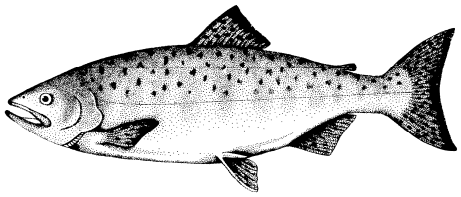
# Biomagnification in Ocean Food Webs: You Are What You Eat



**Topics**
Plastics, Food Web

**Grades**
6-12

**Site**
Indoors, Outdoors

**Duration**
20 minutes for chemistry pre-activity; 45 minutes for activity

**Materials**
see page 2

**Vocabulary**
bioaccumulate, biomagnify, persistent organic pollutants (POPs)

**Next Generation Science Standards**

Practices

Analyzing and interpreting data
Constructing explanations and designing solutions

Core Ideas

LS2.C Ecosystem dynamics, functioning and resilience
LS4.D Biodiversity and humans

Crosscutting Concepts

Cause and effect

Performance Expectations

See page 4

## Focus Question:

*What are implications of biomagnification of toxins such as POPs in the ocean food web?*

## Overview

Plastics are very effective in many ways: from keeping food fresh to providing lightweight protection (helmets, car bumpers, etc.). Certain plastics are also very good at sorbing toxic chemicals called persistent organic pollutants (POPs). In this activity, students take on roles in a simulated ocean food web that includes ingesting POP-contaminated prey. After recording data regarding how POPs bioaccumulate in individual organisms at each trophic level and biomagnify in succeeding trophic levels, students participate in a guided discussion about implications of POPs on ocean and human health. They then brainstorm ideas to reduce the presence of POPs and plastics in the ocean.

## Objectives

Students will be able to:

- Describe how plastics in the environment can sorb POPs and other toxins which may then enter a food web and be passed from organism to organism.
- Explain how bioaccumulation of POPs in individual organisms leads to the biomagnification of POPs in top predators in the food web.
- Describe the biological effects of POPs on wildlife and humans.

## Background

While plastics are good at keeping food fresh and providing many other conveniences for us, their increasing presence in our environment and particularly the ocean is a growing concern. Photodegradation and wave action on plastic marine debris create microplastics which marine organisms often mistake for food. Current research shows that plastics in the environment are also quite good at accumulating to their surfaces a class of hydrophobic (non-water-soluble) chemicals called **persistent organic pollutants**, or POPs. POPs got their name by virtue of their chemical properties:

- Persistent: They are not water-soluble (hydrophobic) and are thus broken down very slowly. This means that, once ingested, they have the ability to remain in an organisms' tissues for long periods of time.
- Organic: They contain carbon.
- Pollutants: They (or their metabolic byproducts) are toxic to nearly all organisms at some dose.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**VOCABULARY**

**Bioaccumulate:** increase in the concentration of a chemical in an organism over time, compared to the chemical's concentration in the environment.

**Biomagnify:** a process resulting from bioaccumulation in individual organisms which causes the tissue concentrations of a contaminant to increase in organisms higher up the energy pyramid

**Persistent Organic Pollutants (POPs):** chemicals that are not water soluble (hydrophobic) and are toxic to most organisms

Examples of POPs include PCBs, DDT and other pesticides, and other hydrophobic compounds. Plastics have been found to accumulate POPs at concentrations of up to 1 million times greater than what is found in the surrounding (ambient) seawater. In addition to adhering to plastics, these POPs sorb to the sea surface microlayer, ocean sediment, the gills and skin of animals as well as phyto- and zoo-plankton which comprise the base of the ocean food web. The high lipid solubility (attraction to fats and oils) of POPs allows them to both pass through cell membranes and to **bioaccumulate** (build up) in the fatty tissues of living organisms. This ability to bioaccumulate some substances (like vitamins A, D, and K, trace minerals, essential fats and amino acids) is essential to the survival of many organisms, including humans. However, organisms can also accumulate unnecessary or even toxic substances like POPs. Once ingested, hydrophobic and lipid-soluble compounds like POPs can be stored in fat tissue and transferred through the placenta and breast milk to developing offspring of humans and other mammals where they can interfere with body processes and healthy development of body systems, particularly the reproductive system, during critical stages of development. The severity of these effects varies depending on the species and timing of exposure, but there is much evidence that POPs have the potential to cause significant adverse effects on the health of a wide variety of organisms, including humans. Often, animals near the top of the food chain are most affected because of a secondary process called **biomagnification**.

Biomagnification of POPs occurs as they move up the food chain when predators consume prey, ingesting the POPs that have bioaccumulated in each prey item. When those prey items have also ingested microplastics carrying concentrated amounts of POPs the result may be a dramatic increase in POPs ingested over and above what would have occurred if microplastics did not occur in the ocean. Such bioaccumulated substances may become more and more concentrated in a food web as animals eat and are eaten in turn. As a result, higher-level predators like carnivorous fish, birds, and marine mammals build up increasingly higher levels of toxic materials than animals lower on the food chain. Humans, at the top of the ocean food web are thus at risk of accumulating these higher levels of toxins.

## Materials

For the class:

- Computer, internet and projector
- **Ocean Molecules and Compounds**
- **POPs Sorbed to Plastic Fragments** and **POPs**

Per student:

- **Ocean Food Web Role** card
- **Data Sheet: You Are What You Eat**
- **Biomagnification** student sheet
- Envelope (to collect molecules and

## Teacher Preparation

1. To better understand the potential for biomagnification of toxins to affect human health, watch the first nine minutes of Stephen Palumbi 's TED talk entitled "Following the Mercury Trail": http://www.youtube.com/watch?v=ooAlleo4AJQ&feature=player_embedded.

2. Make copies of the **Ocean Food Web Role** cards and cut them out so each student will have one. Copy the **Ocean Molecules and Compounds** sheets. Cut them out. You may want to laminate them for reuse. Decide whether you want students to have copies of the **Data Sheet: You are What You Eat** and **Biomagnification** student sheet or merely provide writing prompts and have students use their science notebooks.


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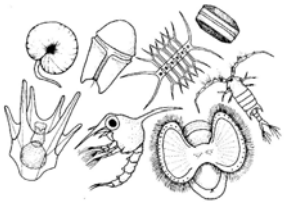
3. Check the link to the prezi presentation at http://prezi.com/m4fempadmzfm/?utm_campaign=share&utm_medium=copy&rc=ex0share. If you don't have internet, you can download it to your computer. Ensure the videos work within the prezi. If they don't, (your school's internet filters may block it), on a computer outside of school, you can go to keepvid.com or savevid.com and follow the instructions there to save a copy you will be able to play in your classroom.

## Procedure

1. **INTRODUCE THE FOCUS QUESTION TO THE CLASS.**
   Share the questions: *What kinds of toxins may be present in the ocean? What are implications for the biomagnification of toxins in the ocean food web?* 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.

2. **PROVIDE THE CONTEXT FOR AN OCEAN FOOD WEB SIMULATION.**
   Give students an **Ocean Food Web Role** card. (There is an organism representing each trophic level. There are 40 provided role cards so adjust numbers for each class ensuring each trophic level is represented.) Ask them which organisms represent which trophic levels (e.g., a phytoplankton is a producer, a salmon is a consumer). Tell students there are many essential minerals and gases in the ocean that their organism needs to survive. Beside water ($H_2O$) and oxygen ($O_2$), there are also sodium ions ($Na^+$), chloride ions (Cl-), sulfate ions ($SO_4^{2-}$), magnesium ions ($Mg^{2+}$), calcium ions ($Ca^{2+}$), potassium ions ($K^+$), strontium ions ($Sr^{2+}$), carbonic acid ($H_2CO_3$), boric acid ($H_3BO_3$), bromine (Br-), hydrogen ions ($H^+$) and hydroxide ions (OH-). Sometimes there are other substances and molecules in the ocean that aren't natural and might even be toxic, or poisonous, to ocean organisms. Also, although producers like phytoplankton create their own energy through photosynthesis other ocean animals need to consume other plants or animals for energy to survive.



3. **SET UP THE SIMULATION.**
   Choose a large floor area for your ocean and distribute the cut up and laminated **Ocean Molecules and Compounds** and **POPs**. Turn the **Ocean Molecules and Compounds** and **POPs** face down in the ocean space so students can't be selective about what they ingest. Note: There are two kinds of POPs, individual molecules and then multiple POPs molecules that have sorbed to plastic fragments (labeled at top of sheet). Tell students this is the ocean and their organism needs to sorb (adsorb or absorb) enough nutrients to survive as well as to consume other organisms.

4. **EXPLAIN THE PARAMETERS OF THE SIMULATION TO STUDENTS.**
   - Each producer or consumer type will get 15-30 seconds to swim in the ocean (facilitator note: experiment with timing). Choose someone to be the timer. When swimming, the goal is to gather as many **Ocean Molecules and Compounds** and prey items (organisms carrying **Ocean Molecules and Compounds**) as possible within the time limit.
   - Swimming sessions will model the energy transfer in an actual ocean food web; first the phytoplankton feeds, then the zooplankton, next the sardines, then the salmon and finally humans.

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- After each timed feeding session, the producer or consumer type will record a few of the names of **Ocean Molecules and Compounds** they accumulated as well as the number of **POPs** and record on their data sheet. If appropriate for your students, tell them that this is a simplified simulation and that in reality each organism excretes approximately 3/4 or 75% of the water soluble compounds ($H_2O$, $O_2$, $CO_2$) and approximately 1/8 or 12.5% of any lipid soluble POPs they ingest back into the ocean. You could even have a discard bowl for some of their **Ocean Molecules and Compounds** to indicate this.
- After recording the data, the organism type should remain in the ocean as possible food for when the next consumer type swims and feeds. The consumers can tag the prey organisms and take their **Ocean Molecules and Compounds.** Then the eaten/tagged organism can go sit down. (Decide if you are going to allow the students or organisms to move or run to avoid predation in the "ocean.") Students with the phytoplankton role card will only have the **Ocean Molecules and Compounds** cards as food.

**THE WORLD'S FINEST WILDERNESS LIES BENEATH THE WAVES.**

**-WYLAND**
***MARINE LIFE ARTIST***

5. **STUDENTS MEET WITH LIKE ORGANISMS AND FILL OUT DATA SHEET: YOU ARE WHAT YOU EAT.**
After all of the feeding rounds, have students meet with their other like ocean organisms (e.g., all phytoplankton meet, all zooplankton meet, etc.) and complete the column on the **Data Sheet: You Are What You Eat**. They should compare the ocean molecules and compounds picked up, record the total number of POPs they all accumulated, record the total number of like organisms (e.g., 20 phytoplankton) and average the number of POPs accumulated per organism. When they are finished have one representative add their data to a class chart projected or written on the whiteboard or chart paper.

6. **AS A WHOLE GROUP, EXAMINE CLASS DATA, DISCUSS POPS AND SHOW PRESENTATION.**
After all organism groups have added their data to the class chart, have them think-pair-share what they notice on the data sheet (the average number of POPs increased or magnified at each trophic level). They should notice that the top predator (human) accumulated the most POPs. Use the presentation at http://prezi.com/m4fempadmzfm/?utm_campaign=share&utm_medium=copy&rc=ex0share to discuss POPs (persistent, organic pollutants like PCBs, DDT and other pesticides, and other hydrophobic compounds that are toxic to organisms, are found in the ocean and are attracted to certain plastics) and how the bioaccumulation of POPs by individual organisms lead to biomagnification in top predators in the ocean food web, including humans.

