Gyre in a Bottle

Topics
Plastics, Density

Grades
6-12

Site
Indoors, Outdoors

Duration
15-20 minutes

Materials
See page 2

Vocabulary
density, gyre, microplastic, photodegrade

Next Generation Science Standards

Practices
Developing and using models
Constructing explanations

Core Ideas
ESS2.C The role of water in Earth's surface processes
ESS3.C Human impacts on Earth systems

Crosscutting Concepts
Systems and system models

Performance Expectations
See page 4

Focus Question

How can a model describe how microplastics move in the ocean?

Overview

In this short demonstration illustrating ocean plastic pollution, students observe a two-liter model of plastic pieces suspended in the water column. Students then review the concept of a gyre, discuss how and why plastic particles are found in gyres and what impact plastics may have on ocean organisms and habitats.

Objectives

Students will be able to:

- Demonstrate how the density of plastic affects its location in the ocean water column.
- Explain how ocean currents like gyres transport photodegraded plastic.
- Identify how a model can be used to describe a phenomenon like the movement of microplastics in the ocean ecosystem.

Background

An ocean **gyre** is a large-scale circular feature, made up of permanent ocean currents that revolve around a central point. Gyres are formed by wind transferring energy to water combined with gravitational forces of the Earth's rotation. There are five major ocean gyres found in the world's oceans: the North Atlantic; South Atlantic; North Pacific; South Pacific and Indian Ocean gyres. Within gyres, waters are relatively constant, remaining stable for long periods instead of circulating around the globe. Gyres have always been areas where large amounts of natural materials, such as driftwood, seeds and pumice, accumulate. In recent decade, plastic has become the overwhelming, unnatural debris in the gyres.

Wind and water movement transports trash from land to the ocean where it is carried by ocean currents to the gyres. The North Pacific Gyre is a vast region that spans an area estimated to be 2-3 times the size of the continental United States. There is a large area within it that has been nicknamed "The Great Pacific Garbage Patch" due to the quantity of plastic and other debris suspended throughout it. The thousands of miles of debris are best described as a plastic

VOCABULARY

Density: mass per unit volume; a type of plastic with a higher density than ocean water will sink. A plastic type with density lower than sea water will float.

Gyre: a large system of rotating currents; there are five major gyres

Microplastic: small, plastic particles

Photodegrade: to break down into smaller fragments when exposed to sunlight; doesn't biodegrade and completely break down

soup since plastics of all sizes, especially small plastic particles, or **microplastics**, are found distributed throughout the water column, from the surface to the deepest parts of the ocean. Recent research from Scripps Institute of Oceanography, estimates that the abundance of microplastics within the North Pacific Gyre has increased a hundred fold over the last 40 years.

Plastics are typically made from fossil fuels and come in all shapes and sizes, serving many different purposes, such as packaging and single-use disposable items like straws and utensils. Unfortunately, plastics are not biodegradable, meaning they will never decompose. Instead plastics **photodegrade**, meaning they break into smaller and smaller pieces when exposed to the sun's UV rays. Different plastics have different densities. **Density** is the ratio of a material's mass to its volume. The varying densities of plastic, ocean water and currents cause some plastic debris to sink to the ocean floor, some to float along the surface, and some to remain suspended throughout the water column, putting many marine organisms throughout the ocean zones at risk of entanglement (before plastics photodegrade) and/or ingestion.

As plastic waste photodegrades into smaller pieces it begins to resemble plankton, which form the base of the marine food web. In some areas of the North Pacific Gyre, microplastics are found to outnumber plankton (Algalita Marine Foundation). Plankton consumers do not discriminate and ingest both plastic and plankton. Beyond the toxic chemicals already found in plastics, other pollutants commonly found in ocean waters, like DDT, PCBs and pesticides, easily adsorb or gather onto the surface of the plastic particles. When animals consume the plastic particles, these toxins bioaccumulate in individual organisms and make their way up the marine food chain, biomagnifying in organisms at higher trophic levels. Scientists are currently studying how these toxins might be impacting the entire marine food web, including humans.

Fortunately, there are many ways that people can reduce plastic waste and help marine animals and ecosystems. Bringing reusable items with you when you shop or travel, like stainless steel straws and to-go containers from home and buying items with less plastic packaging can decrease plastic waste. Supporting legislation that bans or taxes the use of certain plastic items (like plastic bags and Styrofoam), and recycling plastic items can significantly reduces plastics in the waste stream. Reducing plastic waste is an integral part in improving ocean health.

Materials

Whole group or per class

- Clean, clear two-liter plastic soda bottle
- Various types of plastic containers cut into less than 3 cm pieces with scissors or a heavy-duty blender (not to be used for food preparation)
- Water
- Globe or computer access to project Google Earth or Maps

Teacher Preparation

1. Decide if you are going to use one model to do the demonstration in front of the entire class or if each group of students will get a bottle. That will determine how many bottles you need. Be sure to remove the labels.
2. Cut a variety of plastics (with different resin codes) into small enough pieces to fit into the mouth of the two-liter bottle. You may also want to use a heavy-duty, non-food blender to chop them up. Test the blender to ensure it's capable of chopping up the plastics before using in the demonstration.
3. Add the plastics to the empty two-liter bottle and fill it with tap or distilled water (whichever gives best visibility).

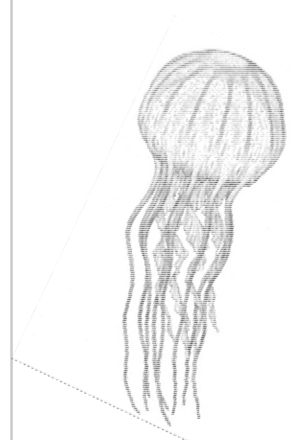
THE MISSION OF THE MONTEREY BAY AQUARIUM IS TO INSPIRE CONSERVATION OF THE OCEANS.

