From Street to Sea: Marine Debris

Grade: Grade 6
Place of Focus: O'Donnell School and surrounding neighborhood, East Boston
Citizen Science Protocol: COASTSWEEP, Ocean Conservancy data sheets, CleanSwell app / Marine Debris Tracker app
Partner: National Oceanic and Atmospheric Association (NOAA)

Massachusetts Curriculum Framework for Science and Technology/Engineering Standards

Preface:

I am a supplementary science provider for the 6th grade and am given the leeway to design units related to, but not strictly mandated by the MA STE standards. My 6th grade units incorporate MA STE standards, but are focused around NGSS (standards, practices, disciplinary core ideas and crosscutting concepts) and the NOAA's Ocean and Climate Literacy principles.

MA STE Standards:

- **6.MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution. Include potential impacts on people and the natural environment that may limit possible solutions.
- **6.MS-ETS1-5 (MA).** Create visual representations of solutions to a design problem. Accurately interpret and apply scale and proportion to visual representations.
- **6.MS-ETS1-6 (MA).** Communicate a design solution to an intended user, including design features and limitations of the solution.

NGSS Standards:

- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. *(cont. next page)*

NGSS Standards - 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. (MS-ESS3-3)
  - 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. (MS-ESS3-3),(MS-ESS3-4)

NGSS Standards - Crosscutting Concepts

- Patterns
  - Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)
- Cause and Effect
  - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-4)
- Connections to Engineering, Technology, and Applications of Science
  - 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. (MS-ESS3-4)
  - The uses of technologies and any limitations 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. (MS-ESS3-2),(MS-ESS3-3)
- Connections to Nature of Science
  - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-ESS3-4). *(cont. next page)*

NOAA's Ocean Literacy Principles

- **Principle 1.**
  - **C.** "Throughout the ocean there is one interconnected circulation system.."
  - **F.** "The ocean is an integral part of the water cycle…"
  - **G.** "The ocean is connected to ….watersheds and waterways because all major watersheds on Earth drain to the ocean…."
- **Principle 6.**
  - **A.** "The ocean affects every human life…and affects human health"
  - **D.** "Humans affect the ocean in a variety of ways…Human development and activity leads to pollution (point source, non-point source…)"
  - **G.** "Everyone is responsible for caring for the ocean.The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all."

Learning Objectives

Students will understand the following:

- There is only one ocean connected to land via watersheds and that marine debris generally enters the ocean from terrestrial pathways.
- The natural systems and mechanisms (water cycle, weather & climate, gravity, topography) and human systems (roads and sewers, waste disposal, food systems) are interconnected.
- The ocean impacts the health of humans and vice versa.
- Debris that ends up on streets ends up in the ocean
- The properties (such as density) of materials impacts the type of hazard debris poses.
- There are a variety of marine organisms impacted by debris and the impact depends in part on the organism's habitat, feeding strategy and other adaptations. *(cont. next page)*

Students will understand the following (cont.):

- There is no one group responsible for debris in the ocean, nor to prevent it. We all have a role in both the problem and the solutions.
- Human behavior change and human ingenuity are part of the solution.
- High quality, long term data can help us understand the problem and which solutions are effective.

By the end of the field lesson, students will:

- Learn how to collect data which can be used by organizations to solve a problem. (i.e., what not to include in the data such as not counting only interesting items, not including items above the highest wrack line as marine debris, how to use data categories to accurately record data).
- Create an in-situ bar graph of types of materials to give an easy visual of the frequency of materials/items found.
- Identify sources of debris ("Whose stuff is it?").
- Make inferences about pathways that the debris followed ("How'd it get here?").
- Learned ways to quantify debris (weight, %).
- Use a simple method and technology to capture quantitative data using the Ocean Conservancy data sheets and the Clean Swell App or Marine Debris Tracker.

Pre-Visit Learning

Prior to the site trip, students should understand:

- Watershed dynamics: gravity and the water cycle drive the flow of natural and human made material towards water bodies.
- Ocean currents and wave energy: carries items that are not too dense to float.
- Properties of materials: materials sink or float depending on density and shape. *(cont. next page)*

Prior to the site trip, students should understand (cont.):

To ensure the prior learning is achieved, I will do a review of learning from earlier grades and conduct a lab on which materials float. I have also arranged a classroom visit from NOAA Marine Debris Coordinator for the Northeast Region, Demi Fox (or Danielle Kamberalis from that office).

To make the best use of the field time, students will practice using the data collection methods at school with their groups before going to the field. This includes using the data sheets, apps, and a quadrat to determine the number of microplastic pieces in a randomly placed area.

Essential Questions

- What mechanisms are responsible for debris moving through the watershed?
- What can be done about the problem of marine debris?