7. **IN SMALL GROUPS, STUDENTS COMPETE BIOMAGNIFICATION STUDENT SHEET.**
Have students turn over their Data Sheet: You are What You Eat and begin to complete **Biomagnification** student sheet. They will be comparing an energy pyramid with a toxins pyramid. They'll notice that while producers form the base of a trophic pyramid, top predators like humans bioaccumulate the highest number of POPs due to biomagnification in the food web.

8. **AS A CLASS, DISCUSS THE SIMULATION AND WAYS STUDENTS CAN HELP REDUCE THE PROBLEM OF POPS IN OUR OCEAN FOOD WEB.**
Be sure to remind students that this activity was a simulation; the concentrations of POPs and other compounds and ratios of primary producers (the phytoplankton in this case) and other components of the food web vary per ecosystem. Next ask students, "What might be some ways to reduce POPs in the environment?" You may also have students think-pair-share about some behaviors they might change or actions they or others could take to reduce plastic in the ocean. Write on the board a summary of the big ideas for behavior changes that would reduce either plastic or POPs in the ocean for students to discuss further and record in their notebooks or student sheet.


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9. **Return to the focus question.**
   Now that students have simulated an ocean food web and observed how toxins like POPS may biomagnify, have them revisit the question: *What are implications for the biomagnification of POPs in the ocean food web?* 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

1. Examine the chemistry of hydrophobic and hydrophilic compounds, specifically POPs. See the Polar versus Nonpolar Compounds (6-8 or 9-12) student sheet on pages 25 and 26. Remind students that compounds are formed when atoms share or steal electrons and then have students Think-Pair-Share what they notice about the two classes of compounds. As a class, have the pairs share their ideas. Key ideas to bring out are that:
   - Polar or hydrophilic substances share electrons unevenly, causing them to carry a slight charge. This in turn causes them to be attracted to the slightly charged portion of water molecules and so they dissolve easily in water.
   - Nonpolar or hydrophobic substances have evenly distributed electrons so they carry no charge and do not dissolve easily in water or other polar substances.
   - Hydrophobic compounds are attracted to other nonpolar substances such as fats and oils which causes bioaccumulation in an organism.
   - Hydrophobic compounds tend to have many double bonds and lots of ring structures which make them very stable and difficult to break down even over long periods of time.

2. Use math to consider the enormity of the POP issue. Sample problems may include:
   - Suppose a salmon eats 300 g of sardines per day. The sardines consumed by the salmon have an average POPs concentration of 0.1 unit/g. What are the total units of POPs the salmon consumes in one day? *[(300g fish/day) (0.1 units of POPs/fish) = 30 units of POPs/day*] OR
   - Suppose a human also eats 300 g of food per day. Suppose 30 g of that food is tuna, and the tuna ate salmon which accumulated 100.0 units of POPs in their tissues. Perhaps 80% of those POPs in turn bioaccumulate in the tuna so the tuna has approximately 80.0 units of POPS/g of tissue. If the human eats 30 g of tuna, what level of POPs does our human friend consume in one day? *[(300g tuna/day)(10.0 units POPs/tuna) = 3,000 units POPs/day]*

## Resources

### Websites

International Pellet Watch http://www.pelletwatch.org/

This citizen science project monitors POPs in the ocean. If your school is near a beach, organize a pellet collection event and send in your samples for analysis to add to the database!

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5 Gyres Project http://5gyres.org

### Recommended Books

*Plastic: A Toxic Love Story.* Freinkel, Susan. Houghton Mifflin Harcourt, 2011.
*Silent Spring.* Rachel Carson, Houghton Mifflin Harcourt, 1962, 2002.
*Plastic-Free: How I Kicked the Plastic Habit and You Can Too.* Terry, Beth. Skyhorse Publishing Inc., 2012.

### References

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Van, A.; Rochman, C.M.; Flores, E.M.; Hill, K.L.; Vargas, E.; Vargas, S.A.; Hoh, E. 2012 *Persistent organic pollutants in plastic marine debris found on beaches in San Diego, California.* Chemosphere 86 258-263.

Mizukawa, K.; Hideshige, T.; Ito, M.; Geok, Y.B.; Hosoda, J.; Yamashita, R.; Santos, I.; Micaelo, C.; Ferreira, A.M. 2013 *Monitoring of a wide range of organic micropollutants on the Portuguese coast sing plastic resin pellets.* Marine Pollution Bulletin, In Press.

Ogata, Y.; H. Takada, K. Mizukawa, H. Hirai, S. Iwasa, S. Endo,Y. Mato, M. Saha, K. Okuda, A. Nakashima, M. Murakami, N. Zurcher, R Booyatumanondo, M.P. Zakaria, L.Q. Dung, M. Gordon, Carlos Miguez, S. Suzuki, C. Moore, H.K. Karapanagioti, S. Weerts, T. McClurg, Erick Burres, W. Smith, M. Van Velkenburg, J. S. Lang, R.C. Lang, D. Laursen, B. Danner, N. Stewardson, R.C. Thompson. *International Pellet Watch: Global monitoring of persistent organic pollutants (POPs) in coastal waters. Initial phase data on PCBs, DDTs, and HCHs.* Marine Pollution Bulletin 58 (2009) 1437–1446.

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

## Standards

### Next Generation Science Standards www.nextgenscience.org

*Performance Expectation*
Relates to MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems

### Common Core State Standards www.corestandards.org

*Language Arts,* SL.8.1
Speaking and Listening: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly


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# Data Sheet: You Are What You Eat

Name:

1. Record your individual data in the chart below after you are done feeding. (That is only the top two boxes in your organism's column.)

| | Producer *Phytoplankton* | Primary Consumer *Zooplankton* | Secondary Consumer *Sardine* | Tertiary Consumer *Salmon* | Top Predator *Human* |
|---|---|---|---|---|---|
| | | | | | |
| Ocean Molecules and Compounds (record chemical names) | | | | | |
| # of POPs in your organism | | | | | |
| Total # of POPs for all individuals at that trophic level | | | | | |
| Total # of organisms | | | | | |
| Average # of POPs per individual | | | | | |

2. After the simulation is over, meet up with like organisms and finish filling out your column above.
   - Record other molecule and compound names, record the total number of persistent, organic pollutants (POPs) all of you ingested, record the total number of organisms like you and then the average number of POPs per individual. (To calculate the average, count up the total number of POPs that all of you collected and divide by the number of your organism.)

3. Now add the class data to the table above (filling out all columns). Discuss:

   - What do you notice?
   - Which consumer type ingested the greatest number of POPs? Why do you think that is?
   - What are POPs?
   - How might POPs affect the health of each consumer type (or producer)?

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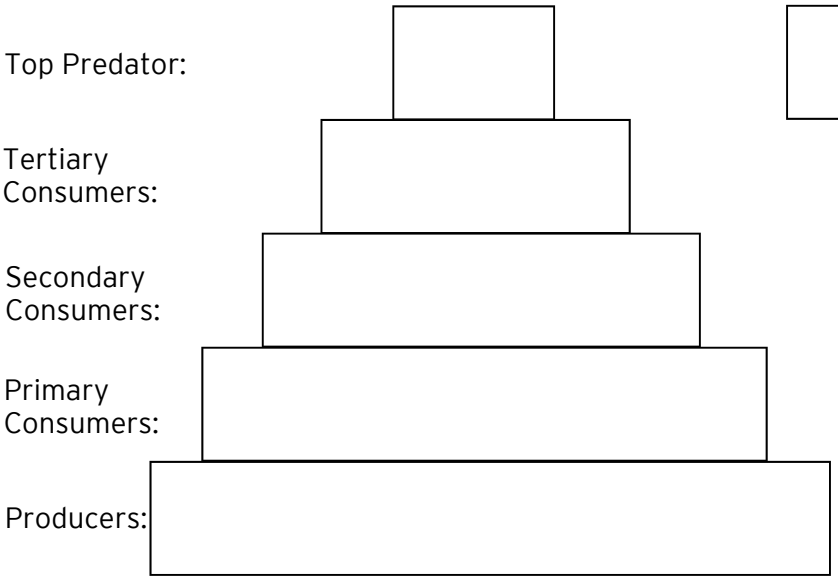
Name:

# Biomagnification

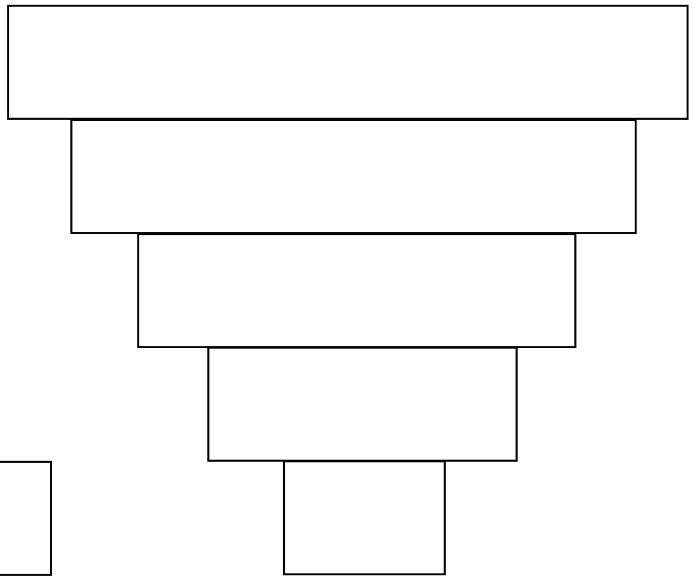
**Bioaccumulation** is an increase in the concentration of a chemical in an individual organism over time.

**Biomagnification** occurs when individual organisms with bioaccumulated chemicals in their tissues are consumed by predators higher up in the food web. This leads to higher concentrations of chemicals in organisms higher up in the food web.

1. Look at the diagrams below.
   - In the energy pyramid, add the organisms' names or next to their consumer type and indicate how many there were of each organism.
   - In the toxin pyramid, add the organism name and average number of POPs to the appropriate level. Then use dots to represent POPs and add them to each level. (You may want to have one dot represent multiple POPs. If you do this, include a key next to the diagram.)




**Energy Pyramid**



**Toxins (POP) Pyramid**

2. Compare the number of POPs that the producers consumed to that of the top predator. What do you notice?

3. In an energy pyramid, there are more producers than consumers so the base of the food web is the largest and consists of producers. Compare the two pyramids. What do you notice?

4. What do you think the biomagnification of toxic chemicals, like POPs, means for the health of humans and the ocean ecosystem?

