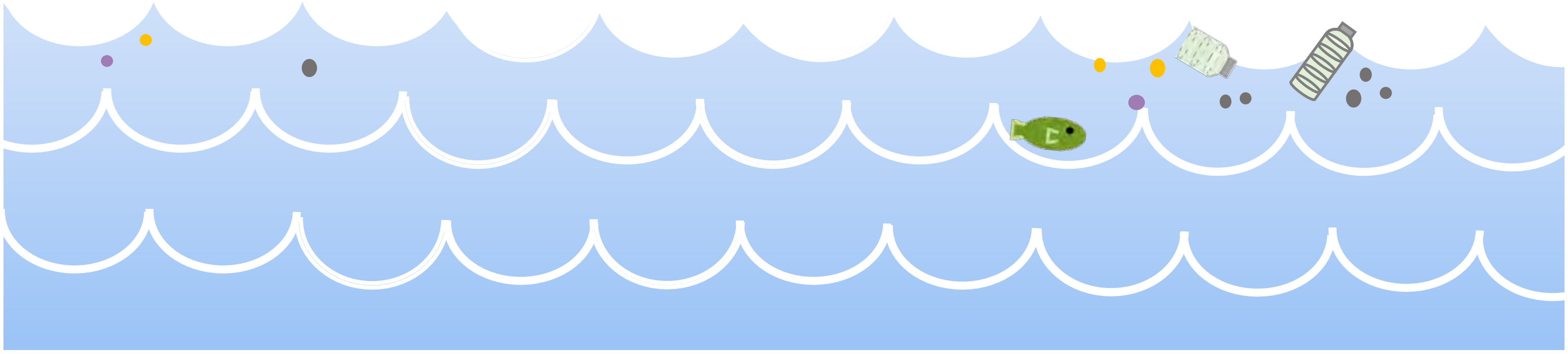
ORESU-E-16-001

Mitigating Microplastics Teacher Lesson Plans

A middle school curriculum about microplastics in our ocean



Contents

Introduction

Grades: 6-8

Summary

Each person's actions have a collective and cumulative impact on the world, either in a positive or negative way. Marine debris is one issue facing our world's ocean that is largely preventable through human actions. Marine debris is anything that does not belong in the ocean, from abandoned ships to tiny plastic fibers from clothes. Plastic marine debris less than 5mm is classified as microplastics. Microplastics can come directly from personal care products with microbeads and laundry lint that washes down the drain, or indirectly from larger plastic debris that fragments into smaller and smaller pieces in the ocean.

This curriculum includes three lessons intended to engage 6-8 grade students with the issue of microplastics in the ocean, analyzing both the problem and possible solutions. The lessons are structured to include opportunities for student inquiry, as well as collaboration and engagement with real data collected by scientific researchers working in the field. Each lesson includes an estimated length, which will vary by classroom. The entire curriculum is designed to take about one week, but may be extended by including a project at the end of the curriculum.

Curriculum materials include

1. Teacher Lesson Plans
    a. Material lists with links to purchase materials when available
    b. Content background
2. Student handouts
    a. Student Lab Notebooks
    b. Student Solutions Guide
3. PowerPoint presentation with lesson content
4. Student Example (Teacher Answer Guide)

Enduring Understandings

1. Everyone's actions have an impact (both positive and negative) on the environment.
2. Scientists make observations, ask questions about the world, collect and analyze data, and work collaboratively in a continuous, nonlinear process.
3. Due to the physical properties of plastics, they have specific impacts on the marine environment.
4. Designing a solution to a problem requires collaboratively defining and constraining the problem, as well as testing and redesigning possible solutions.

Standards

Next Generation Science Standards

ESS3.C: Human Impacts on Earth Systems Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)
MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations
MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
MS-ESS3-4 Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
MS-ESS3.C Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
Patterns Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)

Common Core Standards

RST.6-8.1 – Cite specific textual evidence to support analysis of science and technical texts
RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually
WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research
CCSS.MATH.CONTENT.**7.G.B.6** Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms

Ocean Literacy Principles

6.D Human activity contributes to changes in the ocean and atmosphere.
6.D.17 Pollution affects life in the ocean.
6.D.18 Pollutants move from the land into the ocean as water flows through watersheds via runoff and rivers.
6.D.21 Marine organisms may ingest or absorb harmful toxicants, be impacted by water turbidity and get caught in and ingest marine debris.
6.E.1 Scientists are still learning a lot about marine organisms and ocean ecosystems. New information is useful for helping guide policy decision and individual actions.
6.E.7 Everyone can make informed decisions that reduce human impact on the ocean.
6.E.13 Everyone can make informed choices about what they purchase and which businesses they support in ways that are environmentally friendly.
6.E.15 Everyone can use their knowledge to vote on larger issues that affect the ocean.
6.E.15 Everyone can advocate through their actions and by sharing information about the wise use and protection of the ocean.

Oregon Environmental Literacy Strands

1. Understand the physical and biological world, and our interdependent relationship with it

- **b.** Structure, function and interconnected nature of human systems to the environment and sustainability, such as human choices about consumption, production, distribution and disposal of goods and services and their effect on the sustainability of earth's natural, economic and social systems
- **c.** Interrelationships between people and the environment, such as how human activities and systems (social, cultural, political, and economic) change the environment including physical and living systems
  - How changes in the environment affect human systems (culture and language, economic systems, political systems, and social interactions)
  - How human activities and systems change the environment (physical systems and living systems)

4. Investigate, plan, and create a sustainable future

- **c.** Investigate and analyze strategies that address challenges and create desired futures
  - Evaluate the consequences of specific environmental changes, conditions, and issues for human and ecological systems, including: use the idea of cumulative effects to explain why one set of changes or human actions cannot be considered in isolation from others
- **d.** Decision-making and citizen action such as:
  - Plan and take action, including envision a desired endpoint, develop plans for individual and collective action, articulate clear reasons and goals for action, articulate measures for success consistent with their abilities and the capabilities of the groups involved

① Bags, Bottles, and Beads: Sources of Microplastics

Enduring Understandings
Everyone's actions have an impact (both positive and negative) on the environment.

Objectives
- Students will define marine debris and microplastics
- Students will explain sources of microplastics

Time
One 90-minute lesson

Materials
- Two sealing jars for each group/pair [Buy jars]
- Water (enough to fill each jar about half full)
- Liquid soap or face wash with microbeads
- Liquid soap or face wash with natural exfoliators

[Check this microbead product list for plastic and natural soaps]
- Student notebook: *Bags, Bottles, and Beads*
- Sink
- Coffee filters
- Jar/bucket for microbead disposal

Standards

Next Generation Science Standards
ESS3.C: Human Impacts on Earth Systems Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)
Patterns Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)

Common Core
RST.6-8.1 – Cite specific textual evidence to support analysis of science and technical texts

Ocean Literacy
6.D Human activity contributes to changes in the ocean and atmosphere.
6.D.18 Pollutants move from the land into the ocean as water flows through watersheds via runoff and rivers.

Oregon Environmental Literacy Plan
1. Understand the physical and biological world, and our interdependent relationship with it
- **b.** Structure, function and interconnected nature of human systems to the environment and sustainability, such as human choices about consumption, production, distribution and disposal of goods and services and their effect on the sustainability of earth's natural, economic and social systems
- **c.** Interrelationships between people and the environment, such as how human activities and systems (social, cultural, political, and economic) change the environment including physical and living systems

Set-Up
- Divide students into groups of 2-3
- With enough jars for each group to have two, label half of the jars "A" and the other half "B"
- Place about a tablespoon of soap in each jar
  - Soap with microbeads in jar "A" (For an alternative activity without microbeads, see p. 6)
  - Soap with natural exfoliators in jar "B"
- Make copies of Student Notebook: *Bags, Bottles, and Beads*, pages 1-5
- Have a disposal jar/bucket for microbead soap when the activity is over

Lesson Outline

1. Hook

Say: *Look around the room and silently find as many plastic objects as you can in ten seconds…go!* Time students for 10 s., then have students share some of the objects they identified.

Ask: *Raise your hand if you agree that there is a lot of plastic in this classroom? If you agree that we use a lot of plastic in our daily lives?*

Say: *We use plastic every day, and many of the plastics are single-use. They are designed to be thrown away after being used once. We might not even realize all the products that have plastic, and we don't always know what happens to them after they are thrown away.*

2. Explore – "Soap suds and…plastic?"

*See "success story" below for alternative activities if no products with plastic microbeads are available

Say: *Some products with plastics might surprise you. First, we will talk a little about plastic itself, and then you will have a chance to investigate for yourself.*

- Students will complete the guided notes on page 1 of their notebooks.

Presentation slides include the text from the notebook with the blanks filled in (also see the student example for guided notes answers)

Say (referring to the image on page 1): *Polyethylene is the plastic most microbeads are made from, and you can identify products with microbeads by looking at the ingredients for polyethylene. Repeat after me, "polyethylene."*

Hand out two jars, labeled "A" and "B," to each student group, but don't tell them which soap is which.

- Students read and follow the directions in their notebooks.

Presentation slides also have activity directions for reference.

- Students first make observations of the two jars (color, texture, size and shape of the particles, etc.)

Shaken jars with natural exfoliators (left) and microbeads (right).

- Students fill jars halfway with water, close tightly, and shake the jars to dissolve the soap *(there shouldn't be any soap stuck to the bottom)*.
- Students write down what they observe and draw pictures in their notebooks of how the particles behave inside the soaps.
- Students answer the questions in their notebooks on page 2.

Ask: *What did you notice that was different between the two jars? How did the particles in the soaps behave? Which one do you think has plastic in it? What evidence do you have?*

Reveal the answer, that "A" has microplastics in it!

> ✋MISCONCEPTION ALERT!
> Plastic microbeads will float in the water, but not all microplastics float! Microplastics can be found at many depths, including the ocean floor. Before moving on to the next part of the lesson, clarify that while the plastic microbeads in the investigation floated, not ALL microplastics float in the ocean.

- Students read the "newspaper clipping" on page 2 of their notebook and answer the question.

Discuss: *Why doesn't this law solve the problem of microplastics? Do you think this is a helpful law? Why or why not?*

3. Debrief – "How do microplastics make it to the ocean?"

Say: *One of the reasons the microplastics problem is not solved by this law is that there are many other ways microplastics get into the ocean.*
Presentation slide show slide #5. See the student example for notes.

- Students will complete guided notes on page 3 of their notebooks

Say: *There are two main ways that microplastics enter the ocean. One is directly as small pieces (show microplastics definition and have a student read it aloud). Plastics in toothpaste, face wash, and laundry lint can go directly into the ocean. <u>Most</u> microplastics are from larger plastic marine debris items that are fragmented once they get to the ocean (show marine debris definition and have a student read it aloud). Nurdles are small plastic pieces used in factories to make plastic products.*

4. Connect – "Real researcher: Angel White"

Say: *Now that we know about microplastics and where they come from, we are going to learn about a researcher who studies microplastics.*

- Students will read "Real researcher: Angel White" on page 4 of the student notebook as an introduction to her data.
- Students will answer the questions about Angel's data on page 5. See student example for correct responses. Answers are based on the data table and reading.

Say: *Why is it important to study the amount of plastic in the ocean?* Do a think-pair-share (students silently think about their response for 30 seconds, share with a partner, and then share with the class).
Ask: *Why do you think scientists study microplastics in the ocean? What should scientists like Angel do with their results?*

Clean Up

To keep microbeads from going down the sink drain, you can use a coffee filter to remove the microbeads from the soap. You can dry them and put them in a container to show the amount of plastic in the product!

