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Trawling Through the Five Gyres: A Microplastic Research Study

ACTIVITIES AND PROGRAM MODEL

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ABSTRACT

Plastic pollution is a major problem in the world's oceans (Hale et al., 2020). It is estimated that 10–28 billion pounds of trash entered the oceans in 2010 alone (Jambeck et al., 2015). This plastic is mostly microplastics, or plastic bits smaller than 5 mm (Cozar et al., 2014), which form as plastic products fragment into smaller pieces as they are exposed to environmental conditions. Marine debris researchers are interested in documenting the different types of plastics that accumulate in different oceans, and it is estimated that there are over 170 trillion plastic particles afloat in the world's oceans today (Eriksen et al., 2023). We have developed a lesson plan by teaming marine science graduate students with K-12 teachers and informal educators, and have incorporated current research into an effective teaching product. In this activity designed for middle school, students will count, graph, compare and contrast, and share results with classmates regarding the plastic in one particular gyre of the ocean. Finally, students will create an action plan to reduce their use of single-use plastics.

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BACKGROUND INFORMATION

PROGRAM BACKGROUND

This lesson was created through the Virginia Scientists and Educators Alliance (VA SEA) program developed by educators from the Chesapeake Bay National Estuarine Research Reserve in Virginia (CBNERR-VA) and the Virginia Institute of Marine Science's (VIMS) Marine Advisory Program, during the 2018 cohort. VA SEA is a network of marine science graduate students, K-12 teachers, and informal educators, where graduate students receive training on science communication and lesson plan development, and teachers test, review and implement lessons using authentic science in their classroom. By incorporating authentic and current research examples directly from scientists themselves into science lesson plans, teachers are better able to provide their students with real-world examples of the scientific process.

TOPIC BACKGROUND

Plastic pollution is a major problem in the world's oceans (Hale et al. 2020). Marine plastic pollution is the primary form of marine debris (i.e., any persistent, solid material that is disposed of or lost in the marine environment). It is estimated that 10–28 billion pounds of trash entered the oceans in 2010 alone; the majority of ocean plastic pollution arises from leakage of trash during waste management (Jambeck et al., 2015). As such, single-use plastics (e.g., straws, plastic bags, food containers) which are common in our trash are also common in marine plastic pollution. As plastic travels through the ocean, the plastic fragments into smaller pieces. In fact, the majority of ocean plastic pollution is microplastics, or plastic bits smaller than 5 mm (Cozar et al., 2014) (Figure 1). To keep track of this plastic and understand the problem, scientists have used manta net tows throughout areas of high plastic concentrations (such as the North Pacific Gyre aka the 'Great Pacific Garbage Patch') (Figure 2). In 2014, an extensive research study on this topic found that the most debris is in the North Pacific, followed by the Indian, North Atlantic, South Pacific and South Atlantic (Eriksen et al., 2014). This is a product of the pollution in the countries surrounding those ocean gyres, as well as fisheries and commerce activities through the oceans. In particular, countries surrounding the Pacific and Indian oceans tend to have high plastic product use but waste management infrastructure is not well developed, leading to waste leakage into the environment (Jambeck et al. 2015). Although the Indian gyre is physically the smallest, it still accumulates the second most debris because of poor waste management and very dense populations in the surrounding countries. Scientists have also found that the majority of microplastics come from plastic waste that has broken down into microplastics over time. In order to help with this problem, scientists suggest 'turning off the tap'. This is based on the overflowing bathtub analogy – if your tub is overflowing you aren't going to bucket out the water, you are going to turn off the faucet! We cannot fix the problem by simply removing plastic from the oceans. Instead, decreasing our use of plastics, especially single-use plastics, is the most effective way to help reduce the marine debris problem.

Figure 1 A sample of ocean microplastics.

Image credit: Meredith Seeley.