5. What are some ways we can reduce the amount of POPs in the ocean ecosystem?

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# Ocean Food Web Role Cards

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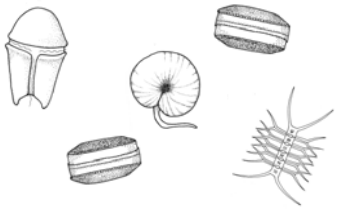
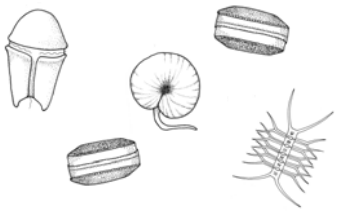
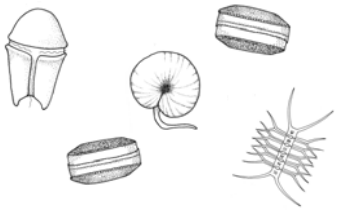
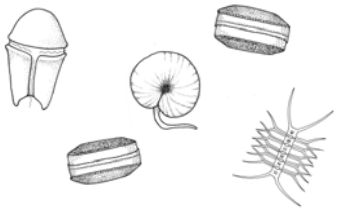
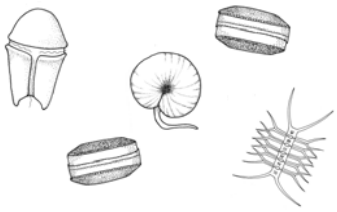
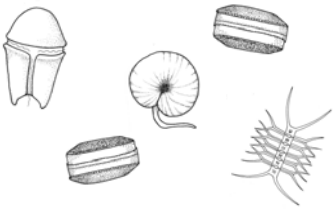
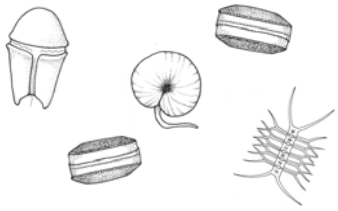
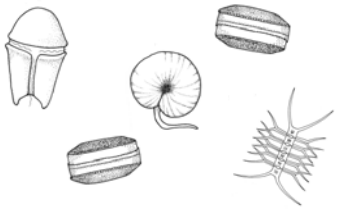
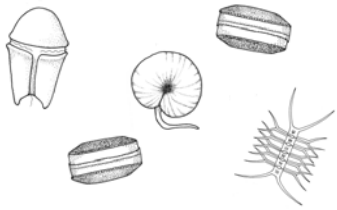
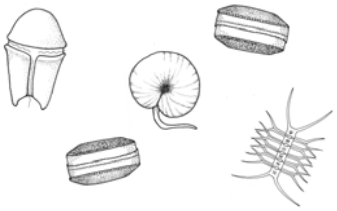
| Phytoplankton  | Phytoplankton  |
| Phytoplankton  | Phytoplankton  |
| Phytoplankton  | Phytoplankton  |
| Phytoplankton  | Phytoplankton  |
| Phytoplankton  | Phytoplankton  |

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# Ocean Food Web Role Cards

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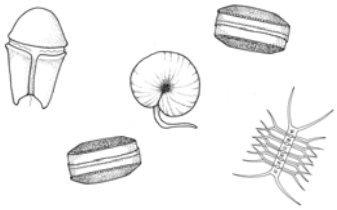
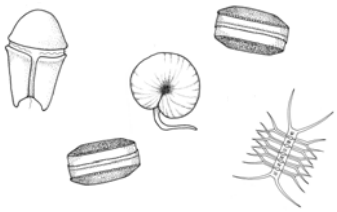
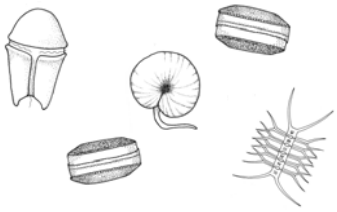
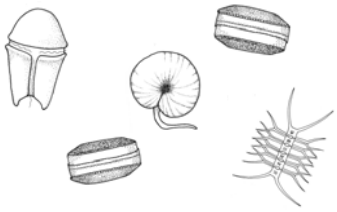
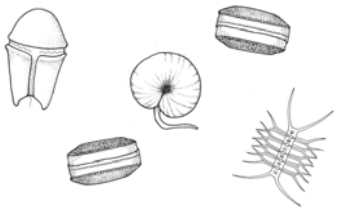
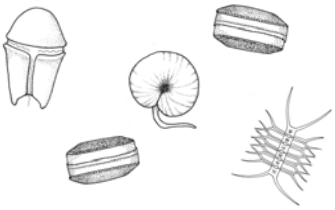
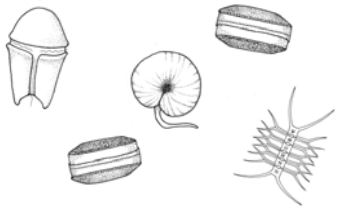
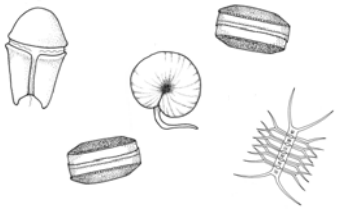
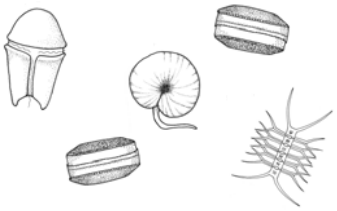
| Phytoplankton  | Phytoplankton  |
| Phytoplankton  | Phytoplankton  |
| Phytoplankton  | Phytoplankton  |
| Phytoplankton  | Phytoplankton  |
| Phytoplankton | Phytoplankton  |

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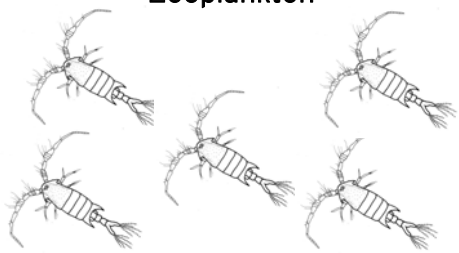
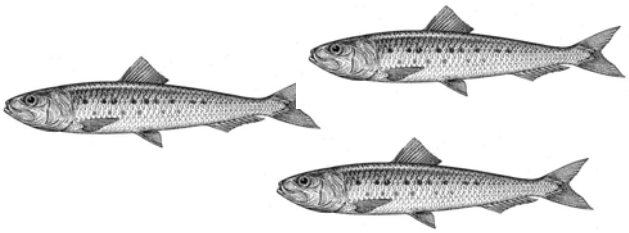
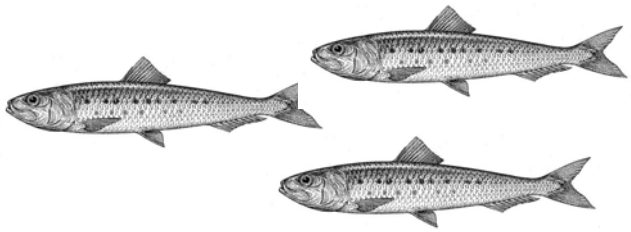
# Ocean Food Web Role Cards

| | |
|---|---|
| Zooplankton  | Zooplankton |
| Zooplankton | Zooplankton |
| Zooplankton | Zooplankton |
| Zooplankton | Zooplankton |
| Sardines  | Sardines  |

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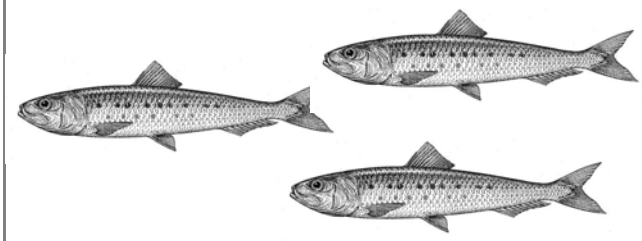
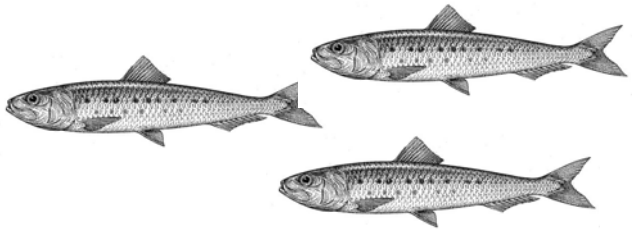
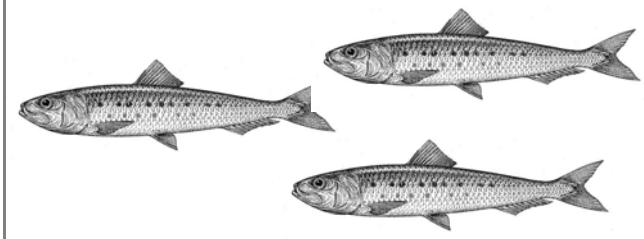
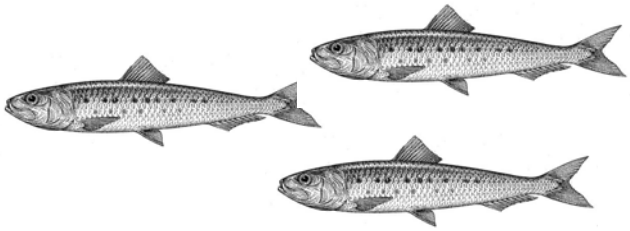
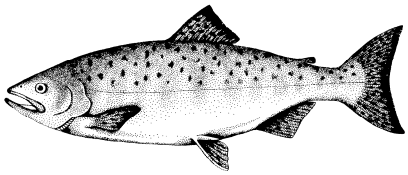
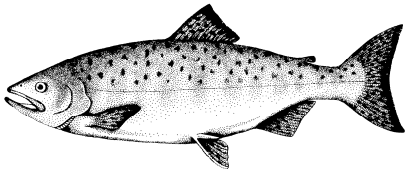
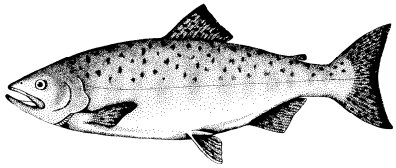
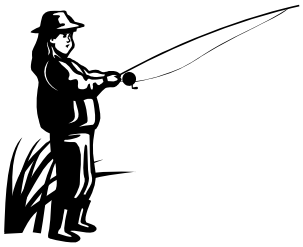
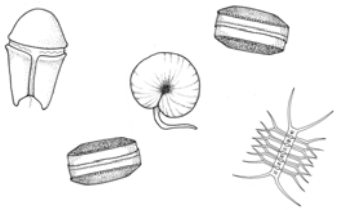
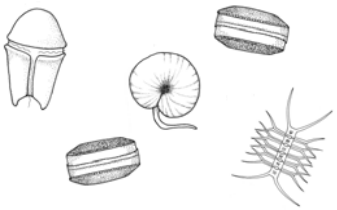
# Ocean Food Web Role Cards

| | |
|---|---|
| Sardines  | Sardines  |
| Sardines  | Sardines  |
| Salmon  | Salmon  |
| Salmon  | Human  |
| Phytoplankton  | Phytoplankton  |

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# POPs

| | | | | | |
|---|---|---|---|---|---|
| POPs | POPs | POPs | POPs | POPs | POPs |
| POPs | POPs | POPs | POPs | POPs | POPs |
| POPs | POPs | POPs | POPs | POPs | POPs |
| POPs | POPs | POPs | POPs | POPs | POPs |
| POPs | POPs | POPs | POPs | POPs | POPs |
| POPs | POPs | POPs | POPs | POPs | POPs |
| POPs | POPs | POPs | POPs | POPs | POPs |