♨ Success Story: Banning Personal Care Products with Microbeads

Plastic microbeads in personal care products like face wash and toothpaste have been shown to enter drains and eventually the ocean, and have largely unknown consequences on the marine environment. After nine states banned the manufacture and sale of products with microbeads, Congress passed the *Microbead-Free Waters Act of 2015*, banning the manufacture and sales of personal care products with plastic microbeads starting in 2017.

Because of this ban, personal care products with plastic microbeads will not be available to purchase beginning in 2017. The plastic from previously used products, however, is still in the ocean and microplastics are still a problem. Microbeads contribute a small part of the total microplastics in the ocean. Synthetic fibers from clothes, as well as the fragmentation of large plastic marine debris, are important and present sources of plastic. Also, while products with plastic microbeads are banned in the U.S., there are many places around the world where microbeads are used. Microplastics is truly a global issue.

Alternative Activity
As an alternative to the first activity "soap suds and…plastic," consider completing the challenge using just face wash with natural exfoliators.

- Have students observe and draw the particles, and then explain that some soaps used to have plastic instead of the natural material.
- Ask students to imagine those particles were plastic, to get an idea of the number of microbeads that might enter the ocean from one product.
- Emphasize that there are other sources of microplastics that enter waterways, including plastic fibers from clothing, and that microplastics are generated all over the world.

Educator Background

Microplastics

Microplastics are very small pieces of plastic marine debris, less than 5 mm in size, that end up in the ocean.[1] **Marine debris** is anything that ends up in the ocean that doesn't belong there. The National Oceanic and Atmospheric Administration (NOAA) defines marine debris as "any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes."[2] Marine debris can be found in the ocean and rivers worldwide, and most of the debris is made up of plastic.[3]

Properties of plastics[4]

Plastics are long chains of hydrocarbons called polymers. Hydrocarbons usually come from petroleum or natural gas. There are several types of plastics with different physical properties that are used for different purposes. Polyethylene is the largest volume of plastic used in the world. Polyethylene is the plastic that makes up microbeads in some personal care products, such as face wash and toothpaste.

Sources

Sources of marine debris. Plastics can enter the ocean from anywhere. Marine debris can come from sources on land or the ocean, not just coastal communities and beach-goers. It is estimated that most marine debris (80%) originates on land.[5] The following list describes some sources of marine debris:

- Individuals can be sources of marine debris if they do not manage their waste properly or if they litter
- Trash on the street (even in inland areas) can be blown into a nearby stream or washed down a drain
- Cities are potential sources of marine debris if there is insufficient infrastructure to capture debris on streets or landfills before it enters waterways
- Marine debris can originate in the ocean with lost fishing gear, dumping of trash, or abandoned boats
- Natural events can also create marine debris when storms wash debris into streams or the ocean[6]

Sources of microplastics. Microplastics mainly enter the ocean in two ways: (1) through the fragmentation of larger plastic marine debris and (2) when small plastics enter waterways and travel to the ocean.[7]

- Fragmentation of larger plastics – Plastics that enter the ocean have been found at the surface, on the bottom, and in between. Many plastic objects are buoyant and float at the surface of the ocean, being moved around by wind and surface currents. Plastics floating at the surface are exposed to sunlight. When they are exposed to UV waves, the plastic breaks into smaller and smaller pieces, or **fragments**. Plastics can also fragment when exposed to wind or wave action.

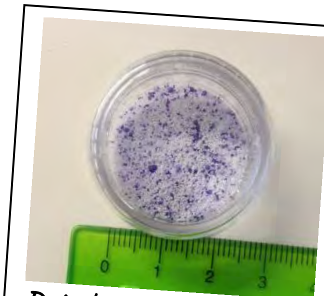
Marine debris that has the potential to fragment and become microplastics
(Photo credit: Briana Goodwin)

- Small plastic pieces entering waterways – One sources of small plastics is industrial materials such as resin pellets (**nurdles**). Nurdles can be lost during transportation and become debris. Another source of microplastics is personal care products. Many face wash, body wash, and toothpaste products contain plastic **microbeads** that act as exfoliators. The plastic microbeads in these products are designed to wash down the drain and are too small to be captured by water treatment facilities. Synthetic fibers from clothing such as fleece also travel through waterways to the ocean. One study found synthetic fibers on 18 beaches around the world and determined that washing one clothing item can produce more than 1,900 fibers that enter the sewage system.[8]

Pre manufacture resin pellets (nurdles)

Sinks

Microplastics can be found not only in the ocean worldwide, but also in rivers and streams. Many plastics are buoyant and stay at the surface of the ocean. However, other **sinks** of microplastics include sand on beaches and offshore. A collaborative study published in 2014 combined data taken by researchers all over the world about the abundance of plastics in the ocean. The data set include 680 tows, in which nets are dragged along the surface of the ocean and then the contents are analyzed. The study estimates that there are about 5.25 trillion plastic particles on the ocean surface. The team also found that there were fewer microplastics particles than they had expected,[9] which may indicate that they are being removed by some process such as degradation, being eaten by animals, or sinking when small organisms attach. There is ongoing research about the sinks and potential impacts of microplastics in the ocean.



Dried microbeads

Glossary

Fragment – To break into smaller pieces

Marine debris – Anything man-made that ends up in the ocean or the Great Lakes and doesn't belong there

Microbeads – Small plastic beads used in personal care products as exfoliators. Microbeads are commonly made out of polyethylene.

Microplastics – Plastic marine debris that is less than 5 mm

Nurdles – Small, pre-manufacture resin pellets

Degradation – The process of objects breaking down; in the case of microplastics, by UV light

Photodegradation[10] – Destruction of a material by UV radiation

Plastic – Manufactured chains of hydrocarbons often derived from natural gas or petroleum

Resin pellets – Pre-manufacture plastic pellets that are used to manufacture plastic products

Sink – Where something ends up

Weathering[11] – Mechanical weathering is the process of breaking down materials into smaller pieces (by wind, waves, etc.)

② Small Plastics, Big Problem

Enduring Understandings

Due to the physical properties of plastics, they have specific impacts on the marine environment.

Scientists make observations, ask questions about the world, collect and analyze data, and work collaboratively in a continuous, nonlinear process.

Objectives

- Students will articulate at least two possible impacts of microplastics on the marine environment
- Students will create an argument using evidence that supports an explanation
- Students will calculate the surface area of rectangular prisms of various sizes

Prior Knowledge

Students should be able to define and calculate surface area of rectangular prisms.

Time

One 90-minute lesson

Materials

- Card stock or cardboard (Manila folders work!)
- Scissors
- Tape/glue
- 1-inch foam cubes (other sizes can be used) x 27 for each group [Buy 1-in. cubes]
- Calculators (optional)

Standards

Next Generation Science Standards

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations

Common core

CCSS.MATH.CONTENT.**7.G.B.6** Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

Ocean Literacy

6.D.17 Pollution affects life in the ocean.
6.D.21 Marine organisms may ingest or absorb harmful toxicants, be impacted by water turbidity and get caught in and ingest marine debris.

Oregon Environmental Literacy

1. Understand the physical and biological world, and our interdependent relationship with it

c. Interrelationships between people and the environment such as:

- How changes in the environment affect human systems (culture and language, economic systems, political systems, and social interactions)
- How human activities and systems change the environment (physical systems and living systems)

4. Investigate, plan, and create a sustainable future

c. Investigate and analyze strategies that address challenges and create desired futures

- Evaluate the consequences of specific environmental changes, conditions, and issues for human and ecological systems, including: use the idea of cumulative effects to explain why one set of changes or human actions cannot be considered in isolation from others.

Set-Up

- Use the template on p. 19 to make paper box for each foam cube “marine debris” piece
- Make copies of the student notebook *small plastics, big problem* (pp. 6-9)
- Divide students into groups of 2-4

Lesson outline

1. Hook – "See-Think-Wonder"

Presentation slide #8 has the "see-think-wonder" photo for students to observe.

Say: *Observe this photo carefully and write down everything you see, think, and wonder about it.*

- Students will observe the photograph in their notebook on page 6, completing the graphic organizer

Discuss: *What did you see? What did you think about it? What do you wonder?*

Say: *This fish seems to have plastic pieces in its stomach. I wonder where they came from. We have learned sources of microplastics, and today we will talk about the possible impacts, or effects, of microplastics on the ocean.*

2. Explore – What happens when plastic fragments in the ocean?

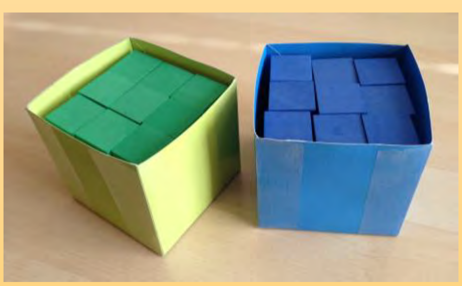
Say: *Now we are going to read about the possible impacts of microplastics on the ocean.*

- Students read "Plastics in the environment" on page 6 as a group
- Students continue reading on page 7 "what happens when plastic fragments in the ocean?"

Say: *Microplastics act differently than big plastic marine debris. We will find out how in this activity.*

Review surface area with students by doing a think-pair-share (students silently think about what surface area is for 30 seconds, then share with a partner, then share with the whole class). Surface area is the total area of all the sides of a shape.

Say: *Now we are going to go through an example of calculating the surface area of an object.*



"Marine debris" cubes

Presentation slides #9-10 have the example from the student notebook. Go through each step with students. The answers are in the student example.

Hand out a piece of "marine debris" (27 foam cubes forming one large cube and held together in a paper box) to each group.

Say: *You are going to investigate what happens to the total surface area when a piece of marine debris breaks down in the ocean.*

The rest of the activity can be more or less guided by the teacher, depending on the class.

- Students will have time to break their cube down into smaller shapes, calculate the total surface area, and complete the table in the student notebook on page 7, then answer the questions. (See student example for answers.)

3. Debrief

Discuss: *What was the highest total surface area you calculated? What happened to the total surface area when the marine debris fragmented? What does this mean for toxins? What does this mean for microbes that live on the outside of plastic marine debris?*

4. Connect – "Real researcher: Laurie Weitkamp"

Say: *Now we are going to meet another researcher who collected data on the impacts of microplastics. This researcher doesn't study microplastics, though. She studies juvenile fish in the Columbia River Estuary in Oregon.*

- Students read "Real researcher: Laurie Weitkamp" on page 8 as a class
- Students answer the questions about Laurie's data
- Go through the answers to the questions (see student example responses)

Say: *We don't really know the impacts of microplastics, but microplastics have more total surface area for toxins to stick. Next, we are going to think about what we can do to solve this problem.*

Extensions/Adaptations

- Using surface-area-to-volume ratio of plastics breaking down in the environment adds complexity.
- If students have not yet learned surface area, an alternative demonstration can be used:
  - *Using the cubes* – Instead of having student groups calculate the total surface area, walk the class through a couple steps of fragmenting and talk about what changes. The inside of the marine debris is exposed when it is broken apart, which provides new surface where something like toxins could stick.
  - *No materials* – Lead the class in a demonstration using your fists held together, representing the piece of marine debris. When you "break" the marine debris by pulling your two fists away from each other, the parts of your hands that were inside are now exposed to toxins.