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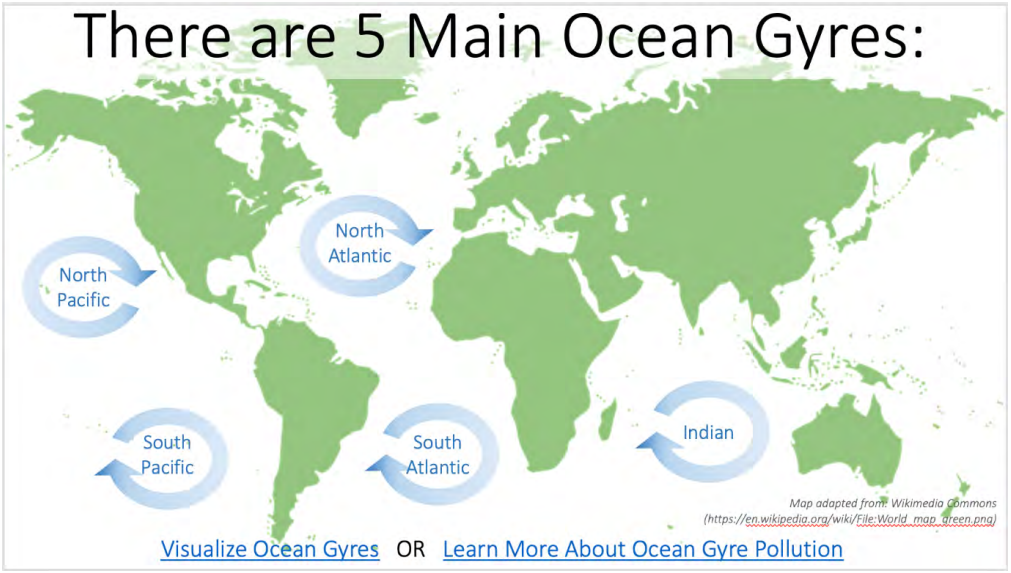

Figure 2 A simplified illustration of the 5 ocean gyres. Map adapted from: Wikimedia Commons.

LESSON PLAN OVERVIEW

This lesson is intended for 6th–8th grade students. Corresponding objectives, next generation science standards and alignment with literacy principles are included in Table 1. In this lesson, students are introduced to the topic of marine debris, specifically plastic pollution, through a Powerpoint. Information in the PowerPoint includes the difference between plastic pollution and microplastics, as well as differentiating between primary and secondary microplastics. Students will then count items found in a simulated research trawl and graph the results, compare and contrast their results to the results from other groups in the class, distinguish between primary and secondary microplastics, and identify what single-use plastics are. Additionally, students are given the optional extension of creating a plan of action to reduce their use of single-use plastics. During this activity, students should gain an understanding of the marine debris problem and the contribution that secondary microplastics make, and the additional 'challenge' activity will help them see how they can make changes in their daily life.

Next Generation Science Standards	MS-ESS3-3 Earth and Human Activity: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-4 Earth and Human Activity: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
Ocean Literacy Principles	OLP-6D Human activity contributes to changes in the ocean and atmosphere. OLP-6E Individual and collective actions are necessary for maintaining, conserving and sustaining a healthy ocean.
Science Objectives	• The student will be able to collect data and compare and contrast their results. • The student will be able to distinguish between primary and secondary microplastics. • The student will be able to identify single-use plastics • The student will be able to understand that humans impact the environment.
Math Objectives	• The student will be able to collect and graphically represent data. • The student will be able to assess data and generate conclusions.
Social Studies Objectives	• The student will design and implement a plan of action to reduce their use of single-use plastics.

Table 1 Relevant Standards (Ocean Literacy and Next Generation Science Standards) and Lesson Objectives.

TEACHER PREPARATION AND MATERIALS

There are two options for collecting supplies for this lesson plan. Option 1 includes a sustainability approach to set an example of 'reusing and recycling' for the students, and teachers can collect free or waste materials to use for manipulatives. Option 2 includes new supplies.

OPTION 1

- 5 pieces of mesh or fabric for the 'trawl net' cut in an approximately 6 in x 6 in square (e.g. an old t-shirt, or the plastic mesh on some flowers in bouquets can be used)
- Rope or string to tie together the trawl net opening
- 7 types of plastics from around the house or trash that you can cut into small pieces (less than 5 mm) such as:
  - Old plastic bag or plastic wrap
  - Old folder, plastic wrap from food (e.g. Cut up soda or water bottle)
  - Pieces of fishing line
  - Styrofoam coffee cup
- Label for each gyre (North Pacific, South Pacific, North Atlantic, South Atlantic, Indian)

OPTION 2

- 5 pieces of mesh or fabric for the 'trawl net' cut in an approximately 6 in x 6 in square
- Rope or string to tie together the trawl net opening
- 7 bead colors, corresponding to each of the plastic types in the net (The most you will need of one color is 144)
- Labels for each gyre (North Pacific, South Pacific, North Atlantic, South Atlantic, Indian)