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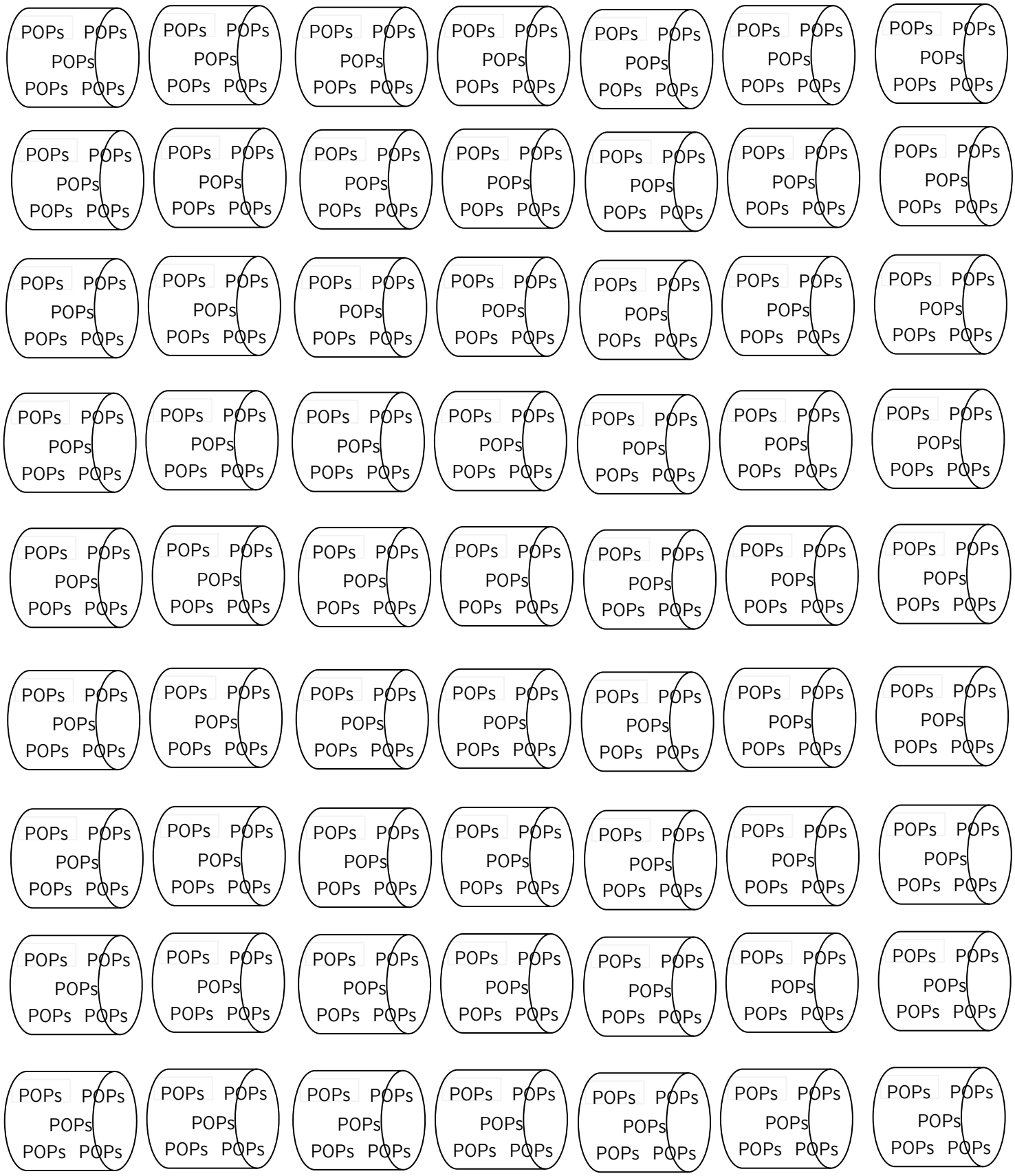
# POPs Sorbed to Plastic Fragments

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# Ocean Molecules and Compounds

| | | | | | |
|---|---|---|---|---|---|
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |

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# Ocean Molecules and Compounds

| | | | | | |
|---|---|---|---|---|---|
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |

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# Ocean Molecules and Compounds

| | | | | | |
|---|---|---|---|---|---|
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |

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| | | | | | |
|---|---|---|---|---|---|
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |

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# Ocean Molecules and Compounds

| | | | | | |
|---|---|---|---|---|---|
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |
| $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ |
| $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ |
| $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ |
| $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ |
| $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ |
| $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ | $Na^+$ |

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## Ocean Molecules and Compounds

| | | | | | |
|---|---|---|---|---|---|
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |

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# Ocean Molecules and Compounds

| | | | | | |
|---|---|---|---|---|---|
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ | $Cl^-$ |
| $SO_4^{2-}$ | $SO_4^{2-}$ | $SO_4^{2-}$ | $SO_4^{2-}$ | $SO_4^{2-}$ | $SO_4^{2-}$ |
| $Mg^{2+}$ | $Mg^{2+}$ | $Mg^{2+}$ | $Mg^{2+}$ | $Ca^{2+}$ | $Ca^{2+}$ |
| $K^+$ | $K^+$ | $Sr^{2+}$ | $O_2$ | $O_2$ | $O_2$ |
| $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ | $O_2$ |

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# Ocean Molecules and Compounds

| | | | | | |
|---|---|---|---|---|---|
| $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ |
| $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ |
| $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |
| $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ | $H_2O$ |

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# Ocean Molecules and Compounds

| | | | | | |
|---|---|---|---|---|---|
| $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ |
| $H_2CO_3$ | $H_2CO_3$ | $H_2CO_3$ | $H_2CO_3$ | $H_2CO_3$ | $H_2CO_3$ |
| $H_2CO_3$ | $H_2CO_3$ | $H_2CO_3$ | $H_2CO_3$ | $H_2CO_3$ | $H_2CO_3$ |
| $H_3BO_3$ | $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ |
| $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ |
| $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ |
| $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ | $Br^-$ |

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# Ocean Molecules and Compounds

| | | | | | |
|---|---|---|---|---|---|
| $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ | $CO_2$ |
| $H^+$ | $H^+$ | $H^+$ | $H^+$ | $H^+$ | $H^+$ |
| $H^+$ | $H^+$ | $H^+$ | $H^+$ | $H^+$ | $H^+$ |
| $OH^-$ | $OH^-$ | $OH^-$ | $OH^-$ | $OH^-$ | $OH^-$ |
| $OH^-$ | $OH^-$ | $OH^-$ | $OH^-$ | $OH^-$ | $OH^-$ |

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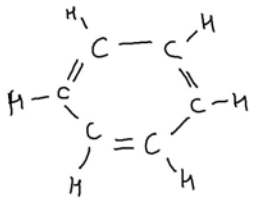
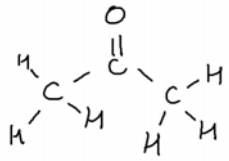
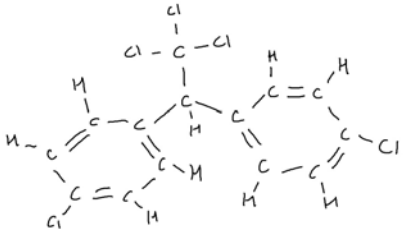
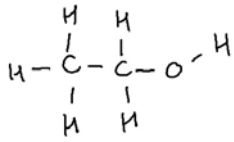
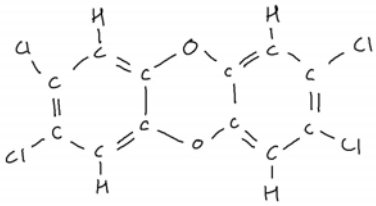
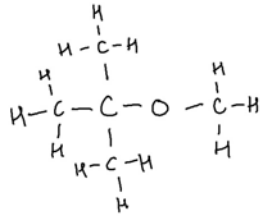
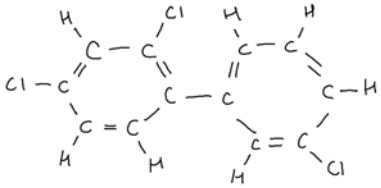
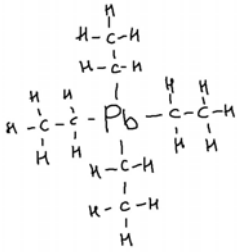
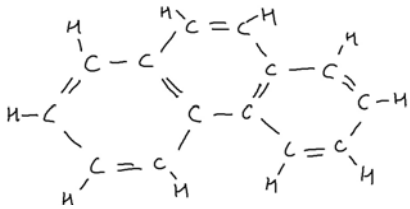
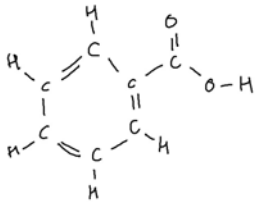
# Polar versus Nonpolar Compounds (Grades 6-8)

| Hydrophobic (POPs) (won't dissolve in water) | | Hydrophilic (will dissolve in water) | |
|---|---|---|---|
|  | **Benzene**<br>Industrial solvent |  | **Acetone**<br>Industrial solvent, used in nail polish remover. |
|  | **DDT**<br>Pesticide (banned in 1972) |  | **Ethanol**<br>Used as an industrial solvent, to make alcoholic beverages, and as a fuel additive |
|  | **Dioxin**<br>By-product of industrial processes including paper production and garbage incineration |  | **MTBE**<br>Fuel additive (banned in California in 2004) |
|  | **PCB**<br>Used in electrical transformers as an insulator |  | **Tetraethyl Lead**<br>Fuel additive (banned in the 1970s) |
|  | **Phenanthrene**<br>Used to produce dyes, plastics, and pesticides; produced when fossil fuels are burned. |  | **Benzoic Acid**<br>Used as a food preservative and to synthesize other chemicals |
| Name one thing that is common to all of these hydrophobic molecules that is different from the hydrophilic molecules. | | Name one thing that is common to all of these hydrophilic molecules that is different from the hydrophobic molecules. | |