Educator Background

Microplastics are small pieces of plastic, 5mm or less in size, that enter the ocean.[1] They can make it to the ocean when tiny plastic particles in personal care products or synthetic clothing fibers are washed down the drain, or from the breakdown of larger plastic debris. Microplastics are a size category of **marine debris**. Marine debris is anything human-made that doesn't belong in the ocean or Great Lakes.

Potential Impacts of Microplastics

There is ongoing research about the impacts of marine debris, and specifically microplastics, on the ocean and the organisms that live there. Microplastics can be found from the surface to the bottom of the ocean all over the world, which makes the impacts they have on the marine environment a global concern. Potential impacts of microplastics include the accumulation of **toxins** on their surface, ingestion of plastics by organisms, and the colonization of **microbes** on their surface.

It is important to note that the term *impacts* simply means effects. It is also important to know that the ways in which small plastics in the ocean are affecting marine environments are continually being discovered, and the subtle implications of these effects are still not well known. At this time, there is not substantial evidence that plastics or any associated chemicals are transferred through the food web in a way that is harmful to humans.

Accumulation of toxins. Toxins is a somewhat ambiguous term used to describe different harmful substances. In this lesson, the toxins referred to are chemical toxins. The US Environmental Protection Agency (EPA) defines something toxic as "any chemical or mixture that may be harmful to the environment and to human health if inhaled, swallowed, or adsorbed through the skin."[12] Toxic substances have been shown to adsorb to the surface of plastic marine debris. Researchers in Tokyo showed that PCBs (polychlorinated biphenyls), DDE (dichlordiphenyldichloroethylene), and NP (nonylphenols) in seawater adsorbed to the surface of plastic.[13] While toxins have been shown to stick to plastics, the extent to which this happens in nature and the impacts on the marine environment are still being studied. There is a need for more information on this topic.

Zooplankton
(Photo credit: Angel White)

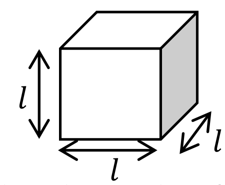
Ingestion of microplastics by organisms. Many organisms have been shown to ingest microplastics, from small filter feeders to larger animals. They can ingest plastics indirectly if they eat another organism containing microplastics, directly when mistaking microplastics for food, or accidentally. Smaller organisms such as plankton[14] and marine isopods,[15] and filter feeders such as sea cucumbers[16] and oysters[17] have been reported to eat microplastics. A species of lobster was shown to eat microplastics present in its food, and the plastics remained in the lobsters' stomachs.[18] Larger animals such as harbor seals[19] and many species of fish and sea bird[20] have had plastics found in their stomachs. The actual impacts of microplastics ingested by these animals is unclear. There may be physical or chemical impacts of eating microplastics.

Impacts of ingestion. Larger microplastics may block the digestive tract of small organisms, but not in others. There is not much evidence for this. The impacts of organisms ingesting plastics are not well known.

Potential impacts on humans. There is not sufficient research to make determinations about the safety of seafood subjected to microplastics. Microplastics have been found in some oysters that were raised for food.[17] The impacts on the marine food web are not clear. Negative impacts on marine ecosystems does potentially have negative impacts on marine resources that people rely on, marine recreation, and economics. It is possible for microplastics to impact fisheries, recreation, and other services provided by the ocean and its connecting waterways.

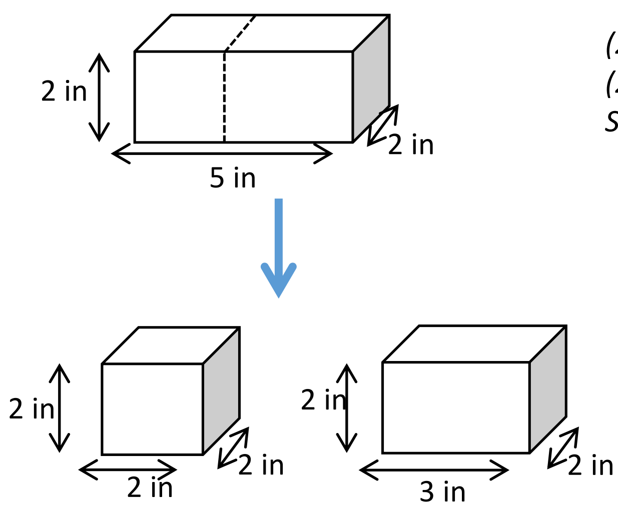
Surface area

$$Surface\ area = SA = 6l^2$$



As a cube is broken down into smaller cubes, the total volume stays the same, but the total surface area increases. The equation above is used only to determine the surface area of a cube. To find the surface area of other objects, it is necessary to find the area of each separate surface and add them together.

Example:



(2 in x 2 in) x 2 = 8 in^2
(2 in x 5 in) x 4 = 40 in^2
SA = 8 in^2 + 40 in^2 = ***48 in^2***

6 x (2 in)^2 = 6 x 4 in^2 = 24 in^2

(2 in x 2 in) x 2 = 8 in^2
(2 in x 3 in) x 4 = 24 in^2
8 in^2 + 24 in^2 = 32 in^2

Total SA = 24 in^2 + 32 in^2 = ***56 in^2***

Glossary

Impacts – The effects of something, either positive or negative
Marine debris – Anything human-made that ends up in the ocean or the Great Lakes and doesn't belong there
Microbes – Microscopic organisms that are found everywhere on Earth
Microplastics – Plastic marine debris that is less than 5 mm
Surface area – The area of the outermost layer of an object
Toxin – "any chemical or mixture that may be harmful to the environment and to human health if inhaled, swallowed, or adsorbed through the skin"[12]

③ Mitigating Microplastics

Enduring Understandings

Everyone's actions have an impact (both positive and negative) on the environment.

Designing a solution to a problem requires collaboratively defining and constraining the problem, as well as testing and redesigning possible solutions.

Objectives

- Students will use scientific data to design a solution to reduce microplastics
- Students will articulate the costs and benefits of their solution to humans and the natural environment

Time

Time for this lesson will vary. At least one 60-minute lesson for discussion and generating solutions will be required, along with any additional time to implement students' plans.

Materials

- Student notebooks
- Folders or large paper
- Markers, crayons, or colored pencils
- Chart paper
- Folders with "student solutions guide" information
  - Individual actions
  - Making laws
  - Education

Standards

Next Generation Science Standards

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
MS-ESS3-4 Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem
MS-ESS3.C Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Common core

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually
WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research

Ocean Literacy

6.E.1 Scientists are still learning a lot about marine organisms and ocean ecosystems. New information is useful for helping guide policy decision and individual actions.
6.E.7 Everyone can make informed decisions that reduce human impact on the ocean.
6.E.13 Everyone can make informed choices about what they purchase and which businesses they support in ways that are environmentally friendly.
6.E.15 Everyone can use their knowledge to vote on larger issues that affect the ocean.
6.E.15 Everyone can advocate through their actions and by sharing information about the wise use and protection of the ocean.

Oregon Environmental Literacy

4 Investigate, plan and create a sustainable future

d. Decision-making and citizen action such as:

- Plan and take action, including envision a desired endpoint, develop plans for individual and collective action, articulate clear reasons and goals for action, articulate measures for success consistent with their abilities and the capabilities of the groups involved

Set-Up

- Inside five folders, write the following questions (alternately, the questions can be written on chart paper or simply used as discussion questions):
    - What's the problem with microplastics?
    - Can we stop using plastic? Why or why not?
    - Do you think plastics are good or bad? Why?
    - How does plastic affect the ocean?
    - Do you think we can clean up all the plastic in the ocean? Why or why not?
- Put students in groups (of 2-4, but may vary depending on the project)
- Make copies of *Student Solutions Guide* pages for each group of students, and place each set in a folder for easier distribution
- Make copies of Student Notebook pp. 10-21, *Designing Solutions for Microplastics,* for each student

Lesson outline

1. Hook – defining the problem "chalk talk"

Place the folders with questions open around the room.

Say: *There are five folders around the room with discussion questions. We are going to have a silent discussion about microplastics. You will take a pencil and respond to the question on the folder. If someone else has already responded, you can write a response to that person or write a separate thought. Make sure to read everything before choosing how to respond.*

- Students circulate around the room, responding to the question or a comment made by another student. Give students 3-4 minutes at each question, depending on their pace. (If you prefer students to discuss, each group can discuss aloud before writing on the folder.)
- Give students time to revisit their first station and read the responses, then debrief with the class.

Ask: *What surprised you? Is plastic in the ocean an easy problem to solve? What makes it easy or difficult? Why is it important to discuss issues like microplastics with people who have different opinions? How do you feel about this problem?*

2. Group solution design project

Hand out "student solutions guide" folders with existing projects and actions people have taken to reduce microplastics in the ocean.

Say: *Now that you know about where microplastics come from and some of the problems that occur when they end up in the ocean, it is your challenge to develop a solution to the problem. We are all able to make a change in our environment, and it is important to use this power to make a positive change. You have a folder with different actions people are taking to address the problem. In your group, you will review these solutions, and then come up with your own. It is important that the solutions that you and your group develop are effective and that you are able to actually make this change* (for example, building a machine to clean up the gyre may not be feasible for this project).

- Students first review the existing solutions and then individually brainstorm ideas for actions they can take to reduce microplastics.
- Students use the graphic organizer on page 10 of their notebook to guide their conversation about a feasible, actionable solution to microplastics.
- Students should discuss each section of the graphic organizer, and each student writes the group's thoughts in his or her notebook.

- Students create a presentation for their solution and explain it to the group.

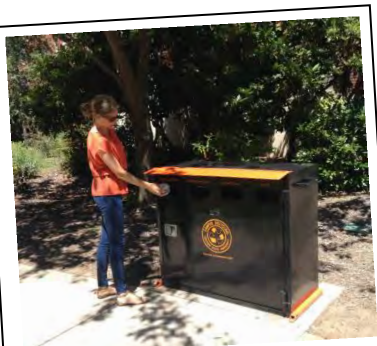
(This can be formal or informal, depending on the time and technology available. Students can receive feedback on their ideas, or the class can develop a single project to implement together.) Help students implement their ideas! Teachers are encouraged to help students choose projects that are feasible but ambitious.

3. Debrief

Ask: *What are some challenges in designing a solution to microplastics?*
What were the challenges in implementing your solution? What was easy about it?
Why do you think it's important for students to think about issues like microplastics?

Extensions

The solutions that student groups design can be implemented within the classroom or community. This can be done in a variety of ways, depending on your school. The implementation phase gives students a sense of empowerment around the issue of microplastics that can seem daunting. Building community, promoting awareness, and taking concrete actions help students think about their world differently.



Recycling

Using reusable bags

Researching microplastics

Educator Background

Microplastics are small, plastic marine debris, commonly defined as less than 5 mm in size. The impacts of these plastic pieces on the marine ecosystem are not well understood, and more plastics are entering the oceans every day. Action is needed to reduce the amount of plastic in the ocean. There is no one "right" solution to marine debris and effective solutions will require creativity, collaboration, and dedication from many groups. A few ways people are addressing the issue, including legislation, education, and individual actions, are described below.