Prepare the mesh bags with the different plastics or beads according to the chart on the next page (Table 2). You will determine the debris type/color depending on the approach you chose to take when gathering your supplies. Count and sort debris according to each gyre and place them on your fabric/mesh 'net', tie the fabric to keep the debris inside, and label according to each gyre type (Figure 3). All gyres have the appropriate total of plastic according to research to represent what is seen in the actual ocean. The proportion of each type of plastic is also accounted for, according to preliminary research. BUT, scientists are still learning about what plastics are most common and where, and the student is 'helping' to answer that question. For example, we know there is a low abundance of nurdles and microbeads relative to secondary microplastics, therefore, those counts are relatively low. We also know that hard plastics (e.g. made of polyethylene and polypropylene polymers) are the most common debris found in all of the ocean, so that is very high.

Table 2 Representative data to build gyre trawl samples for lesson plan activity.

DEBRIS COLOR/TYPE	TYPE OF PLASTIC	COUNT PER GYRE					
		NORTH PACIFIC	INDIAN	NORTH ATLANTIC	SOUTH PACIFIC	SOUTH ATLANTIC	TOTAL
	Plastic Film	11	10	9	12	6	**48**
	Foam	25	19	17	15	14	**90**
	Hard Plastic	35	33	30	23	23	**144**
	Rubber	15	13	10	8	8	**54**
	Nurdle	10	8	5	2	1	**26**
	Fiber	14	10	9	6	4	**43**
	Microbead	10	7	5	4	4	**30**
	TOTAL	**120**	**100**	**85**	**70**	**60**	**435**

ENGAGE

To assess students' prior knowledge, the teacher can ask students about any beach trips they have taken, and what types of plastics, if any, they encountered on the beach. The teacher can then use the lesson plan's associated Powerpoint to introduce the lesson topic and set the stage. Remind students that marine scientists across the world need the help of citizen scientists. Scientists have observed plastic floating in the ocean, but need to learn more about

Figure 3 An example gyre sample using beads to represent different plastic types.

this plastic to help law-makers decide how to manage the problem. To help these scientists, students will be collecting data on microplastics collected from the five main ocean gyres.

Ocean gyres are areas where the ocean currents move in a circular pattern, leading to an area of calm water in the middle. Plastic pieces from all over the world are carried by the currents and accumulate in these gyres. The majority of these plastics are microplastics, or pieces of plastic less than 5 mm in size. They can be primary microplastics, which are microplastics that were always small (like a plastic bead) or secondary microplastics which came from the fragmentation of a large piece of plastic (like a small piece of a broken Styrofoam cup). To observe these microplastics, scientists have used a manta trawl net (Figure 4). This net is pulled behind a research vessel, collecting all the plastic debris.

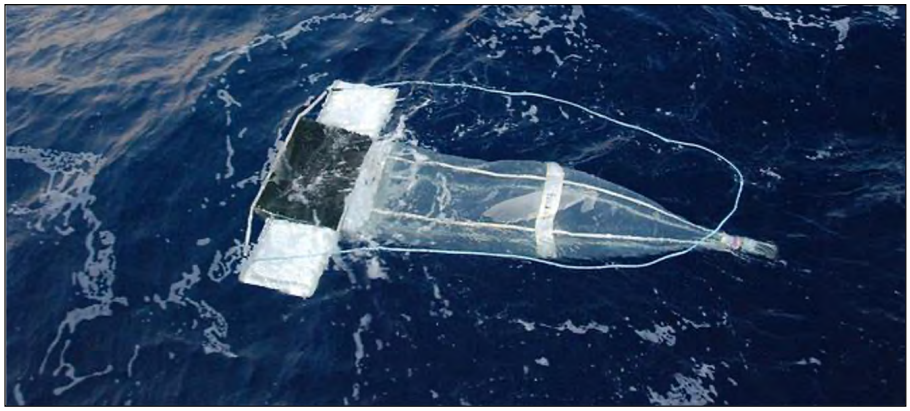

Figure 4 A manta net used for collection ocean microplastics.

Image Credit: NOAA Photo Library.