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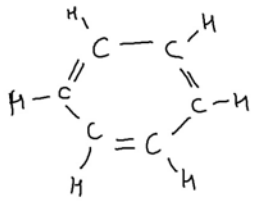
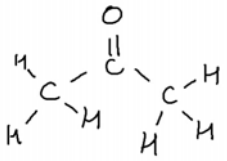
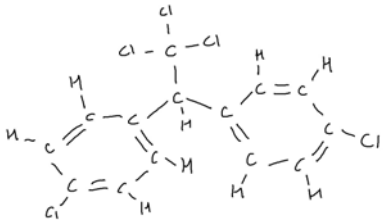
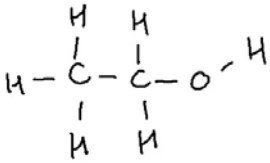
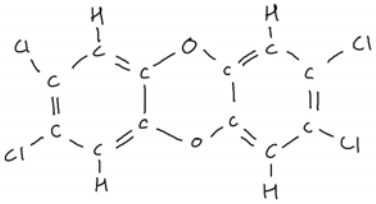
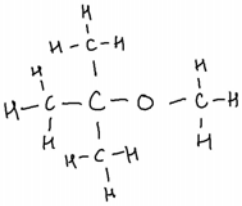
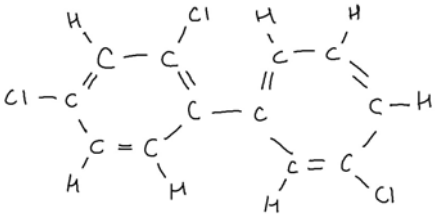
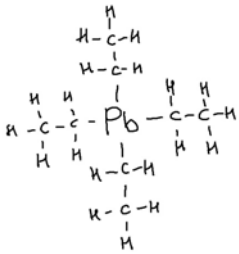
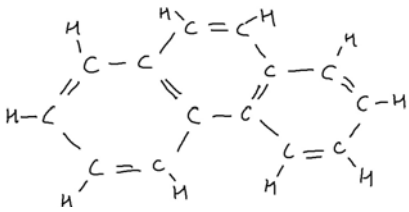
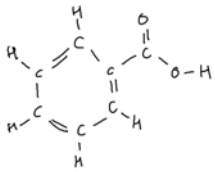
# Polar versus Nonpolar Compounds (Grades 9-12)

| Hydrophobic—Not Soluble in Water (POPs) | | Hydrophilic—Soluble in Water | |
|---|---|---|---|
|  | **Benzene**<br>Industrial solvent |  | **Acetone**<br>Industrial solvent, used in nail polish remover |
|  | **DDT**<br>Pesticide (banned in 1972) |  | **Ethanol**<br>Used as an industrial solvent, to make alcoholic beverages, and as a fuel additive |
|  | **Dioxin**<br>By-product of industrial processes including paper production and garbage incineration |  | **MTBE**<br>Fuel additive (banned in California in 2004) |
|  | **PCB**<br>Used in electrical transformers as an insulator |  | **Tetraethyl Lead**<br>Fuel additive (banned in the 1970s) |
|  | **Phenanthrene**<br>Used to produce dyes, plastics, and pesticides; produced when fossil fuels are burned. |  | **Benzoic Acid**<br>Used as a food preservative and to synthesize other chemicals |
| What are some characteristics of hydrophobic substances?<br>In what ways are they different from hydrophilic substances? | | What are some characteristics of hydrophilic substances?<br>In what ways are they different from hydrophobic substances? | |

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# 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

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


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**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


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## 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).

## 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.

**The mission of the Monterey Bay Aquarium is to inspire conservation of the oceans.**

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"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


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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

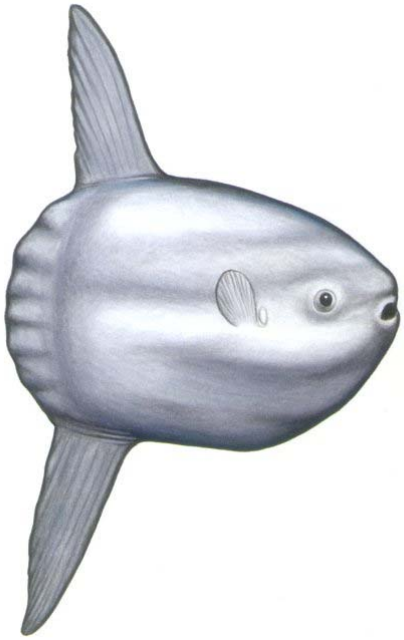
**Next Generation of Science Standards** www.nextgenscience.org

*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

Many thanks to Patrick Adams for originating this activity and his classes at Bellarmine College Preparatory in San Jose who keep him coming up with great ideas!



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

Dr. Sylvia Earle

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# Inspiring Conservation Behavior

**Topic**
Conservation

**Grades**
3-12

**Site**
Indoors, Outdoors

**Duration**
40 minutes

**Materials**
- Whiteboard or projector
- **Inspiring Conservation Behavior** student sheet (one per student)
- Sticky notes

**Vocabulary**
barrier, conservation, motivation

**Common Core State Standards**
See page 4

## Focus Question

*How can we motivate people to change their behavior regarding an important social or environmental issue?*

## Overview

If we know a behavior is healthy for both us and the environment, what prevents us from taking action? In this activity, students examine barriers to conservation behavior and identify motivations for enacting the behavior. They choose a medium (comic, public service announcement video, screencast, animation, meme or infographic) to inform a target audience about reasons and ways to change their behavior.

## Objectives

Students will be able to:
- Explain conservation behavior, specifically in terms of plastic consumption.
- Identify barriers to and motivations for enacting a specific behavior.
- Communicate a message through diverse multimedia formats to a target audience about a social or environmental issue.

## Background

With all the gloom and doom of environmental destruction, inspiring and empowering people to take action to protect the environment becomes essential. Some people question the benefit or impact of individual actions; however, arguments for encouraging individual behavior change abound. Nicole Ardoin (2009), a Stanford professor and environmental education researcher, outlines several:

> "Encouraging easily implemented behaviors may develop self-efficacy and enhance a sense of personal control." (pp. 61-62)
>
> "Smaller actions can accumulate to create greater benefits." (p. 62)
>
> "Support, engagement, and active involvement of local populations are necessary for conservation efforts to succeed in the long term." (p. 62)

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**VOCABULARY**

**Barrier:** interfering with or preventing action

**Conservation:** preservation or restoration from loss, neglect or damage

**Motivation:** desire to take action

The challenge is in figuring out how to motivate conservation behavior change. Monroe (2003) identifies two broad avenues for encouraging conservation behaviors: social marketing tools and cultivation of environmental literacy. Social marketing tools focus on targeting specific audiences, reducing barriers to behavior change (a significant factor with many environmental behaviors), providing meaningful information, and creating a sense of commitment, sometimes through incentives (Monroe, 2003). Environmental literacy, on the other hand, refers to a longer-term connection to and stewardship of the environment and is often supported by significant life experiences or education. Regardless of the method, there is no time better than today to cultivate a caring society and empower people to take action to protect our planet's fragile biodiversity.

## Teacher Preparation

1. Gather materials and make copies of the student sheet. You'll need to decide if each student will get one or there will be one per student group.
2. Identify and secure tools for students to use in creating public service announcements (iPads, computer lab, smart phones, digital cameras, poster supplies, props for skits, etc.).

## Procedure

1. **Introduce the focus question to the class.**
   Share the question: *How can we motivate people to change their behavior regarding an important social or environmental issue?* 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.

2. **Introduce the social or environmental issue to students.**
   You may choose to do a classroom activity to introduce the issue or show a short video. For example, if the issue is plastic pollution, use the Plastics in the Water Column activity in **Resources** to introduce impacts of plastic on ocean animals. Ask students to think-pair-share about the issue.

3. **As a class, examine barriers to healthy behaviors.**
   Write the following actions on the board. *Eat five servings of fruit and vegetables. Drink 8 glasses of water. Wear sunscreen. Exercise for at least 30 minutes. Floss.* Ask students to consider how many times they have done those actions each day in the last week. Lead a discussion: *How many people said yes to all five actions? Four? Three? Two? One? How many of you have heard that these suggestions are good for your health? So why don't you follow them? Are there barriers to certain behaviors that are out of your control?* They may come up with barriers that include lack of time, low motivation, etc.

4. **In pairs, students think-pair-share about motivations for behavior change.**
   Divide students into pairs and have them think-pair-share (think silently then share with their partner) about a behavior they have changed and what made them change it. Give each pair a couple of sticky notes and have them write their behavior change and the motivation for it on a sticky note. You may want to differentiate an action from behavior at this point. (An action is doing something once and behavior is comprised of consistent actions over time.)

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5. **As a class, students debrief motivations for behavior change.**
On a poster or white board, write broad categories of motivations (increased knowledge, financial incentive, social/peer pressure, fear, life-changing experiences, etc.) Have students come up and place their sticky note under the relevant heading. Discuss: *What seems to motivate people most? Why do you think that is so?*

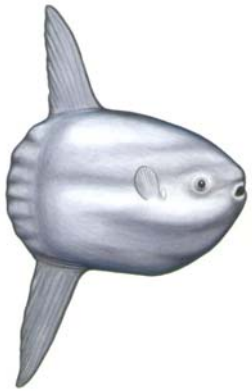
6. **Students work in small groups or individually to plan a social marketing campaign.**
Refer back to the social or environmental issue you are addressing. Tell students they are going to be communicating a message about that issue to a specific audience in order to effect behavior change. Pass out the **Inspiring Conservation Behavior** student sheets. Give students 10-15 minutes to work through the sheet. They will identify their main message and audience and work to decide on a social marketing strategy that best meets the audience's needs.

7. **Students choose the best medium to communicate their message.**
Take about 10 minutes to show students examples of various methods of social marketing. These examples might include comics, public service announcement videos, screencasts, animations, memes and infographics. Then, allow students to choose which method of communication would best suit their audience. Give students time to plan and create a product. To create these, students can use the following tools:
   - Comic: free bitstrips iPad app or pixton.com
   - PSA: iMovie iPad (this costs) app or wevideo.com
   - Screencast: free Educreations iPad app or educreations.com
   - Animation: free Toontastic iPad app or goanimate.com
   - Meme: free PhotoPad app or picmonkey.com
   - Infographic: infogr.am

8. **Return to the focus question.**
Now that students have targeted an audience, identified motivations and obstacles and communicated their message, have them revisit the question: *How can we motivate people to change their behavior regarding an important social or environmental issue?* Students may think on their own or discuss with a partner. Then in their notebook, you may have them draw a line of learning and under it add to their original thoughts about the question.

**One is not born into the world to do everything but to do something.**

**Henry David Thoreau**



## Resources

### Websites

Monterey Bay Aquarium's Plastics in the Water Column activity
http://www.montereybayaquarium.org/PDF_files/teaching_activities/Plastics_in_theWater_Column6-8.pdf

Do One Thing. Alliance for Climate Education
http://www.acespace.org/dot

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

Books

*Beyond Ecophobia: Reclaiming the Heart in Nature Education.* Sobel, David. Orion Society, 1999.

## References

Ardoin, N. (2009). Behavior-change theories and free-choice environmental learning. In J. Falk, J. Heimlich, and S. Foutz (eds.), *Free-Choice Learning and the Environment* (pp. 57-76). Lanham, MD: AltaMira Press.

Ardoin, N. (15, Feb. 2012). Learning beyond museums: Environmental education and its outcomes. *EDUC 357X: Science and Environmental Education in Informal Environments*. Lecture conducted from Stanford University, Stanford, CA.

Monroe, M.C. (2003). Two avenues for encouraging conservation behaviors. *Human Ecology Review, 10*(2), pp. 113-125.

## Standards

Next Generation Science Standards www.nextgenscience.org

*Disciplinary Core Idea*
Relates to ESS3.C Human Impacts on Earth Systems

Common Core State Standards www.corestandards.org

*Speaking and Listening,* SL.3-12.1
Engage effectively in a range of collaborative discussions with diverse partners on grade appropriate topics and texts, building on others' ideas and expressing their own clearly

*Speaking and Listening,* SL.5-12.5
Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes

*Speaking and Listening,* SL.6.2
Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text or issue under study


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Name(s):

# Inspiring Conservation Behavior

ISSUE

AUDIENCE

DESIRED BEHAVIOR

Motivations

Obstacles

STYLE

How are you going to effectively engage your audience? (humor, drama, appeal to values, celebrity, simplicity, scientific language, evidence-based, etc.)