Procedure

1. INTRODUCE THE FOCUS QUESTION TO THE CLASS.
   Share the question: *How can a model describe how plastics move in the ocean?* You may write it up on the whiteboard or have students add it to their science notebook. Give students time to write their initial thoughts down or discuss with a partner. Depending on their prior knowledge, you may need to spend some time exploring the issue of plastic pollution.

2. STUDENTS MAKE OBSERVATIONS ABOUT THE MODEL.
   Hold the liter bottle upright without obscuring your observers' view. Have students make observations of the model. What do they notice? Then shake or swirl the model in one direction to suspend the plastic confetti, illustrating the different densities and their presence throughout the water column. Ask students: *What do you notice about the movement of plastics? (some sink, some float) What may account for how the plastics move in the water column? What phenomena is this model describing?*

3. AS A CLASS, EXAMINE A GLOBE OR USE GOOGLE EARTH TO IDENTIFY GYRES.
   Review the concept of gyres with students: *strong winds, combined with the Earth's rotation, sweep ocean waters into a spinning spiral called a gyre. This occurs in various locations around the globe – there are five such gyres in the world's oceans.* You can find the location of the five largest gyres and plastic pollution within each at 5gyres.org.



4. STUDENTS CONSIDER HOW PLASTICS MIGHT MAKE IT INTO THE WATER COLUMN.
   Have students do a think-pair-share about how plastics reach the ocean. *On land, our plastic trash escapes from trash cans and landfills or is carelessly dropped and makes its way into waterways through rain or wind, eventually ending up in the ocean.*

5. STUDENTS OBSERVE THE VARIETY IN DENSITY AMONG DIFFERENT PLASTICS.
   Ask students to consider why some plastics sink and some float. What causes something to float or sink? Depending on their prior knowledge, you may need to define or do an activity teaching density. Students will notice that there are a variety of plastics with different densities. See Resources for a link to a Plastics in the Water Column activity exploring different kinds of plastics.

"FAR AND AWAY, THE GREATEST THREAT TO THE OCEAN, AND THUS TO OURSELVES, IS IGNORANCE. BUT WE CAN DO SOMETHING ABOUT THAT."

Dr. Sylvia Earle

6. STUDENTS INFER IMPACTS ON MARINE LIFE.
 You may show some images of ocean animals and review food webs. Some students may have heard about sea turtles mistaking plastic bags for jellyfish. Discuss a variety of animals like albatrosses and fishes that feed on plankton and small fish. Ask students why an animal may mistake plastic for food. Many critical members of the ocean food web are often found swimming in and ingesting this plastic debris.

7. STUDENTS DEFINE THE LIMITATIONS OF THE MODEL.
 Ask students to discuss how this model compares to reality. *How does this physical model compare to an actual gyre? What elements are missing? How might those elements affect the plastics?* Instead of a blender, physical and chemical forces like wave action and UV exposure will break the plastic items into smaller, confetti-like pieces that ride the ocean waves, currents and gyres. Plastic doesn't biodegrade so it will stay in the environment indefinitely. There are many more forces involved in moving the plastic pieces around the gyre than can be observed in this simplistic model. The suspension of plastics does vary based on the density of each kind of plastic. Pose a question challenging students to come up with a method for cleaning the plastic out of the gyres. (They'll realize it's very difficult.)

8. RETURN TO THE FOCUS QUESTION.
 Now that students have observed and discussed how microplastics move in the water column, have them revisit the question: *How can a model describe how plastics move in the ocean? Limitations of that model?* Students may think on their own or discuss with a partner. Then in their science notebook, you may have them draw a line of learning and under it add to their original thoughts about the question.

Extensions

Use salt water in one model and fresh water in another model to note and discuss the difference in water densities. (Note: there will not likely be much difference due to the small increments of difference between plastic resins and the difference in water densities.)

Resources

Websites

Monterey Bay Aquarium's Plastics in the Water Column activity
http://www.montereybayaquarium.org/-/m/pdf/education/curriculum/6-8-plastics-in-thewater-column6-8-monterey-bay-aquarium.pdf

NOAA Education Resources on Ocean Pollution
http://www.education.noaa.gov/Ocean_and_Coasts/Ocean_Pollution.html

NOAA Marine Debris Program
http://marinedebris.noaa.gov/info/plastic.html

5 Gyres
http://5gyres.org/

Algalita Marine Research Institute
http://www.algalita.org/index.php

The Story of Stuff Project: The Story of Bottled Water
http://storyofstuff.org/movies/story-of-bottled-water/

Standards

Next Generation of Science Standards www.nextgenscience.org

Performance Expectation

Relates to MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resource impact Earth's systems

Acknowledgements

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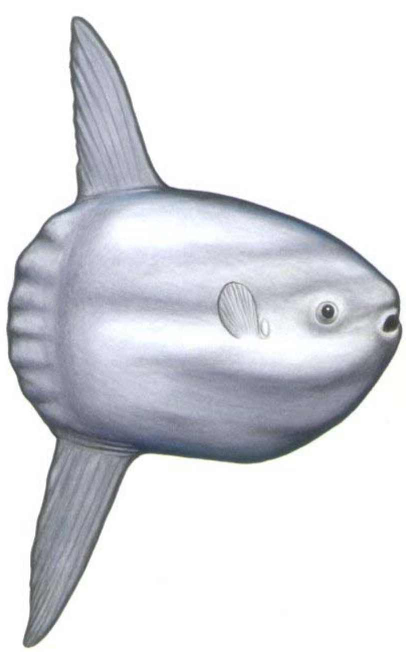

"Sincerely, I hope that I shall someday see a beach, a wave that's plastic free."

Dr. Sylvia Earle