EXPLORE

Students are charged with sorting and counting microplastics collected in a trawl net from one of the five major ocean gyres. Split the class into five groups, each receiving one sample trawl net. Students should open their net and sort the microplastics by color/type, then identify the type of debris it came from. Students will then count each type of plastic and record the number in a table in their student worksheet (see link to full lesson plan with student worksheets and answer keys at end of article). Finally, students will graph the results of the plastic type and the quantity of each on the graph.

EXPLAIN

After students collect the data, they will interpret their results. Working as a group, students should answer the following questions:

- Describe the microplastics found in your ocean gyre.
- What plastic is most abundant?
- What is least abundant?

Students will then share their data as a group with their classmates. How did their gyres compare to the other four gyres? Students should take notes on what the other groups found in their gyres and write a short summary to compare their gyres to others. Finally, students will look at the information provided on Slide 11 in the lesson plan's associated Powerpoint that illustrates what types of plastic products lead to the microplastics in your ocean gyre. In groups, students will determine if their microplastics were mostly primary or secondary microplastics, and what trends they noticed about the most common products that lead to microplastics.

ELABORATE

Students will have likely noticed that most of the microplastics come from single-use plastic. Policy makers are working to create laws that will help reduce the waste. In the meantime, students can take action to reduce this plastic waste in their everyday lives. Working as a group, students should brainstorm some single-use plastics that they use daily, and should pick one that they use the most. Students will estimate how many of that item their group throws away each week. Finally, students will create an action plan for how they can reduce their use of that single-use plastic. For example, students could bring a reusable fork to the cafeteria to lower their use of disposable cutlery. Remind students that their solutions can be simple.

Students will design a poster explaining why they chose that single-use plastic and their plan to reduce waste. When their group is done, they will present their action plan to the class. For each group's presentation, take the estimate of that plastic use each week and multiply it by five to estimate for the entire class. Write the number on the board. Repeat for each group's presentation, and then add all of the single-use plastic estimates together. You will likely have a pretty large number. Tell students to imagine how much single-use plastic they could save by adopting the action plans they've made!

EVALUATE

To assess student learning, teachers can use the student worksheet and participation within their group, as well as their classroom presentation and poster creation. To wrap up the lesson, ask students for ways that they could initiate change to the way people deal with waste when visiting the beach, as well as if they see a connection between their trash and marine debris. Science has shown that most marine debris doesn't come from people littering on the beach; it actually comes from waste that was thrown in the trash but did not make it to the landfill because waste management across the globe does not always work perfectly (Jambeck et al., 2015). So even if students throw their trash away, it may still make it to the ocean. Therefore, we need to make decisions to lower our use of single-use plastics, which will lower the amount of marine debris and show companies that we want solutions for the single-use plastic problem. As an extension, this lesson plan could lead to opportunities to discuss the ocean currents and how those currents carry items in different directions and distribute them to different locations.

ABOUT VA SEA

This lesson, created by Dr. Meredith Seeley, while she was completing her Ph.D. in marine science at VIMS, encourages students to investigate the types of microplastics in the five main gyres of the ocean, and learn how our habit of using single-use plastics can affect this pollution. The lesson plan was created as part of the VA SEA program (Figure 5), a network of graduate students, teachers, and informal educators aimed at translating scientific research into usable lesson plans. VA SEA was created in 2015 by educators from the Chesapeake Bay National Estuarine Research Reserve in Virginia (CBNERR-VA) and VIMS Marine Advisory Program. The objectives of the program are two-fold. One, to train graduate students to communicate their research at a level that most could understand, and two, to increase the research skills that K-12 students are able to develop by sharing authentic research with teachers. Since 2015, 58 graduate students from several higher education institutions in Virginia have developed 65 lesson plans based on their current

research. Classroom teachers pilot test the lesson plans and provide feedback to the graduate students as they finalize their lessons. A teacher reviewer shared this feedback on the lesson plan, "Lesson was engaging and had a definite hook to entice students to want to complete the lesson. Students were eager to work with the hands-on portion of the lesson and find out what their trawl nets held." All VA SEA lesson plans connect science to issues in the public sphere, and allow students to investigate scientific phenomena with real-world data and scenarios.

Figure 5 The Virginia Scientists and Educators Alliance (VA SEA) logo.

To access the full lesson plan, including student worksheets, answer keys, associated PowerPoint, please visit – Lesson Plan (PDF) and Powerpoint.

To access the entire VA SEA lesson plan collection, visit www.vims.edu/vasea.

COMPETING INTERESTS

The authors have no competing interests to declare.

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