MESSAGE OR TAGLINE:

Try to keep it to one sentence and target one or more motivations or obstacles.

METHOD OF COMMUNICATION:

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# Plastics Use Audit

**Topic**
Plastics

**Grades**
6-12

**Site**
Indoors, Outdoors

**Duration**
One hour plus

**Materials**
See page 3

**Vocabulary**
audit, plastic, recycling, waste

**Next Generation Science Standards**

Practices

Planning and carrying out investigations

Core Ideas

ESS3.C Human impacts on Earth systems

Crosscutting Concepts

Cause and Effect

Performance Expectations

See page 5

## Focus Question

*What types of plastics do we use the most? How can we reduce our use of single-use plastics?*

## Overview

How much plastic do we consume? In this activity, students design an investigation and conduct an audit of waste (trash and recycling) at home or in their schools to discover the types and quantities of plastics that are consumed. They use their findings to raise awareness about which items show up most frequently. Then they conduct a follow-up audit and provide information on whether increased awareness influenced people's behaviors with regard to plastic use.

## Objectives

Students will be able to:

- Conduct an investigation to determine the types and quantities of plastic waste generated in the classroom, home and/or school-wide.
- Gather and make sense of information that plastics, which are made from natural resources, can have positive and negative effects on the environment.
- Design, evaluate and refine a solution for reducing the amount of plastic waste generated.

## Background

Nearly all plastic ever produced, whether disposed of responsibly or not, still exists today (www.sustainablecommunications.org). In 2011 alone, Americans discarded approximately 32 million tons of plastic waste with only 8% of that recovered for recycling (Environmental Protection Agency). The remainder ends up in landfills or the environment, especially the ocean. Plastic pollution has become a global dilemma requiring resolution.

### What is Plastic?

Plastic is an easily shaped substance, composed of polymers typically made from fossil fuels. Plastics can be malleable or rigid, flimsy or nearly indestructible. It is


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**VOCABULARY**

**Audit:** an unbiased examination and evaluation of something like finances or, in this case, waste

**Plastic:** a readily-molded substance made from fossils fuels through chemical reactions

**Recycling:** processing an existing material or product into a different material or product, uses energy and additional raw materials

**Waste:** unwanted and discarded materials

also relatively economically inexpensive to produce. Due to this versatility, plastics are everywhere, used in electronic devices, tools and food packaging. While some uses of plastic are both practical and beneficial, an estimated 50% of plastics used daily are single-use disposable items. This is problematic as plastic is too valuable and long-lasting a material to be used once and discarded.

## Plastic Problems

Producing plastics is energy intensive. According to the U.S. Energy Information Administration, in the U.S. production of plastics required an estimated 191 million barrels of liquid petroleum gases and natural gas liquids in 2010 (about 2.7% of total U.S. petroleum consumption) (http://www.eia.gov/tools/faqs/faq.cfm?id=34&t=6). Made from nonrenewable resources and chemicals, plastics are not biodegradable. They are photodegradable, breaking into smaller fragments when exposed to the sun's UV rays. Plastic objects or small plastic fragments can contaminate soil and water and are easily ingested by many organisms. This is particularly concerning in the ocean, where millions of tons of plastic debris is accumulating. The majority of this debris consists of small plastic particles resulting from the break down of larger plastic items over time by wind, wave and UV action.

These tiny plastic particles can pack a toxic punch. Most plastics are composed of many types of toxic chemicals, while persistent organic pollutants (POPs) found in ocean waters adsorb to certain plastics, increasing their toxicity. Due to their small size and abundance, these toxic plastic pieces are mixed with the plankton at the very base of the marine food web. Evidence is accumulating that these toxic chemicals work their way up the food chain, potentially affecting the top consumer in the ocean food web, humans. Removing this plastic debris is not practical, so preventing the continuous flow of plastic waste from land to sea is the way to resolve this problem.

## Action

Fortunately, there are many ways to reduce plastic waste and help maintain healthy ocean animals and ecosystems. First, increase awareness of your own plastic waste by tracking the amount of disposable plastics you use. Then attempt to reduce disposable plastics whenever possible. You can also refuse to use plastic utensils and instead carry a personal set of reusable utensils when you go out to eat. You can also buy foods like crackers, pretzels and other snacks in bulk and store them in reusable containers, rather than purchasing smaller, individually wrapped portions. You can also use reusable containers to store classroom tools like paper clips, markers, pencils, pens, etc. Recycling plastic waste is important but requires additional energy and materials. Reducing the amount of plastic waste generated is the most effective way to reduce plastics in the waste stream. While plastic pollution, especially in the ocean, is a global threat, increasing awareness of this problem at individual and community levels is the first step in reducing its proliferation.


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## Materials

- Large tabletop or floor space
- Tarps
- Buckets for liquids
- Rubber gloves
- Bathroom or digital scale(s)
- Access to soap and water or disinfectant hand wipes
- Recycling/waste bin contents
- Copies of the **Plastics Audit Data sheet** and **Plastics Audit Analysis sheet** (pages 6-9)
- Graphing program or paper

## Teacher Preparation

Gather the materials for each student group to conduct an audit on an ongoing basis. See materials first and read over procedure to determine amount of materials you will need. Make desired number of student sheets.

## Procedure

1. **Introduce the issue of plastic pollution and focus question to students.**

   Use the Gyre in a Bottle activity (on the Aquarium website) or show a movie like *Bag it!* (see **Resources**) to introduce the issue of plastic pollution and illustrate its scale. Ask students to respond to this focus question as a quick write in their notebooks: *What types of plastics do we use the most? How can we reduce our use of single-use plastics?*

2. **As a class, determine a question or problem to investigate with a plastics audit.**

   Discuss what an audit is (an unbiased observation using data) and what you want to investigate (e.g., How big is our plastics problem? How much plastic waste will we find in the cafeteria?) The class may want to reduce plastic school-wide, take a census of their household's plastics use or just assess how much plastic they use in various settings. Pass out the **Plastics Audit Analysis** student sheet. Have students write in the investigation question and a prediction for that question.

3. **Design the investigation as a class.**

   Depending on the class question, discuss the plastic audit procedure. How will you measure plastic consumption? Will you measure plastics found in trash bins and/or recycling bins? Will you compare plastics to other trash and/or recycling? Consider things like the duration of the audit, location of recycling/trash bins to examine (i.e., if you want to see how much plastic the school cafeteria uses, then include all bins where lunch waste may be discarded) and the number of people who use the bins. To start small, you may choose to begin with an audit of your classroom. Students will need to gather information on variables that can affect the data, such as regular collection time (when is waste collected in your locations?), special events happening, etc. Collecting data more than once will give you more accurate results. After gathering this information, have students decide when and where they will collect the recycling/trash. Have students use the **Plastics Audit Analysis** sheet to record the procedure and revise their initial prediction.

**The mission of the Monterey Bay Aquarium is to inspire conservation of the oceans.**

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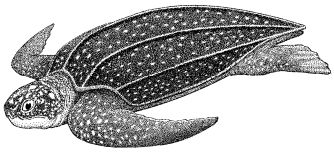
**4. Conduct the audit.**

For the actual audit, see **Materials** for what to have on hand. Generally, for each bin, spread a tarp on a large floor or outdoor space. Small student groups (three to six is ideal) should choose roles. Roles may include sorters to differentiate plastics from nonplastics, researchers to look up unknown materials, measurers to count quantity of plastic items and assess weight or volume and data recorders. Pass out the **Plastics Audit Data Sheet** for ideas. Students should wear gloves and avoid sharp objects, biological hazards such as blood, or anything else that may cause injury. (Avoid bathroom waste bins and exercise caution if auditing kitchen waste bins.) Return all nonplastics to waste or recycling bins.

NOTE: Repeat the audit more than once to generate multiple samples (for methodological precision) and to collect an accurate representation of the type of waste being generated.

**5. Analyze audit data.**

Ask each group to create a graph of their results to display. As a class discuss: *What is the total number of items and their weight/volume? What patterns did you notice? Were there any surprises? What more do you want to know? What other questions do you have? How much plastic is used each week? Each month? Per year?* You may want to compare the amount of plastic or other waste items discarded at your site to the national average or to other countries around the world. See the EPA's website for recent statistics: http://www.epa.gov/osw/nonhaz/municipal/pubs/MSWcharacterization_508_053113_fs.pdf



**6. Students formulate a conclusion.**

Students can write conclusions on the **Plastics Audit Analysis** sheet. They should include evidence to show whether their prediction is accurate or not. Have them go back and add to their original answer to the question: *What kinds of plastic do we use the most? How can we reduce our use of single-use plastics?*

**7. Propose an awareness campaign or message about plastic consumption for your school, classroom or student households.**

See the **Use Less Plastic: Inspiring Conservation Behavior** activity (on the Aquarium website) for more information about targeting specific plastic consumption behaviors. Share your audit data with the school and other classes. Come up with a few specific actions for people to take to reduce the amount of plastics used. For example, encourage students to come up with more creative solutions than a reusable water bottle and a bag. Have them think about things like individual packaging, straw use, disposable dinnerware.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**8. Conduct a follow-up audit and compare results with intial audit.**

Have students follow the same investigation procedure (collect, record and analyze data). Then have your students analyze the effectiveness of their awareness campaign or message by comparing the initial and follow-up audit. *How did the data change or stay the same? What was surprising? What seems to be the most effective strategy for using less plastic? How are you going to continue these actions after this class is over?*

**9. Return to the focus question.**

Now that students have collected data about their plastic use and discussed their results, have them again revisit the question: *What kinds of plastic s do we use the most? How can we reduce our use of plastics?* 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.

**Plastics: made to last forever, designed to throw away.**

**5 Gyres**

## Resources

### Websites

*Environmental Protection Agency (EPA)* www.epa.gov/osw/

Learn about different kinds of waste and how you can take action to reduce waste.

*Monterey Bay Aquarium* www.montereybayaquarium.com

Find curriculum about conservation issues like plastic pollution and many other themes.

*Plastic Oceans* http://www.plasticoceans.net/the-facts/what-a-waste/

The Plastics Ocean Foundation is a nonprofit based in the United Kingdom dedicated to research, policy and fundraising regarding plastic pollution in the oceans.

*5Gyres* http://5gyres.org/what_is_the_issue/the_problem/

This organization's mission is to conduct research and communicate about the global impact of plastic pollution in the world's oceans and employ strategies to eliminate the accumulation of plastic pollution in the 5 subtropical gyres.