Legislation

Bans on microbeads in personal care products – Illinois was the first state to pass legislation addressing plastic microbeads. This state banned **personal care products** with **microbeads** in June 2014.[21] By December 2015, when the federal *Microbead-Free Waters Act of 2015*[22] was passed, nine states had banned the manufacture and sales of microbeads and several others (Massachusetts, Michigan, Minnesota, and Oregon) were considering similar legislation. Table 1 includes details of the microbead ban bills that have passed. Laws are listed in order of passage, with the most recent at the top. This table has been adapted from 5 Gyres.[23]

Table 1. Existing microbead legislation at the time of the passage of the federal microbead ban

				Phase out dates			
Statute	*Passed*	*Strength*	*Biodegradable*	*PCP[1] Manufac.*	*PCP[1] Sales*	*OTC[2] Manufac.*	*OTC[2] Sales*
United States (HR 1321)	12/28/15	weak	No exception	2017	2018	2018	2019
California (AB 888)	10/8/15	strong	No exception	NA	2020	excluded	excluded
Wisconsin (SB 15)	7/2/15	weak	Does not define	2018	2019	2019	2020
Connecticut (HB 5286)	6/30/15	strong	Allows for study	2018	2019	2019	2020
Maryland (HB 216)	5/12/15	strong	Specific definition	2018	2019	2019	2020
Indiana (HB 1185)	4/15/15	weak	Does not define	2018	2019	2019	2020
Colorado (HB 15-1144)	3/26/15	weak	Does not define	2018	2019	2019	2020
Maine (SP 0033)	3/24/15	weak	Does not define	2018	2019	2019	2020
New Jersey (SB 2178)	3/23/15	weak	Does not define	2018	2019	2019	2020
Illinois (SB 2727)	6/9/14	weak	Does not define	2018	2019	2019	2020

[1]Personal Care Products
[2]Over-the-counter products

The laws provide phase-out dates for the manufacture and sale of personal care products and over-the-counter products containing plastic microbeads. The table rates each law as "strong" or "weak." This rating is based largely on analysis by environmental groups, and focuses on the definitions of plastic microbeads and the presence of loopholes. The "biodegradable" column provides information about whether or not the term biodegradable is defined in the law or if there is a loophole for "biodegradable plastics." The development and potential of such materials is a topic of uncertainty at the time of writing this curriculum.

Bans on larger plastic products – In addition to legislative bans on microbeads, bans on other plastic products impact the abundance of microplastics in the ocean. For example, banning plastic items reduces the amount of plastics available to enter the waterways. The following list[24] includes states where some of their cities or counties have banned plastic bags. Some include a charge on paper bags to encourage use of reusable bags.

- Alaska
- District of Columbia
- Maine
- New York
- Rhode Island
- California
- Florida
- Maryland
- North Carolina
- Washington
- Colorado
- Hawaii
- Massachusetts
- Oregon
- Connecticut
- Iowa
- New Mexico
- Texas

Individual use plastic water bottles have also been banned in multiple US cities, notably Concord, Massachusetts, and San Francisco, California.

Education

Education about marine debris and microplastics is important to promote awareness of the issue, change behaviors, and inspire responsibility and stewardship for the environment.[25] Educating people about what marine debris is, where it comes from, and what individuals can do about it empowers positive change. This can happen on the individual, school, community, or global levels. The list in Table 2 includes organizations that are dedicated to educating people about the issue of marine debris and promoting change.

Table 2. Marine debris educational organizations

Organization	*Description*	*Website*
5 Gyres	The mission of 5 Gyres is to involve people in designing solutions to plastic pollution.	www.5gyres.org
Algalita: Marine Research and Education	Founded by Captain Charles Moore, Algalita strives to protect marine ecosystems through research and education. The website includes research as well as classroom resources.	www.algalita.org
Beat the Microbead	An international campaign to eliminate microbeads. The site includes research, policies, and an app to help consumers identify products containing microbeads.	www.beatthemicrobead.org
US Environmental Protection Agency (EPA)	The EPA website has informational resources including sources, prevention, legislation, and research.	water.epa.gov/type/oceb/marinedebris
NOAA Marine Debris Program	This NOAA website houses informational pages, research, and K-12 resources on marine debris.	marinedebris.noaa.gov
Oregon Coast STEM Hub	This page contains teacher resources for grades 4-12.	oregoncoaststem.oregonstate.edu/marine-debris-steamss
Sea Education Association (SEA)	An environmental education opportunity for undergraduate students, SEA cruises collect data on plastics, and have access to research and K-12 lesson plans on their website.	www.sea.edu
Surfrider Foundation	An activist network of people dedicated to protecting marine ecosystems and resources. They promote campaigns and organize events around the country.	www.surfrider.org

Individual Actions

Although small in scale, individual actions are important in reducing the amount of plastics in the ocean. Changing our individual behaviors can not only reduce our personal plastic contribution, but can act as an example to inspire change in others. Some possible individual actions include:

- Recycling
- Using reusable containers (bags, water bottles, etc.)
- Managing personal waste in a responsible way
- Avoiding products with microbeads

A note on cleaning up marine debris as a solution

It has been estimated that there are over 5.25 trillion pieces of plastic marine debris[9] floating in our ocean. Plastic can be found not only on the surface, but at all depths as well as in the sediment. Because marine debris is so extensive, cleaning up all the plastics currently in the ocean is not a feasible solution. While beach clean-ups and other removal activities have positive results, a substantial change in the abundance of plastics in the ocean will not happen without efforts to reduce the plastics being put into the ocean and waterways.

Glossary

Marine debris – Anything human-made in the ocean or the Great Lakes that doesn’t belong there

Microbeads – Small plastic beads in personal care products, commonly made of polyethylene

Microplastics – Plastic marine debris that is less than 5 mm

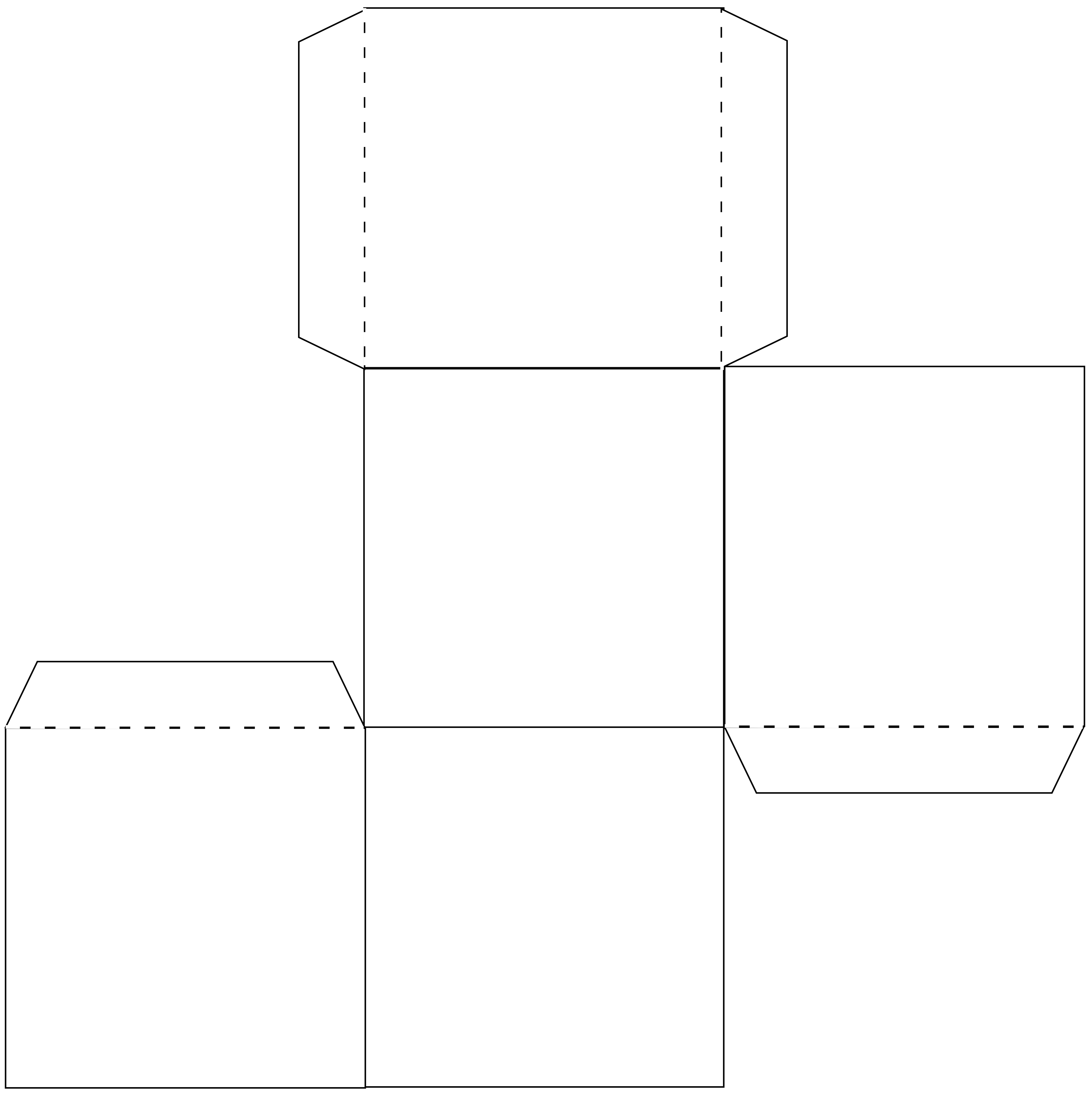
Personal care products – A non-prescription product used for personal hygiene or beauty

Paper Cube Template

If you are using the 1-inch cubes, the box will need to be a little more than 3 inches in each direction (these squares are 3.2 inches). Thin cardboard (cereal boxes, etc.) works well because it is large and sturdy.

Directions:

1. Print out this template on 11 x 17 paper and trace it on a piece of cardboard
2. Cut out the shape
3. Fold the flaps up along the dotted lines
4. Fold each side of the box up, gluing the flaps on the inside of the box



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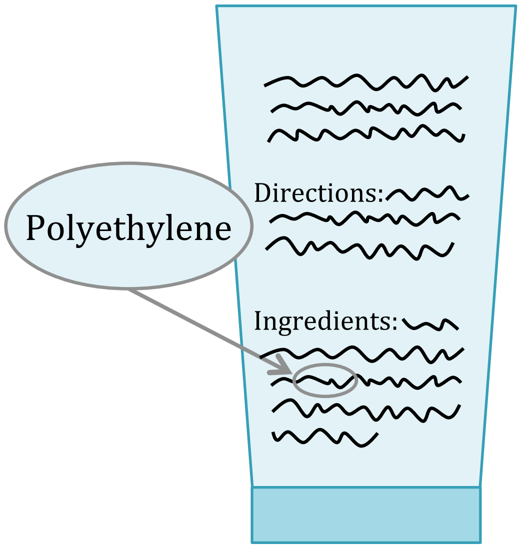
Microplastics

Pointing out Plastic

Plastics can be found in many products at school and home. Plastics are created by ___people___ from _oil_ or ___natural gas___. There are lots of types of plastics.

One surprising product that has plastic in it is __some soap___.
Some soaps have small pieces of __polyethylene___ (a type of plastic), which are called ______microbeads__________.