Guiding Questions

1. Whose items end up as marine debris?
2. How does marine debris enter the ocean?
3. What individual and collective actions can be employed to reduce the debris in the ocean?

Field Visit Preparations

Time

Travel: Constitution Beach is an 8 minute drive from the O'Donnell School.

On-Site: Three hours would be an ideal amount of time for this trip. This would allow time for directions, clean-up/data collection, creation of an in-situ graph of found items, discussion, proper disposal, free exploration and bathroom/clean-up time prior to departure.

Tide Considerations: The trip day and time is tide dependent. Ideally we would get to the beach during dead low tide or a mid falling tide.

Materials and Supplies

- First Aid Kit
- Portable battery
- Phone with weather tracking app to ensure safety
- Clipboard case from Stone Living Lab to hold the data sheets, extra pencils, sharpeners, group lists, emergency forms, key phone numbers, etc.
- Data sheets: Ocean Conservancy
- Clipboards with attached pencils (school has them)
- Phones: use with CleanSwell or Marine Debris Tracker App
- Gloves: 12 pairs of gardening gloves that I have for this use and additional box of 100 Hardy vinyl gloves from Harbor Freight $5.99
- Trash bags: Simply Bio trash bags from Home Depot $18.54
- Hand sanitizer: GermX 32 oz. from Walmart $6.47
- AWS Hanging Scale to measure weight of debris removed $25.99
- 4 PVC quadrats: for use in counting micro plastic density/meter
- Tarp for viewing/sorting debris collected, but making it easy to get back into bags
- Sharps container (teacher use only): glass jar with cap labeled "HAZARD!"

Logistics

- Constitution Beach is located at 799 Bennington St, Boston, MA and managed by the Department of Conservation and Recreation. We would need to take a bus.
- There is plentiful parking as well as room for a bus to turn easily.
- The bathhouse is open through October and there are port-o-potties.
- There are several small sheltered areas to gather in addition to an open deck at the bath house
- There is an office onsite and the phone number is (781) 485-2804 ext. 105
- One drawback of the site is that it is near to Logan Airport runways and the planes are loud and could be a visual distraction for students.
- The beach is long and open. If it is a windy day, that could prove to be a challenge to comfort and doing the in-situ bar graph on the beach with debris.
- The 6th grade is small (approximately 32 students). I would try to have 3 other adults from school attend–their classroom teachers and maybe the floating sub. Ideally, a representative from NOAA marine debris program, Bow Seat or other organization could also join us.

** If funds for a bus are not feasible, there are two other options for doing this project.*

1. We could walk to a small section of coast on Boarder Street that is within a five minute walk of school.
2. I could collect debris and bring it to school to allow students to do the data collection.

Scientific Protocol

There are several participatory science options for marine debris. To determine which one I will ultimately use, I have to find out when I can get approval for the field trip (Fall or Spring). *(cont. next page)*

Scientific Protocol (cont.)

Fall Protocol:
If the field trip is in September or October, we would be participating as part of the **COASTSWEEP** managed by Massachusetts Office of Coastal Zone Management and contributing data to the **International Coastal Cleanup** sponsored by the Ocean Conservancy. (resource links below)

COASTSWEEP
International Coastal Cleanup
Data Sheets: Ocean Conservancy
Cleanswell App

Spring Protocol:
If the field trip is in the Spring, then we will use the **DebrisTracker App** which is one of SCISTARTER's participatory science tools. (resource link below)

Marine Debris Tracker

Activity:
The method involved is to identify an area to be cleaned and record the geographic location, approximate distance cleaned and items found. Information is recorded on either the Ocean Conservancy paper form or can be put into the NOAA CleanSwell App (Fall version), or in the Marine Debris Tracker (Spring version).

Teams of three or four students would work together taking turns in the roles of picking up trash, recording data and being the data QA/QC checker.

**Depending on the amount of time it takes to remove larger pieces of debris, we might try to collect some data on microplastics along the wrackline area using a random quadrat method where the quadrat is randomly tossed rather than set along a transect.*

Field Visit Outline

Introduction

Students would be gathered at the deck of the bath house and given a site orientation of where they are (this is part of Boston Harbor which connects to the Gulf of Maine which is part of the Atlantic Ocean, which is part of the ONE ocean on Earth that takes care of us all)!

Students receive a reminder and reinforcement of the purpose of the trip (to clean the beach, but even more powerful, to collect data that can be used to address the problem at the root causes)

A verbal and visual timeline of activities will be provided along with how students will know when it is time to transition (quick transition practice).

Students will be reminded of what behaviors and physical areas are “out of bounds” as well as consequences.

Directions would be given with examples provided for how to safely collect debris (including what not to touch) and how to accurately collect data.

