic reactions) and your surroundings (be aware of changing or hazardous weather conditions and be careful of where you step).
- Gather all tools and equipment and return them to the muster spot when finished.
- Do not dispose of any waste products or waste chemicals outside. All waste products should be collected and returned to the classroom for proper disposal.
- Our field study may require disturbing a habitat (e.g., stirring up pond sediment, removing organisms from their homes) so be sure to restore the area to its original condition when finished.
- Wash hands and any exposed skin thoroughly with soap and water upon returning to the classroom and complete a tick/insect check.

Learning Tasks

30 minutes for delineating testing area as a class, taking a Stream Selfie and conducting Habitat Assessment in lab groups

10 minutes per water quality test in stations/rotation (biochemical oxygen demand, dissolved oxygen, nitrate, phosphate, pH & coliform bacteria, turbidity & temperature).

**if needed to save time have all groups do turbidity and temperature and assign the other chemical tests out to each group (six groups of 4 or 5 students)*

40-60 minutes for macroinvertebrate sampling and identification

10 minutes for species richness and tallying up the ratio of indicator macroinvertebrates

10 minutes for overall impressions by group about quality of the stream

Reflections

With your groupmates, discuss your overall impressions of the stream.

1. Were any of the water quality tests outside of acceptable ranges?
2. Did you find more pollution-tolerant or pollution-sensitive organisms?
3. Were you surprised by anything?
4. What was the most exciting or impactful part of our trip?

Post-Visit Learning

Day 5. Building Data into a slide deck to use as a class.
At home brainstorm your answers to the following questions, relying on the data we collected.

1. Was the habitat Poor, Marginal, Suboptimal, or Optimal? What signs of human impact are there in this habitat?
2. How biodiverse (species richness) was the stream? What was the proportion of pollution sensitive and pollution tolerant macroinvertebrates? What score did the stream receive on the Pollution Tolerance Index (Excellent, Good, Fair, or Poor)?
3. What other bodies of water in town do you wonder about?

Day 6. In your group discuss and write out your consensus answers to the questions from homework. Support each Claim with Evidence and Reasoning.

1. There are many ways to protect or improve the habitat of the stream, look at the suggestions from the Town.
2. How can you help protect your water source? Reference Needham website for protecting water sources.
    a. Which of these actions can you do where you live?

Full Unit Outline

Day 1. Introduce the town's Municipal Vulnerability Preparedness Plan of Action. Find Priorities for the town to identify potential areas to test.
Needham Municipal Vulnerability Preparedness Plan of Action

> *"-All stormwater flows to the Charles River. Clear channels of trees, clear stormwater outfalls, remove sediment.*
> *-Monitor groundwater quality to protect the aquifer. Enforce protections.*
> *-Assess invasive species and recruit volunteers to help manage invasives.*
> *-Identify where groundwater is infiltrating the sewer system; do strategic repairs, continue Special Permit process that requires upgrades."*

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Full Unit Outline

Day 1. Introduce the town's Municipal Vulnerability Preparedness Plan of Action. Find Priorities for the town to identify potential areas to test. (cont.)
Explore the area using USGS Water Mapping Tool in real time to see where the watershed lines are as well as what is identified as the different bodies of water. Use the Flood Mapping tool to look at potential areas of flooding in the town.
Use USGS Water Mapping Needham (Real Time)

- Toggle the "Layers" on and off to see what each piece of information tells us. What do you notice about the dots and lines and our town?

Use Charles River Flood Model

- Type in the address of the school. Zoom out until you see icons on the map. How close is the river to infrastructure? Do you think those buildings are at a flooding risk?
- Click on the Design Storms icon on the top of the screen. Toggle on one layer at a time and look at the impact of each "Present & Future Storm." What do you think the sections of the river that are potential flood areas look like? How might these areas be protected from flooding?

Day 2. Look at the history of water use within the town, starting from the Town Website (Department of Public Works) and then broadening to any brochures or reports from Charles River Watershed Association and the Environmental Protection Agency to help identify potential streams/river areas to test.

- Needham Public Works Source Water Protection Page
- SourceWater Protection Report for Needham Water Division
- Charles River Canoe and Kayak Guide
  - Where are safe places to access the river?
- Needham as part of the Charles Water Rivershed EPA
  - What is the main pollutant problem?
  - What is the proposed solution?
  - Are any of the areas nearby or used by us?

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Full Unit Outline

Day 3. Once the site(s) has been chosen, introduce the water quality indicator parameters and concept of bioindicators.
Factsheet on Water Quality Parameters: Habitat Assessment

- Habitat Assessment Form A2: EPA Habitat Rapid Bioassessment Protocols
- Habitat Assessment Form A2 Reference Guide
- Which vocabulary words do we need to better understand? See video with examples of each parameter.

Introduce the Biological Monitoring Training for how to sample macroinvertebrates in class.

- Note that we will be identifying the macroinvertebrates at the site and then releasing them at the very end of the field trip instead of preserving them in alcohol.

Use the dichotomous keys and/or Pocket Macros App to learn about the differences in the structures of the organisms. Practice identifying them using: Macroinvertebrates.org Quiz

- Practice gathering and identifying using a prepared leaf pack. Calculate the Pollution Tolerance Index Score. leaf-pack-network-biotic-index-sheet (1).pdf

As a reference for how to conduct biological monitoring of benthic macroinvertebrates, look at Methods used by Massachusetts: CHARLES RIVER WATERSHED 2002 BIOLOGICAL ASSESSMENT

Day 4. Field Trip to Site on Lab Day (2hr science block in the morning, 3 hours better)

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Full Unit Outline

Day 5. Building Data into a slide deck to use as a class.
At home, brainstorm your answers to the following questions, relying on the data we collected.

- Was the habitat Poor, Marginal, Suboptimal, or Optimal? What signs of human impact are there in this habitat?
- How biodiverse (species richness) was the stream? What was the proportion of pollution sensitive and pollution tolerant macroinvertebrates? What score did the stream receive on the Pollution Tolerance Index (Excellent, Good, Fair, or Poor)?
- What other bodies of water in town do you wonder about?

Day 6. In your group, discuss and write out your consensus answers to the questions from homework. Support each Claim with Evidence and Reasoning.
There are many ways to protect or improve the habitat of the stream, look at the suggestions from the Town.
Town of Needham website: How to help protect your water source?

- Which of these actions can you do where you live?

References

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USGS | National Water Dashboard. https://dashboard.waterdata.usgs.gov