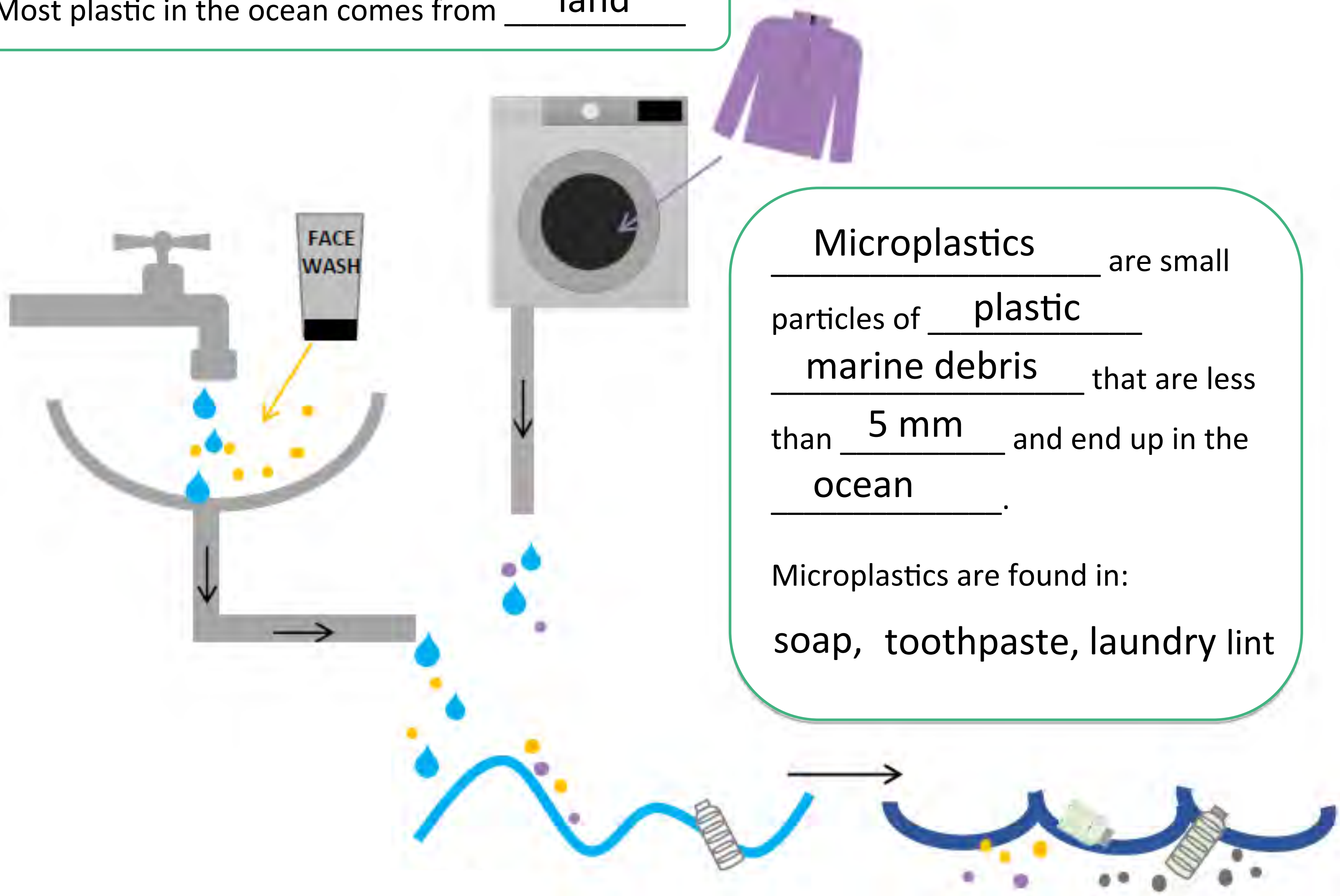
Which soap has plastic in it?

CHALLENGE: Which soap has plastic in it?

STEPS:

1. Observe the two soaps using your senses of smell and sight (NOT taste or touch)
2. Fill the jar halfway with water, then put the lid on your jar and shake it up!
3. Observe again with words and pictures, using your sight (NOT taste or touch)
4. Answer the questions on the next page.

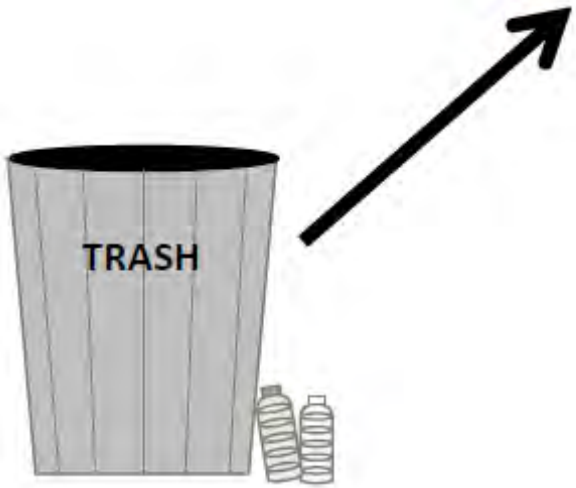
Most plastic in the ocean comes from ___land___



___Microplastics___ are small particles of ___plastic___ ___marine debris___ that are less than ___5 mm___ and end up in the ___ocean___.

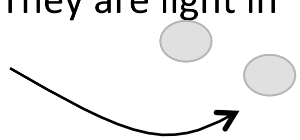
Microplastics are found in:

soap, toothpaste, laundry lint



___Marine debris___ is anything that ends up in the ocean or Great Lakes that doesn't belong there. Plastic marine debris ___fragments___ in the ocean.

Microplastics can also come from ___factories___ that use small plastic pellets to make their products. These pellets are called ___nurdles___. They are light in color and about this big



Angel White’s Data

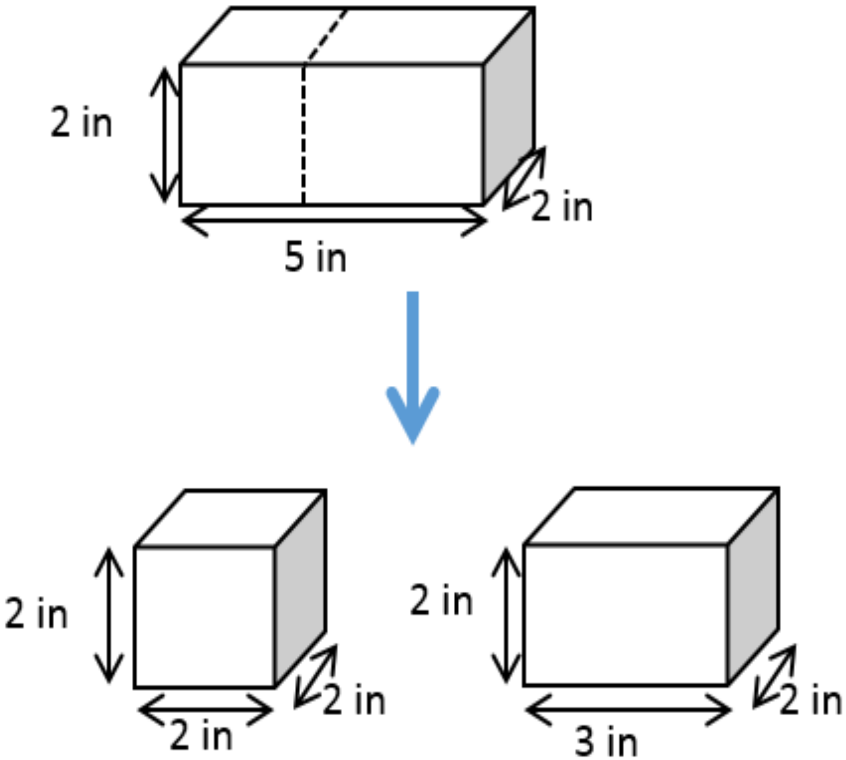
Angel White’s Data:
Plastics found in 10 tows in the Pacific Ocean

Tow Number	***Total Number of Plastics* (2mm + 5mm)***	***Volume of water (m^3)***
1	127	362
2	127	361
3	504	320
4	343	357
5	320	359
6	281	358
7	901	361
8	543	360
9	1,334	360
10	515	360

Small plastics, big problem

What happens when plastic fragments in the ocean?

Example:

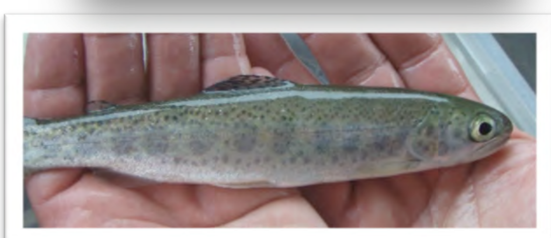


$4(5in \times 2in) + 2(2in \times 2in)$
$= 4(10\ in^2) + 2(4\ in^2)$
$= 40\ in^2 + 8\ in^2$
$= 48\ in^2$

$6(2\ in \times 2\ in) = 6(4\ in^2) = 24\ in^2$

$4(3in \times 2in) + 2(2in \times 2in)$
$= 4(6\ in^2) + 2(4\ in^2)$
$= 24\ in^2 + 8\ in^2 = 32\ in^2$

$24\ in^2 + 32\ in^2 =$ **$56\ in^2$**



Laurie Weitkamp's Data: Juvenile salmon diets in the Columbia River Estuary

Species	*Total number of fish*	*Number with plastic in their stomachs*	*Percent of fish with plastic in their stomachs*
Chinook	1,009	28	3%
Coho	174	12	7%
Steelhead	219	3	1%

Designing solutions to microplastics

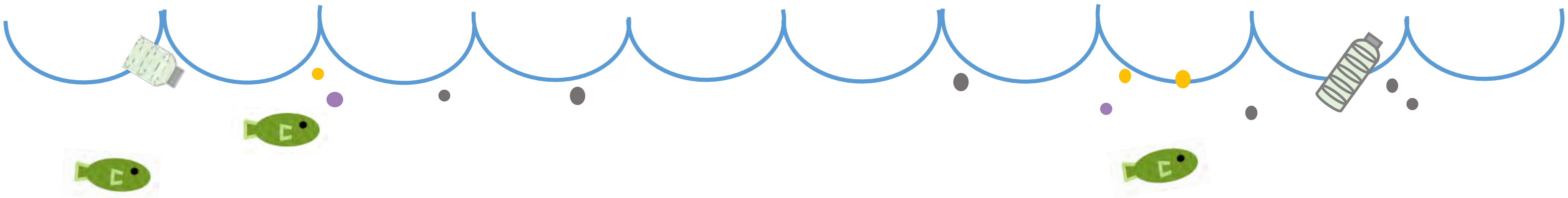
Individual Actions	Making Laws	Education

Designing solutions to microplastics

1. Work with your team to review the materials in the "Solutions" folder and the data in your notebook
2. Design a solution to microplastics. Use page 10 of your notebook to think about the details of your plan
3. Use the poster paper to create a visual to help you explain your solution everyone
4. Share your idea!

Name: ____________________________

Date: _____________



Microplastics

Laboratory notebook

Words to know:

1. Bags, Bottle, and Beads: Sources of Microplastics

Microplastics

Polyethylene

Marine debris

Nurdle

Manta trawl

Dilute

Plastic

2. Small plastics, big problem

Fragment

Toxin

Organisms

Surface area

Microbes

3. Designing Solutions to Microplastics

Microplastics

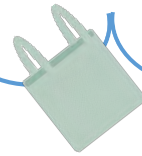
Reduction

Ban

Marine debris

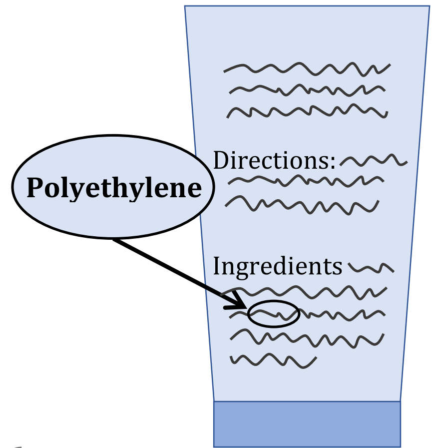
Lesson 1

Bags, Bottles, and Beads: Sources of Microplastics



Soap suds and…plastic?