All students will be encouraged to use the bathroom.

Learning Tasks

Teams would be assigned to a section of beach to clean. They would remove debris, recording data as they collected.

- We will follow the COASTSWEEP protocol, which does not involve use of transects.

**Adult volunteers will have quadrats and can show teams that finish early how to use a quadrat to collect data on microplastics if time allows.*
(full activity cont. on next page)

Learning Tasks (cont.)

This schedule assumes a 9:30am arrival, but tides will determine the actual time.

9:30am	Meet at the bathhouse deck for orientation.
9:45am	Bathroom and snack break
10:00am	Teams gather and receive data sheets, clipboards, bags, and gloves
10:05am	Clean up
10:45am	Meet at the tarp area by the benches to weigh bags and turn in data sheets.
11:00am	Contribute items to the whole group in-situ debris graph
11:30am	Bag up debris and take a group photo.
11:45am	Wash up–wash hands.
12:00pm	Small group reflection
12:15pm	Individual reflection
12:20pm	Closing celebration/ head back to school.

Reflections

Small Group Reflections (facilitated by a chaperone and/or guest expert): Teams gather together with group leaders, who will facilitate discussions and record responses to be used in the classroom.

- What did we find? What surprised you?
- Whose stuff gets in the ocean?
- How did you think it gets in the ocean? (incorporate discussion about land-based sources, water cycle/watershed)
- Did you see evidence of any animals that live here / are potentially harmed by the trash? (students may have noticed bivalve shells, crab molts, fish skeletons)

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Reflections (cont.)

Individual Reflection:
Participants are asked to sit quietly given a few minutes to "just be" and reflect on:

- What feelings came up for you?
- How did it feel to take action and take care of the beach?
- Is there some action you want to take or something you want to learn as follow-up to this experience?

Departure Expectations:
Prior to leaving the site debris will be disposed of (I am hoping to collaborate with the MA Dept. of Conservation/Recreation to dispose of the debris. An alternative might be the Porazzo rink).

- I will lead a land/ocean acknowledgement.
- People Check: Group leaders will check their people against a list.
- Someone will be assigned to check the bathrooms for anyone who may have left their group after check.
- Some students will have been assigned to help carry materials to the bus (clipboards, etc.).
- I will check students off a list as they board the bus.

Post-Visit Learning

- Students will aggregate and compare their data to previous CoastSweep data to look for trends/variation.
- Students will then do street and storm drain debris surveys on Trenton, Meridian, Lexington and Marion streets and compare that data to the marine debris data.

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Post-Visit Learning

- They will incorporate what they learned from their data into design criteria for an engineering challenge - Design a Drain where they will be tasked with designing a storm drain that allows water to flow through, while minimizing debris entering the storm drain.
- Students will make orthographic drawings and prototypes of their ideas.
- Students will test their design ideas and share results.

Optional Extensions

Artistic Expression Options:

- Students will be visited by people who work at Bow Seat and NOAA Marine Debris Program Both organizations hold annual marine debris art contests that students can participate in. Interested students will be encouraged to make submissions to one of the following:
  - Boston based Bow Seat Ocean Awareness Contest
  - NOAA Marine Debris Program Art Contest

Full Unit Outline

- The overall intention guiding this unit is for students to feel agency and hope around a seemingly intractable global environmental problem. Students already have some idea of the problem but it is disconnected from science concepts they have learned and also from local impacts and potential local solutions. It is just a BIG problem over which they have no agency.
- This unit is designed to allow them to apply science and engineering concepts to gain understanding and to also provide experiences that allow them to see that they can take action by leveraging their unique interests.

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Full Unit Outline

Introduction

- One Ocean Activity and map and globe work (to teach the idea of one connected ocean).
- Impacts of Ocean Pollution

Review

- Revisit the 5th grade Pacific Garbage Patch reading
- Review water cycle/watershed dynamics covered in 5th grade

Data Collection and Organization Intro

- Data lesson (Students will learn what data is, how it is collected and what it can be used for).
- Field Prep class: (Students will practice using data forms,apps and quadrats in preparation for the field trip. They will make a life sized graph using natural objects found on the playground such as acorns, leaves, rocks).

Field Trip to Constitution Beach

The field visit allows students to:

- observe the problem first hand
- make inferences about who the source of the debris is and the pathways to the ocean
- collect data that can be analyzed, graphed and shared
- observe some marine organisms potentially impacted (most likely via shells and molts of organisms that live in Boston Harbor)
- practice field science methods such as using a quadrat (if time allows)

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Full Unit Outline

Follow-up Lessons

Data organization

- Student data will be shared with MA CZM and The Ocean Conservancy.
- The Constitution Beach data will be analyzed to find out the frequency of items found. Students will then compare it to past COASTSWEEP and International Coastal Cleanup data.