### Videos

Bag it! Is Your Life Too Plastic?

http://www.bagitmovie.com/

## Standards

**Next Generation Science Standards** www.nextgenscience.org

*Performance Expectations*

Relates to MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

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# Plastics Audit Data Sheet

Name(s):

| | |
|---|---|
| Location of waste bins (specify if recycling or trash): | |
| Description of location (e.g., class-room, cafeteria, close to high use areas? etc.) | |
| Frequency of collection (when are the bin contents collected?) | |

| Type of Plastic | Number | | Weight | |
|---|---|---|---|---|
| Date & Day of Week: | My Data | Class Data | My Data | Class Data |
| Bottles | | | | |
| Food packaging | | | | |
| Non-food Packaging | | | | |
| Other | | | | |
| *Total* | | | | |
| Date & Day of Week: | | | | |
| Bottles | | | | |
| Food packaging | | | | |
| Non-food Packaging | | | | |
| Other | | | | |
| *Total* | | | | |
| Date & Day of Week: | | | | |
| Bottles | | | | |
| Food packaging | | | | |
| Non-food Packaging | | | | |
| Other | | | | |
| *Total* | | | | |
| **Average of all audit totals:** | | | | |
| *Average # bottles* | | | | |
| *Average # food packaging* | | | | |
| *Average # non-food packaging* | | | | |
| *Average # other items* | | | | |

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# Plastics Audit Analysis

Name(s):

**QUESTION/PROBLEM**
What do you want to investigate about plastic use? Where? (home/school/community)

**PREDICTION**
What do you think you'll find?

**PROCEDURE**
How are you going to conduct your investigation? What evidence will you collect?

**ANALYZE RESULTS**
Graph and discuss your data (e.g., The data show...)

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# Plastics Audit Analysis

CONCLUSION
Was your prediction accurate? What is the evidence? Do you need more information? What other questions do you want to investigate?

SOLUTION
What actions can you take to address the issue/problem? How might you communicate your findings and solution?

NEXT STEPS
Repeat the audit after implementing your solution and graph that data here. Did your actions have an effect?

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# Plastics: Reduce Use or Recycle?

**Topic**
Plastics

**Grades**
6-8

**Site**
Indoors, Outdoors

**Duration**
45 minutes

**Materials**
see page 2

**Vocabulary**
disposable, fossil fuels, monomer, plastic, polymer, recycle, upcycle

**Next Generation Science Standards**

Practices

Asking questions and defining problems

Core Ideas

PS1.A Structure and properties of matter
ESS3.C Earth and human activity

Crosscutting Concepts

Structure and function

Performance Expectations

See page 4

## Focus Question

*How do we use plastics? Are there better or worse uses of plastics?*

## Overview

From contact lenses to medical tubing to single-use disposable yogurt containers, plastics are ubiquitous in our daily lives. But how wisely are we using these durable, versatile materials produced from fossil fuels - a nonrenewable resource? In this activity, students examine different kinds of plastics and investigate what happens after plastic objects are thrown in the recycling bin. They are also challenged to think about whether some of the ways we use plastics are better than others.

## Objectives

Students will be able to:

- Observe and describe the physical and chemical properties that can be used to identify different types of plastics.
- Differentiate single-use plastics from other plastics.
- Examine society's use of plastics and recognize that plastic is made from a nonrenewable resource.

## Background

In 2012, the United States generated almost 14 million tons of plastics as containers and packaging, about 11 million tons as durable goods such as appliances, and almost 7 million tons as nondurable goods, such as plates and cups. Only 9 percent of the total plastic waste generated in 2012 was recovered for recycling (www.epa.gov/osw/conserve/materials/plastics). Plastic is ubiquitous in our modern world. Plastic is used to make durable items like contact lenses, vehicle parts and electronics. It is also used to make items that are used just once like water bottles, plastic bags, straws and food containers. Plastic is lightweight, durable and relatively economical to manufacture. However, it does not biodegrade; instead it photodegrades into smaller and smaller pieces so it remains in the environment indefinitely. There is a high environmental cost to single-use, disposable plastic; wildlife ingestion and entanglement and habitat alteration are some of the side effects of discarded plastic. In addition, harmful human health effects have been linked to additives in plastics (phthalates and bisphenol A among others).


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**VOCABULARY**

**Disposable:** a product designed for single use after which it is recycled or disposed of in a landfill

**Fossil fuels:** the remains of plants and animals buried in the Earth's crust and heated and pressurized into crude oil, natural gas, coal and heavy oils

**Monomer:** a molecule that chemically binds to other molecules creating polymers

**Plastic:** an easily-shaped substance made from fossils fuels through chemical reactions

**Polymer:** a large molecule made up of monomers

**Recycle:** processing an existing material or product into a different material or product; uses energy and additional raw materials

**Upcycle:** processing an existing material or product into a higher quality material or product

Plastics are primarily synthetic polymers made with chemicals that are derived from nonrenewable fossil fuels, specifically petroleum or natural gas. There are thousands of different kinds of plastics. Plastics can be differentiated by certain chemical and physical properties. These properties are surface appearance, transparency, rigidity, density and flammability. The Society of the Plastics Industry developed identification codes for six of the most common types and a seventh that includes a number of different plastic types. These are the numbers located in what has come to be called the "recycling symbol" on plastic objects. It is a misconception that this identification code means the object can be recycled. The codes were developed to help recyclers differentiate between various kinds of plastic. Some plastics are cheaper and less energy intensive to recycle (numbers 1 and 2) while others often don't get recycled at all (number seven). Regardless, recycling is costly in terms of energy and other resources. It is much less costly, both economically and environmentally, to reduce the amount of plastic used. Every municipality and/or county is different in what it may or may not recycle. Contact your local waste management company for details on recycling in your community.

## Materials

- Computer and projector
- Variety of clean plastic packaging and objects (enough for each student group to have 4-5 pieces)
- **Plastics: Reduce Use or Recycle** prezi (see link in procedure)
- **How We Use Plastics** cards (one set per student group)
- **Plastics: Reduce Use or Recycle** student sheet (one per student)
- **Types of Plastics** student sheet (one per student)

## Teacher Preparation

1. A week before the lesson, ask students to bring in a variety of rinsed out plastic objects. Make sure you get a variety of resin identification codes (numbers on each object). Ideally, have five pieces per student group.
2. Make a set of **How We Use Plastics** cards (page 9 and 10) for each student group. You may want to laminate them for reuse with different classes.
3. Decide if you want copies of the **Types of Plastics** student sheet and **Plastics: Reduce Use or Recycle** student sheets or if you'll have them use their science notebooks.
4. Check the prezi link to make sure it works. Use the presentation notes on page 7 to run through the presentation before class.

## Procedure

1. **In small groups, students write down everything in the room made of plastic.** Give students 30 seconds to write down everything in the room made of plastics. What kinds of objects are made of plastic? How are they used? Are they used multiple times or only once? Does the plastic all look the same? Feel the same? How many of the items in the room are made of plastic compared to other materials (wood, metal, glass)?


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2. **Introduce the focus question to the class.**
Share the question: *How do we use plastics? Are there better or worse uses of plastics?* 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.

3. **Students categorize illustrations of a variety of plastic items according to how we use them.**
Pass out a set of **How We Use Plastics** cards to every student group. Have them sort the cards into categories depending on how they are used. Depending on the level of the students, you may have them sort into "single-use" versus "multiple-use" or if they have more prior knowledge, "wise uses of plastics" versus "unwise uses of plastics." In their science notebooks, ask them to record the item, what category they placed it in and their reasoning. You may want to model creating a three-column table with "item," "single-use"/"multiple-use" or "wise"/"unwise" and "why."

4. **Students examine and differentiate a variety of plastic packaging.**
Pass out a variety of rinsed plastic packaging with different resin identification codes (RIC). Pose the question: how do we tell different kinds of plastics apart? Give students time to sort them into categories of different plastics. Then solicit ideas from the class on how to tell plastics apart (may range between use, color, number, etc.). Discuss the resin identification codes and how they are an industry code for differentiating plastics but that doesn't always mean the plastic objects are recycled.

5. **As a whole group, discuss the observable properties of different plastics.**
Pass out **Types of Plastics** student sheet. Have students examine the plastic objects and record the observable properties of different plastics. If time, you may challenge them to plan an investigation(s) to distinguish between plastic types. The physical and chemical differences can be found by examining surface appearance (smooth, glossy, rough), how light travels through the plastic (transparent, translucent, opaque), rigidity (or flexibility), density and flammability. If you have time, you may choose to do Plastics in the Water Column activity which explores density of plastics. (See **Resources**.)

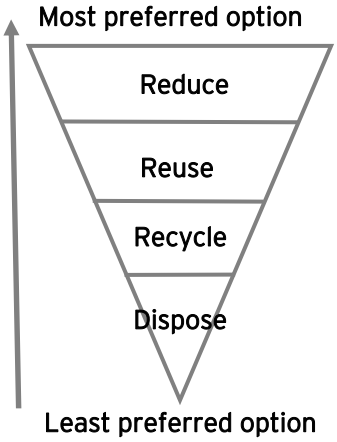
6. **Share the Plastics: Reduce Use or Recycle presentation.**
Challenge students to think about where plastics come from and how efficiently (in terms of energy and the environment) they are used while sharing the presentation at: http://prezi.com/dsxiusp6vh9a/plastics-reduce-use-or-recycle-2014. See page 8 for the presentation talking points.

7. **Students reassign illustrations of plastics into "wise" and "unwise" uses.**
Now that students understand that plastics are versatile yet also ultimately nonrenewable and resource-intensive to recycle, ask them to go back and reorganize illustrations of plastics into "wise" and "unwise" uses. Have them explain what they mean by "wise" and why they categorized each illustration as they did. Be sure they understand the difference between single-use disposable plastic and durable uses of plastics.

**Only we humans make waste nature can't digest.**

**Charles Moore**
***Algalita Marine Research Foundation***

Hierarchy of Waste Pyramid

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8. **As a class, discuss reducing and reusing versus recycling.**
Ask your students about the "3Rs." Make sure they understand that there is an intentional order to them (reduce, reuse, and then recycle). Ask them to come up with ways to reduce and reuse plastic products that they typically recycle. Discuss which plastics their municipality recycles or if they don't know, brainstorm how to find out. You may even come up with sample questions to ask the local materials recovery facility (MRF) or waste management district.

9. **Return to the focus question.**
Now that students have examined what plastic is and how we use plastic, have them revisit the question: *How do we use plastics? Are there better or worse uses of plastics?* 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.

**If you think you are too small to make a difference, try going to bed in a room with a mosquito.**

**African proverb**

## Extensions

Have students investigate which plastic types are more commonly recycled where they live and develop tips about how to better assist the recycling process (compacting plastics, rinsing them, putting all plastic bags and film in a plastic bag, etc.). Then develop a communications campaign to educate your school, community or city.

## Resources

### Websites

California's Department of Resources Recycling and Recovery (Cal Recycle)
http://www.calrecycle.ca.gov/

5 Gyres Project
http://5gyres.org

Monterey Bay Aquarium's Plastics in the Water Column activity
http://www.montereybayaquarium.org/PDF_files/teaching_activities/Plastics_in_theWater_Column6-8.pdf

Society of the Plastics Industry
http://www.plasticsindustry.org

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

### Recommended Books

*Plastic: A Toxic Love Story.* Freinkel, Susan. Houghton Mifflin Harcourt, 2011.
*Plastic-Free: How I Kicked the Plastic Habit and You Can Too.* Terry, Beth. Skyhorse Publishing Inc., 2012.