Plastics can be found in many products at school and home. Plastics are created by _________________ from _________ or _______________________________. There are lots of types of plastics. One surprising product that has plastic in it is _______________________. Some soaps have small pieces of _____________________ (a type of plastic), which are called ____________________.



What to look for on the back of soap to see if it has plastic

CHALLENGE: Which soap has plastic in it?

STEPS:

1. Observe the two soaps, using your senses of smell and sight (NOT taste or touch)
2. Fill the jar halfway with water, put the lid on your jar, and shake it up!
3. Observe again with words and pictures, using your sight (NOT taste or touch)
4. Answer the questions on the next page

	Jar _____	Jar _____
Observations	1. 2. 3.	1. 2. 3.
Pictures (*after shaking*)		

CONCLUSIONS:

1. What was different about the two soaps?

____

____

2. Which jar do you think has plastic in it? Explain your reasoning. Be specific.

____

____

3. What do you think happens to the plastic in the soap after someone uses it to wash his or her face?

____

____

____

President Obama Signs *Microbead-Free Waters Act of 2015*

December 28, 2015

Washington D.C. – A federal law was passed and signed by President Obama that bans the production and sale of personal care products with plastic microbeads. Some personal care products, such as toothpaste and face wash, have plastic microbeads that can go down the drain and into the ocean. Scientists are not sure how microbeads affect the ocean environment. To stop more plastic from entering the ocean, Congress decided to ban personal care products with microbeads, starting in 2017. Nobody will be allowed to make or sell personal care products with microbeads anywhere in the United States.

Do you think this solves the problem of microplastics in the ocean? Why or why not?

____

____

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____

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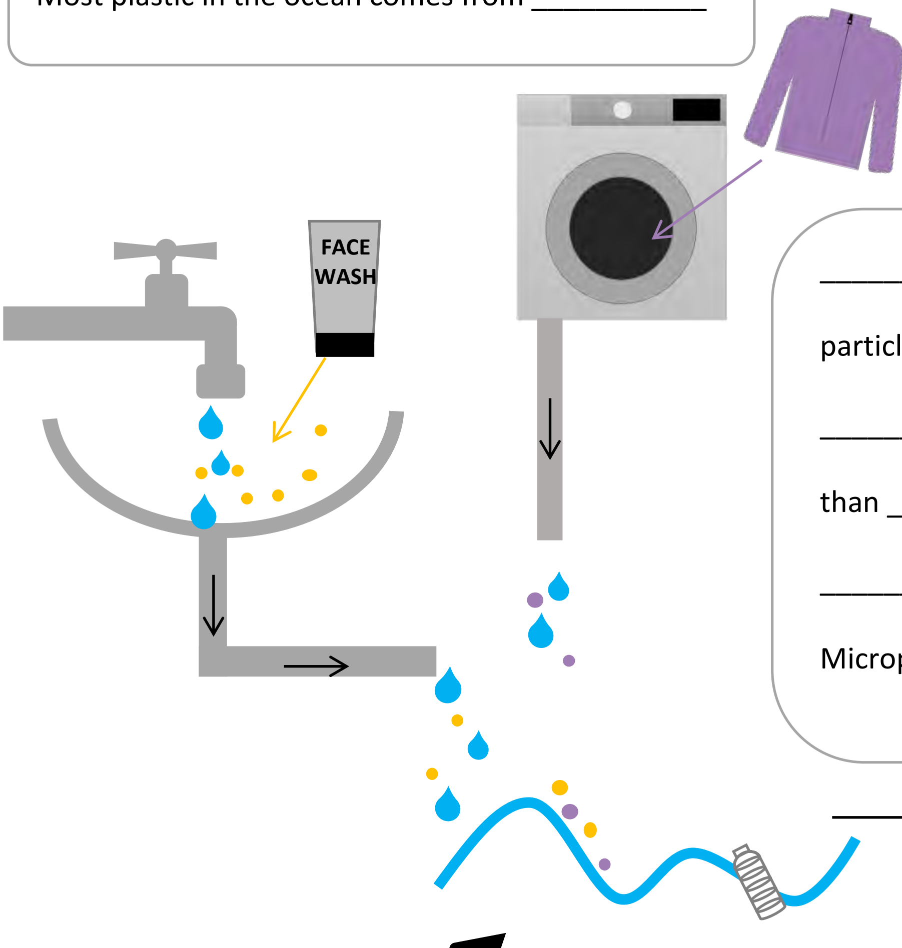
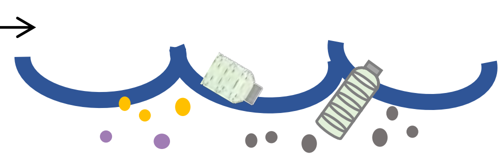
Sources of Microplastics:

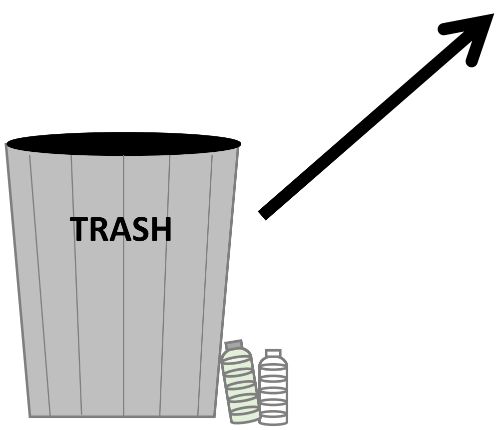
Most plastic in the ocean comes from ___________



________________________ are small particles of _____________ ______________________ that are less than __________ and end up in the ______________.

Microplastics are found in:





_______________________ is anything that ends up in the ocean or Great Lakes that doesn't belong there. Plastic marine debris ______________________ in the ocean.

Microplastics can also come from ________________ that use small plastic pellets to make their products. These pellets are called _______________. They are light in color and about this big

From the Field

Angel White

Name: Angel White

Career:
Researcher at Oregon State University

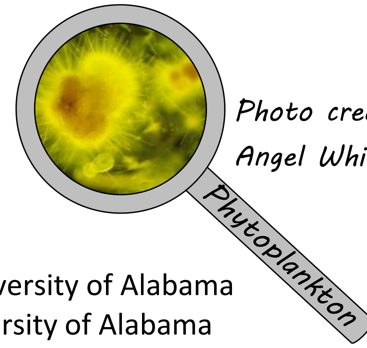
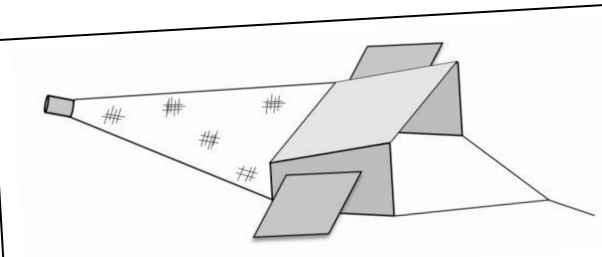


Photo credit: Angel White

Education:
Bachelor's degree in biology from University of Alabama
Master's degree in biology from University of Alabama
PhD in biological oceanography from Oregon State University

Research: how materials move through ecosystems, phytoplankton, harmful algal blooms

Notes:
In 2008, Angel had the chance to go on an expedition with other scientists to study the amount of plastic in the ocean. To do this research, Angel went with a team of scientists to the Pacific Ocean (shown by the star on the map below). Angel had heard that there were big patches of garbage in the middle of the ocean. However, when she went out on the expedition, she did not see piles of trash floating in the water. In fact, the water looked clean! She sampled the water using a **manta trawl**. A manta trawl is a large net with a bottle at the end that captures anything too big to fit through the net (like plastic in the water). Scientists pull the manta trawl behind a boat along the surface of the water, and then analyze what is caught in the net. Each time the net is dragged behind the boat, it is called a tow. Each tow filtered about 360 m^3 of water, which is about the size of a school swimming pool. The scientists separated the plastic from the net and counted the number of pieces in each sample. After looking at the data, Angel was surprised that the plastic was so **dilute**, even though plastic can be found all over the ocean!



Manta trawl net

Small plastic that could get caught in a manta trawl net

The data in the table was collected by Angel and the other scientists on her expedition to the Pacific Ocean. Even though many researchers have found plastic in the ocean, people continue to study the amount of plastic in the ocean, where plastic can be found, and what type of plastic is in the ocean. This is important because people want to know how plastic in the ocean will affect living things.

Look at the table that shows Angel's data, then answer the questions.

Angel White's Data:
Plastics found in 10 tows in the Pacific Ocean

Tow Number	*Total Number of Plastics* (2mm + 5mm)*	*Volume of water (m^3)*
1	127	362
2	127	361
3	504	320
4	343	357
5	320	359
6	281	358
7	901	361
8	543	360
9	1,334	360
10	515	360

1. Circle the *tow number* with the **largest** number of plastics found. What is the value? ______
   Draw a box around the *tow number* with the **least** plastics. What is the value? ______