Comparison of beach and street debris

- A survey of the streets and storm drains on the 4 streets around the school will be conducted during a science class using the same data sheets used at the beach (Meridian St., Trenton St, Marion St., Lexington St.).
- Students will compare their beach data and their street data to compare/contrast debris items. **It is my assumption based on my experience that they will find many similar items.*

Engineering challenge

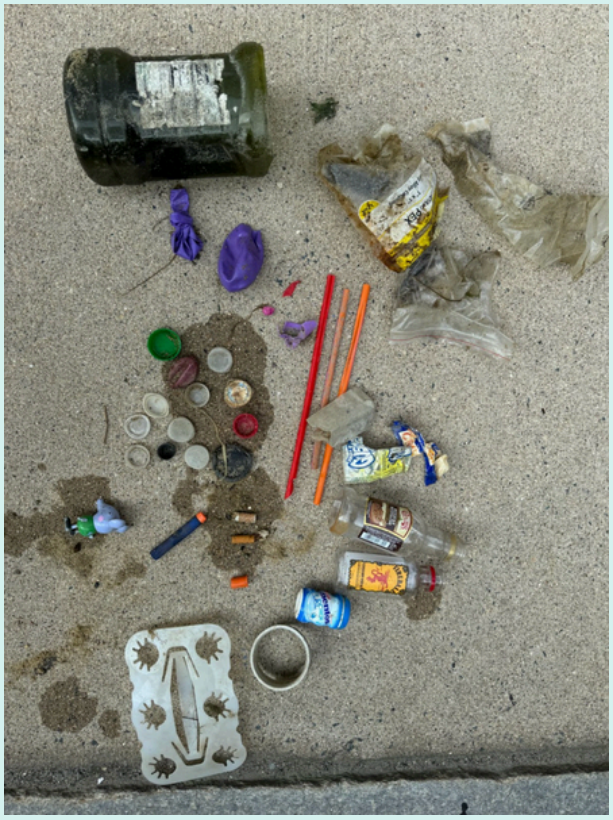
- An engineering challenge will allow students to engage in the design and engineering cycle. They will design inventions that prevent debris from entering waterways (storm drain) or remove debris from the ocean (floating debris removal machine). This will involve orthographic drawings and prototype creation, testing. After their design stage, they will do research on inventions currently in use to reduce and remove debris from waterways to get ideas to improve their own inventions/see overlap between their ideas.

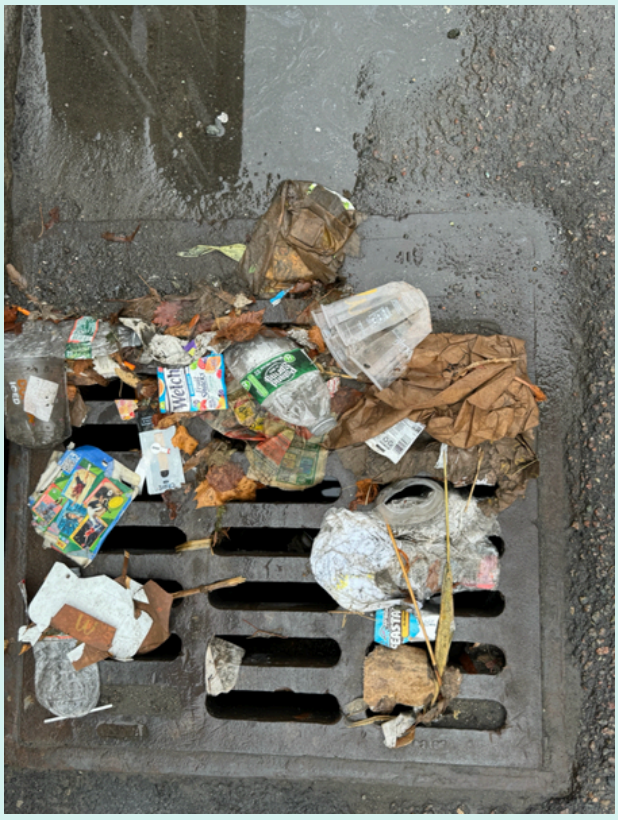
Communication

- Students will decide on a method of graphing the data to use in a community information campaign to inform the school community and residents near the school of the issue of street to sea transport of debris. This could include posters, brochures, etc.

**Optional: students can submit work to Bow Seat or NOAA Marine Debris contests.*

Photos





Note: I scouted Constitution Beach to determine if it was a good site for this project. The debris on the left is from the beach. I also scouted the streets around the O'Donnell School on the same day. You can see that there are similarities in the debris items.