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## References

Andrady, A.L. & Neal, M.A. 2009 *Applications and societal benefits of plastics*. Phil.Trans. R. Soc. B 364, 1977-1984

*Plastics Recycling Primer*. Moore Recycling Associates Inc: Recycling Implementation Specialists. June 2011. Prepared for the Maine State Planning Office. http://www.maine.gov/spo/recycle/docs/Plastics/PlasticsRecyclingPrimer.pdf

## Standards

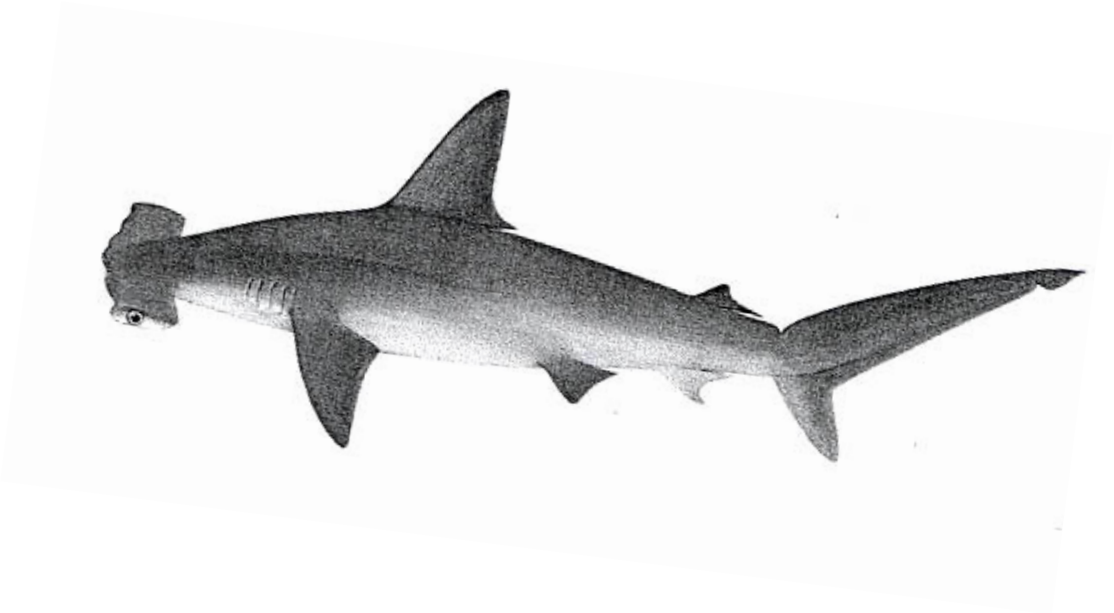
**Next Generation Science Standards** www.nextgenscience.org

*Performance Expectation*
Supports MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

**Common Core State Standards** www.corestandards.org

*Language Arts,* SL.6-8.1
Speaking and Listening: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly

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



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Name:

# Plastics: Reduce Use or Recycle?

1. List as many objects made of plastic in this room as possible.

| Item | Is it used multiple times? | Is it used once? | What alternative materials could it be made out of? |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Discuss:

- What did you notice?
- How did the number of objects made of plastics compare to objects made with other materials (wood, glass, metal, etc.)?
- What is plastic?

2. Sort the illustrated cards into categories of how plastics are used. Explain the criteria you used.

3. After the plastics presentation, answer these questions in your science notebook or on a separate piece of paper.

- Is plastic a renewable or nonrenewable resource? Explain.
- Explain what the number on each piece of plastics means.
- How might you figure out what plastics your community recycles (or if they do at all)?
- How could you personally reduce the amount of plastic you use?
- Explain what you consider wise and unwise uses of plastic. What criteria are you using?

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# Types of Plastics

Name:

Properties

| Resin ID Code and Name | Types of Products | Surface Appearance (glossy, rough, smooth) | Rigidity (rigid, semi-rigid, flexible) | Transparency (transparent, translucent, opaque) | Density (sinks, floats, neutrally buoyant in fresh water) | Ways to Reduce Use |
|---|---|---|---|---|---|---|
| 1 **PETE** Polyethylene terephthalate | | | | | | |
| 2 **HDPE** High-density polyethylene | | | | | | |
| 3 **PVC** Polyvinyl chloride | | | | | | |
| 4 **LDPE** Low-density polyethylene | | | | | | |
| 5 **PP** Polypropylene | | | | | | |
| 6 **PS** Polystyrene (two kinds) | | | | | | |
| 7 **Other** Many kinds | | | | | | |

MONTEREY BAY AQUARIUM

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# Plastics: Reduce Use or Recycle?
# Presentation Notes, Part One

**Frame 2:** Think-pair-share: What is plastic? Where does it come from?

**Frame 3:** Plastics are made using fossil fuels. Some are made using liquid petroleum and some are made using liquid natural gas. These fuels are what we use to power our cars and houses. Fossil fuels are a nonrenewable resource.

**Frame 5:** Plastics don't biodegrade because during the manufacturing process, extreme temperatures in the presence of a catalyst link smaller molecules together to create strong bonds within large chainlike molecules called polymers. Organisms in nature don't recognize the bonds created (not in all polymers, just in petroleum-derived plastics) and thus can't break them down. See http://www.livescience.com/33085-petroleum-derived-plastic-non-biodegradable.html These chainlike molecules also make plastics strong and versatile.

**Frame 6:** Show the educreations animations depicting how monomers link to make polymers. Note: Students may not recognize molecular models yet.

**Frame 7:** There are thousands of different resins, or plastics. The plastics industry stamped the number on the bottom (a resin ID code) to quickly be able to distinguish broad groups. If you didn't have those numbers, you can tell plastics apart using the physical and chemical properties that students observed earlier: surface appearance (smooth, glossy, rough), how light travels through the plastic (transparent, translucent, opaque), rigidity (or flexibility), density and flammability. You may want to hold up plastic objects to point out these characteristics.

**Frame 8:** *Show the resin codes - ask which code they think soda bottles have (1) or iPhone cases (7) Show real examples of plastics with different resin codes.*
These are the resin identification codes (#1-7). Certain numbers are more often recovered for recycling than others. For examples, #1 and #2 are more often recovered. This has to do with infrastructure (factories and processing plants) as well as the chemical/physical properties of the plastic. And even though water bottles are often #1s and are more often recycled, additional materials/resources need to be added during the recycling process to make a new water bottle. Some plastics like the mix of #7 are often never recycled. In the U.S., only 8% of plastics used are actually recycled. *Think-Pair-Share: If only 8% gets recycled where does the rest go?*

**Frame 9:** The cost of disposable plastic to environmental health is enormous. Have you ever seen plastic waste on the beach? *Note to teacher: you may want to Google image search ocean plastic entanglement to show the breadth of the issue*. Animals may become entangled in the debris or even ingest it. They may also use it as unnatural habitat. This waterway is down near Los Angeles.

**Frame 10:** This video shows how turtles can mistake plastics for food.

Continued on next page...

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# Plastics: Reduce Use or Recycle?
# Presentation Notes, Part Two

**Frame 11:** Ask students: When you recycle something, what do you think it comes back as? Recycling plastics are better than not recycling. But it's best to REDUCE our use of plastics by using less. Recycling has quite an economic cost. Many material recovery facilities (landfills, waste management agencies, etc.) in the U.S. ship our plastics to other places like China where they process the plastics and turn them into other items (like plastic yarn used in astro turf, lawn furniture and/or many other objects. Where is your waste management facility? Does your city use single-stream recycling or multiple-stream recycling? Single stream means you put all glass, plastics, paper, aluminum into one bin and it's sorted at the facility. Multiple stream means families and businesses sort the recycling into different bins before it's picked up.

**Frame 12:** *Think-Pair-Share: How do you think plastic is recycled? What process might it go through?* Show the video of the plastic bag recycling center. It takes a lot of energy to recycle. Again a good idea to use less especially when it comes to single-use disposable plastics.

**Frame 13:** So to recap, plastics are made from nonrenewable resources (fossil fuels), they cannot biodegrade and thus remain in the environment indefinitely, they are strong and versatile, they can be recycled but recycling uses a lot of energy and often additional plastic needs to be added to the process, only 8% of plastics in the U.S. are recycled and some of the rest ends up in the ocean and waterways. *Think-pair-share: so how can we use plastic more wisely*? Pack reusable utensils and containers for snacks, ask for no straw, reusable bags and water bottles, etc. It's important to use less disposable plastic. Why use something made to last forever, only once?

**Frame 14:** There are many people, including youth/students raising awareness about the amount of single-use plastic we use. This is Milo Cress speaking at the Monterey Bay Aquarium (photo on left) about his Be Straw Free campaign. He has asked restaurant staff to ask people if they want a straw, before automatically putting one in a drink. The photo on the right is a school group who educated their school about single-use plastics and actually reduced the amount of disposable water bottles used at their school. *Think-Pair-Share: What is one thing you could do to use less plastic?*

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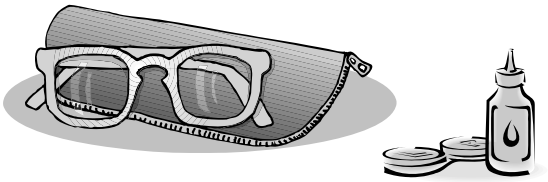
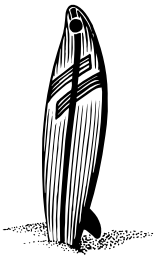
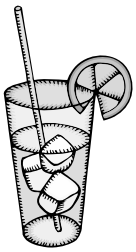
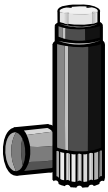
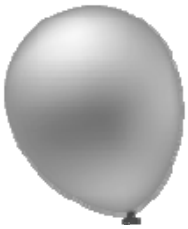
# How Do We Use Plastics?

| | |
|---|---|
| Glasses/Contact Lenses  | Fleece Sweatshirt/Jacket |
| Surfboard  | Grocery Bag |
| Straw  | Cell Phone |
| Pen | Lip Balm/Lip Gloss  |
| Toy | Balloon  |

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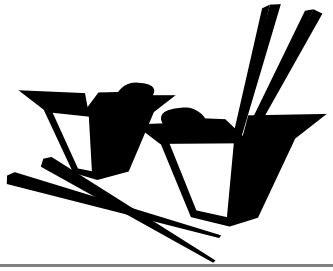
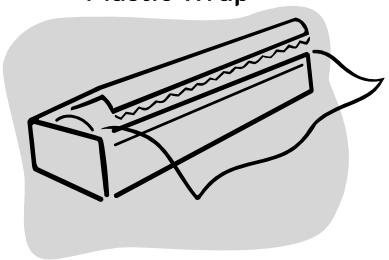
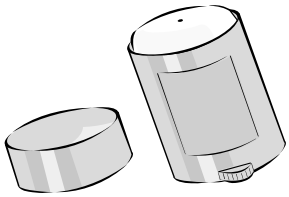
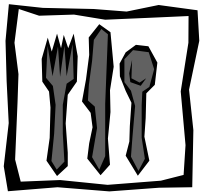
# How Do We Use Plastics?

| | |
|---|---|
| Vehicles | Take Out/Left Over Containers  |
| Plastic Wrap  | Yogurt Cup |
| Cleaning Products | Pacifier |
| Child Car Seat | Single-serving Chip Bag |
| Deodorant/Body Spray  | Plastic Dinnerware  |

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