2. How deep in the water did these microplastics come from? Underline your evidence in the text.

____
____
____
____
____

3. What are two possible **sources** of the microplastics that Angel and the research team found?
____
____

4. Angel had heard that she would find a large island of trash. What did she find instead?
____
____
____

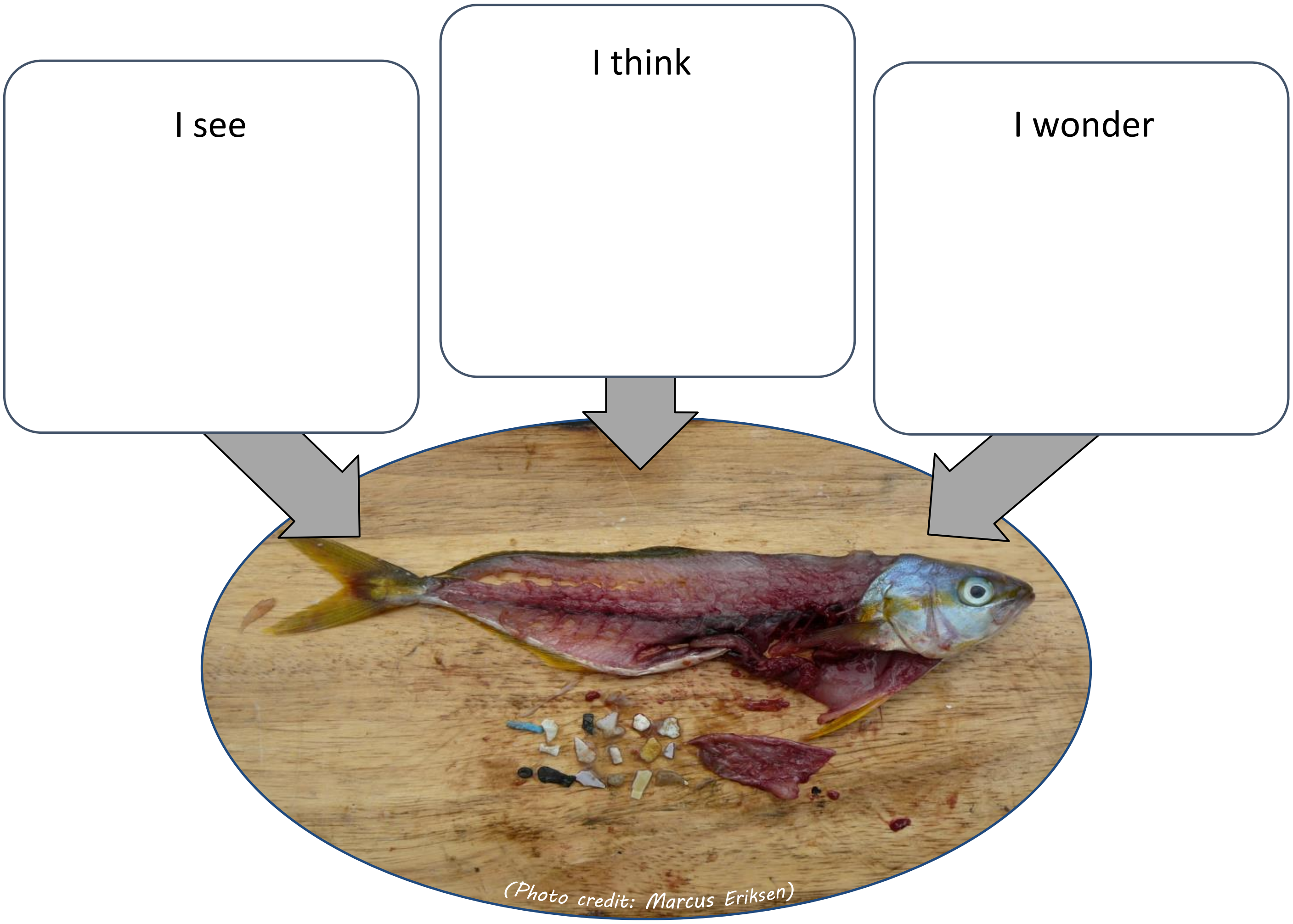
Another team with scientists from all over the world did a study about how much plastic was in the ocean. They collected data from net tows and visual surveys (scientists looked over the side of a boat and recorded all the trash they saw), and 92.3% of the tows had plastic in them. The scientists used the data to create a computer model that estimated how much plastic was in the ocean. The model showed that there should have been a lot more microplastics. Where are they going? Scientists aren't sure, and they will have to do more research to find out.

5. After reading about this worldwide research on plastic in the ocean, was Angel's data unusual or does it fit in with this data? How do you know?
____
____
____

Eriksen, M., Lebreton, L. C. M., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., Galgani, F., Ryan, P. G., & Reisser, J. (2014). Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. *PLOSone, 9(*12*).*

See-Think-Wonder

Study the picture and describe what you see, what you think about it, and what you wonder about the image.



Plastics in the environment

Anything that doesn’t belong in the ocean is **marine debris**. Plastic marine debris comes in many shapes, sizes, and colors. It ends up on beaches, floating at the surface, sinking to the bottom, and many places in between. Plastics in the ocean are exposed to waves, wind, and sunlight, which causes them to break into smaller pieces over time, or **fragment**. This is one way that plastic marine debris becomes **microplastics**.

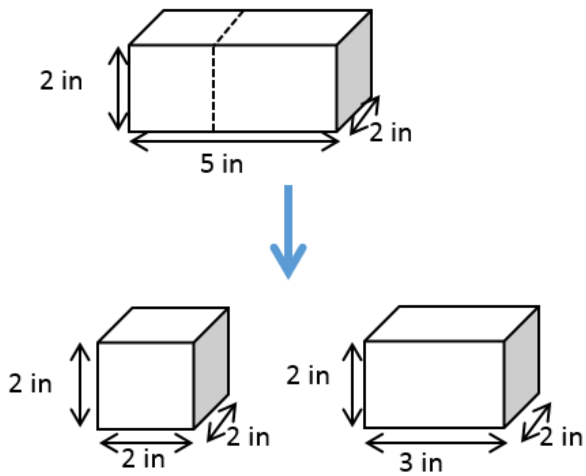
Like the fish pictured above, debris like microplastics can be eaten by animals. The animals *might* mistake the plastic pieces for prey or they might be filter feeders, which means they take in whatever is in the water. Sometimes microplastics can get stuck in the guts of animals and cause problems, but not always. Another possible problem with microplastics is that the plastic attracts **toxins** from the water that stick to the surface of the plastic. Researchers have also found that **microbes**, very small organisms, form colonies (groups) on the surface of plastic marine debris. These are all **impacts**, or effects. Scientists do not know all the impacts of microplastics in the ocean. Researchers are working to understand these impacts.

What happens when plastic fragments in the ocean?

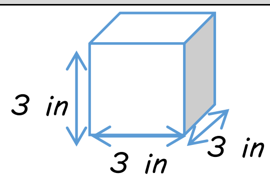
To find out what happens to plastic when it breaks into smaller pieces in the ocean, you will use plastic cubes to represent marine debris. Over time, plastic marine debris is exposed to sunlight, wind, and seawater, and it fragments. Your challenge is to find out how the total **surface area** of plastic changes when it fragments.

To calculate surface area of a cube or rectangular prism, find the ***area*** *of all the sides and* ***add*** *them up.*

Example:



Record how your marine debris fragments in the table below.

Number of pieces	Work	Total Surface Area
1		

Questions

1. When did this marine debris have the **smallest** surface area? The **biggest** surface area?

   ____

   ____

2. When more surface area is exposed to water, there is more space for toxins or microbes to attach. Does marine debris hold more toxins when it is big or when it is fragmented into microplastics? Why?

   ____

   ____

Read the text and look at the data table below, then answer the questions.

From the Field

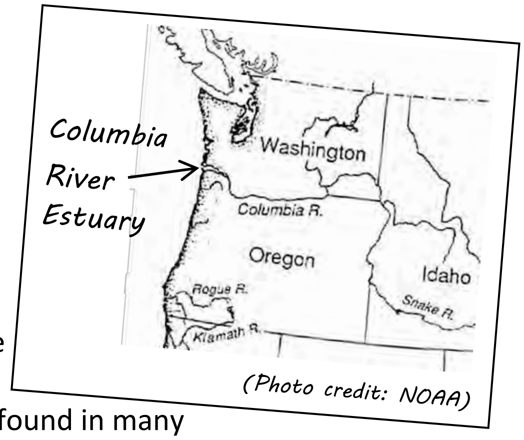
Laurie Weitkamp

Name: Laurie Weitkamp

Career: Fisheries biologist with NOAA (National Oceanic and Atmospheric Administration)

Education: Bachelor's degree in zoology from University of Washington
Master's degree in fisheries from University of Washington
PhD in aquatic and fisheries science from University of Washington

Research: Pacific salmon and factors that affect their survival



(Photo credit: NOAA)

Notes: Laurie and her team work in the Columbia River Estuary, which is between Oregon and Washington, where the Columbia River meets the Pacific Ocean. They wanted to find out what juvenile salmon in the Columbia River were eating. They wanted to understand their biology and wondered if they get food from the marshes people have been restoring nearby. Salmon mostly eat small animals such as insects. The scientists looked inside the salmons' stomachs, and some of them had plastic inside. The plastic pieces were about the same size as the insects, but were found in many different colors (white, red, blue, and black). The scientists recorded the plastic they saw, but not how much or what kind. Sometimes scientists make observations and record data on something completely different from the focus of their work!

Laurie Weitkamp's Data: Juvenile salmon diets in the Columbia River Estuary			
Species	***Total number of fish***	***Number with plastic in their stomachs***	***Percent of fish with plastic in their stomachs***
Chinook	1,009	28	3%
Coho	174	12	7%
Steelhead	219	3	1%

1. How many steelhead had plastic found in their stomachs?

   ____

2. Which species had the highest percentage of fish with plastic in their stomachs? ________________

Wild Juvenile Steelhead
(Photo credit: Laurie Weitkamp)

3. What does this data tell you about what juvenile salmon in the Columbia River Estuary are eating? Support your statement from #3 with specific evidence from the data table.

____

____

____

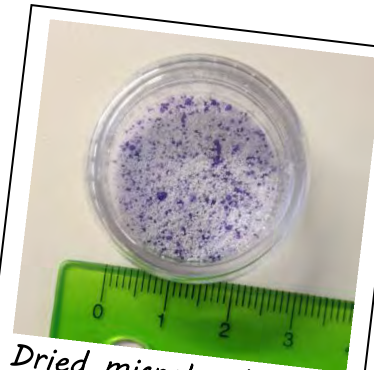
4. Do you think it is acceptable for these juvenile salmon to have plastic in their stomachs? Why or why not?

____

____

____

____



Dried microbeads

5. A student named Sara looked at Laurie's data and said, "These fish are eating plastic because they look like bugs!" Is this a claim she can make from the data *shown in the table*? If it is, state the evidence from the table. If it isn't, correct her statement.

____

____

____

____

6. List two impacts of microplastics on the ocean.

Impact
1.
2.

7. Microplastics do not just impact animals! They also impact people. How do microplastics impact people?

____

____

____

Lesson 3

Designing Solutions to Microplastics

Using the information in your notebook and the scientific data to develop a possible solution to microplastics. Think about the plan's costs and benefits as well as its feasibility (if it's possible). Answer the questions in the graphic organizer below, then put all your ideas together.

Chinook Salmon
(Photo Credit: Laurie Weitkamp)

The Problem		
What are microplastics?	*How do microplastics get in the ocean?*	*What is the problem with microplastics?*

Our Solution	
What solution did your group decide on?	*What made you decide on this solution?*

Evidence to Support our Solution	
What evidence supports your solution?	*What evidence does not support your solution?*

Costs and Benefits	
Costs of your solution:	*Benefits of your solution:*

Glossary

Dilute – Less concentrated because water has been added to it

Degradation – The process of objects breaking down; in the case of microplastics, by UV waves (photodegradation)

Ecosystem – All the living organisms and non-living things in an environment

Estuary – An area where freshwater and salt water mix

Fragment – To break down into smaller pieces

Impacts – The effects of something, either positive or negative

Manta trawl – A net with floats and a bottle at the end to capture small particles at the surface of the ocean

Marine Debris – Any trash or other solid material that ends up in the ocean or the Great Lakes without a purpose

Microbes – Tiny organisms that live everywhere on Earth

Microbeads – Tiny plastic particles added to many types of personal care products

Microplastics – Plastic marine debris that is less than 5 mm

Nurdles – Small, pre-manufacture plastic pellets

Plastic – Manufactured long chains of hydrocarbons, often derived from natural gas or petroleum

Polyethylene – The most common type of plastics, with a wide variety of uses, including packaging, shopping bags, and clothes

Prey – An animal that is eaten for food

Organism – A living animal, plant, or single-celled creature

Sink – Where something ends up

Surface Area – The area of the outermost layer of an object

Toxin – Poisonous substance

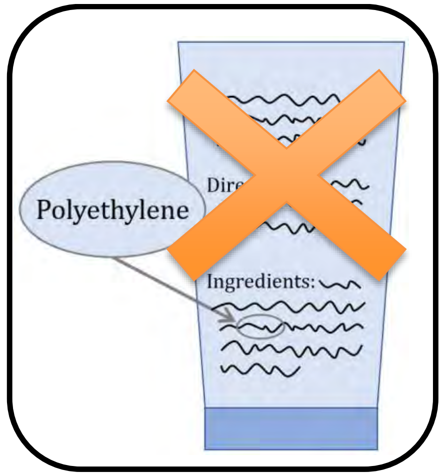
Weathering – Mechanical weathering is the process of breaking down materials into smaller pieces

Oregon coast

Solution: Individual Actions

These are examples of actions people can take to reduce the amount of plastic entering rivers and the ocean. These are not the only possible actions!

Recycling



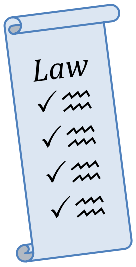
Not buying products with microbeads

Placing waste in the **proper** place

Using reusable bags

Things to think about:

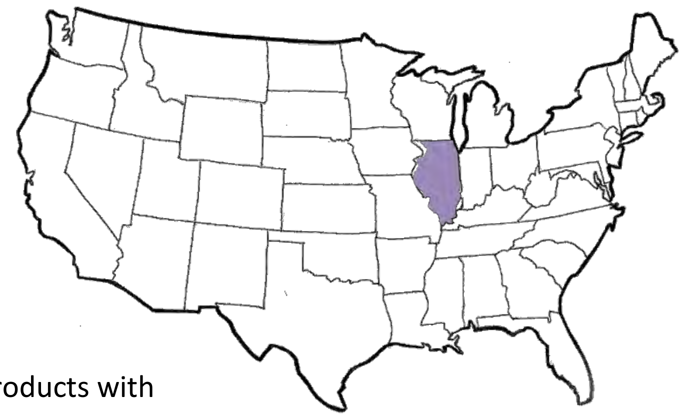
- What other things can individuals do to reduce the amount of plastic entering the ocean?
- Will individual actions make a difference?
- What are you already doing to reduce the amount of plastic entering the ocean?
- How can you use individual actions to start bigger group actions?



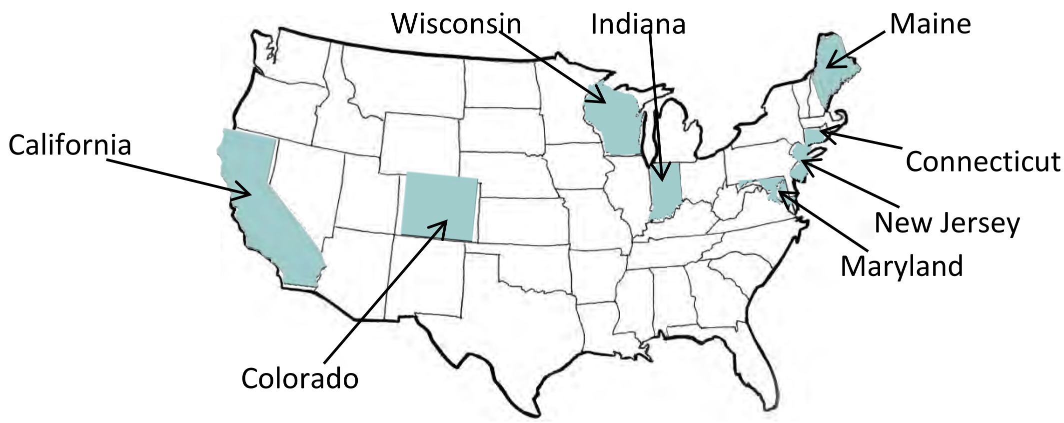
Solution: Making Laws

A possible solution to microplastics is to make laws that stop companies from making and selling microplastics. If we don't use them, they won't go into the ocean, right?

- In June 2014, Illinois was the first state to pass a law banning the making and selling of microbeads in personal care products (face wash, soaps, etc.).



- These states have also passed laws that restrict products with microplastics.



> ### President Obama Signs *Microbead-Free Waters Act of 2015*
>
> December 28, 2015
>
> Washington D.C. – A federal law was passed and signed by President Obama that bans the production and sale of personal care products with plastic microbeads. Some personal care products, such as toothpaste and face wash, have plastic microbeads that can go down the drain and into the ocean. Scientists are not sure how these small plastic beads affect the ocean environment. To stop more plastic from entering the ocean, Congress decided to ban personal care products with microbeads, starting in 2017. Nobody will be allowed to make or sell personal care products with microbeads anywhere in the United States.

Things to think about:

- How will this help the problem with microplastics?
- How can students help with this?
- Why is it important for many people to work together to stop microplastics from entering the ocean?

Photo credits: NOAA

Solution: Education

From the Field

Photo Credit: Marcus Eriksen

Name: Marcus Eriksen

Career: Director of Research and Co-founder of 5 Gyres, an organization that works to end plastic pollution in the ocean. They study marine debris, educate people about the issue, and work with people making laws.

Education: PhD in science education from the University of Southern California

Research: Marine debris

Notes: In 2014, Marcus was part of a team that published a paper about the amount of plastic in the ocean. They estimated that there were more than 5 trillion pieces of plastic floating in our ocean! Marcus says a big part of his job is “myth-busting.” Many people think there is a big garbage patch floating in the ocean, but Marcus has said it’s more like “plastic smog.” As with air pollution, it’s a difficult task to clean up plastic in the ocean. That means that we will have to work together to come up with creative solutions to plastic marine debris. 5 Gyres works to stop marine debris through educating students, decision-makers, and people who can help reduce marine debris (that’s everyone!). Marcus feels that his job is rewarding, and that working to prevent marine debris is the right thing to do.

Advice:

1. Explore your core values to find what is important to you
2. Be part of a team
3. Commit to your cause

Things to think about:

- Why is it important to work as part of a team?
- How can you get people to understand microplastics?
- What is the most important thing people need to know about microplastics?

Microplastics – Student Example

Teacher Answer Guide

This “Student Example” document includes sample student responses. The purpose of this document is to provide insight into the questions in the student notebook and show an example of high-quality student work. Many of the questions do not require one correct answer and may vary in detail or focus. In these cases, the example response is just one possible response, and a note is made by the author. Additional content information can be found in the “Educator Background” section of each lesson plan.

Sea Grant Oregon

OSU Oregon State University

Words to know:

1. Bags, Bottle, and Beads: Sources of Microplastics

Microplastics Plastic marine debris less than 5mm

Polyethylene The most common type of plastic

Marine debris Anything that ends up in the ocean or Great Lakes that does not belong

Nurdle Small, pre-manufacture plastic pellets

Manta trawl A net used to capture small particles at the surface of the ocean

Dilute Less concentrated because water has been added to it

Plastic Made by people from oil or natural gas

2. Small plastics, big problem

Fragment To break into smaller pieces

Toxin Poisonous substance

Organisms A living animal, plant, or single-celled creature

Surface area The area of the outermost layer of an object

Microbes Tiny organisms that live everywhere on Earth

3. Designing Solutions to Microplastics

Microplastics Plastic marine debris less than 5mm

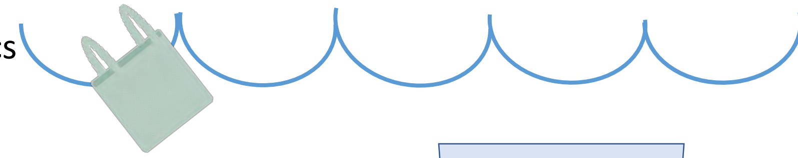
Reduction Making the amount of something smaller

Ban Make it illegal to manufacture or sell a particular product

Marine debris Anything that ends up in the ocean or Great Lakes that does not belong

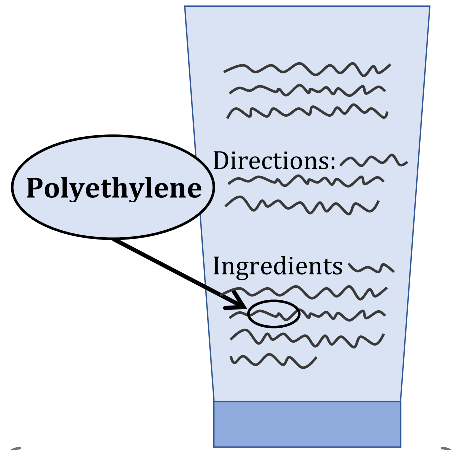
Lesson 1

Bags, Bottles, and Beads: Sources of Microplastics



Soap suds and…plastic?

Plastics can be found in many products at school and home. Plastics are created by ______people______ from ___oil____________ or _______natural gas________________. There are lots of types of plastics. One surprising product that has plastic in it is _____some soaps_____. Some soaps have small pieces of ___polyethylene_______ (a type of plastic), which are called ____microbeads___.

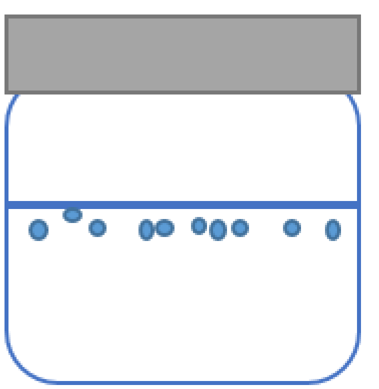
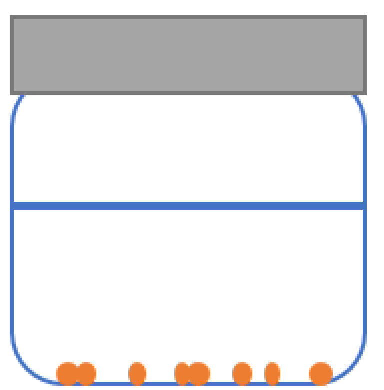


What to look for on the back of soap to see if it has plastic

CHALLENGE: Which soap has plastic in it?

STEPS:

1. Observe the two soaps using your senses of smell and sight (NOT taste or touch)
2. Fill the jar halfway with water, put the lid on your jar, and shake it up!
3. Observe again with words and pictures, using your sight (NOT taste or touch)
4. Answer the questions on the next page

	Jar ___A___	Jar ___B___
Observations	1. There is white foam at the top of the mixture. 2. The water and soap mix, and the whole mixture is blue. 3. The blue pieces float to the top of the liquid.	1. The pieces in the mixture sink to the bottom 2. The mixture is orange 3. There is white foam at the top
Pictures (after shaking)		

CONCLUSIONS:

1. What was different about the two soaps?
_______ When we shook up both jars, the pieces in jar A floated to the top of the liquid, and the pieces in jar B sank to the bottom.____

2. Which jar do you think has plastic in it? Explain your reasoning. Be specific.
______ I think that jar A has plastic in it because it floats in water. ____________________________________

____

3. What do you think happens to the plastic in the soap after someone uses it to wash his or her face?
_____After someone uses one of these soaps to wash their face, they rinse it into the drain and it travels out into rivers and oceans.____

____

President Obama Signs *Microbead-Free Waters Act of 2015*

December 28, 2015

Washington D.C. – A federal law was passed and signed by President Obama that bans the production and sale of personal care products with plastic microbeads. Some personal care products, such as toothpaste and face wash, have plastic microbeads that can go down the drain and into the ocean. Scientists are not sure how these small plastic beads affect the ocean environment. To stop more plastic from entering the ocean, Congress decided to ban personal care products with microbeads, starting in 2017! Nobody will be allowed to make or sell personal care products with microbeads anywhere in the United States.

Do you think this solves the problem of microplastics in the ocean? Why or why not?

__I do not think that this law solves the problem of microplastics because there are many other ways that plastic gets into the ocean. Microbeads make up a small portion of the plastics that end up in the ocean, and it is important to address those too. The law also only applies to the U.S. There are other countries that use products with plastic microbeads. This law was important in raising awareness about microbeads in personal care products, and it is also important in reducing the amount of plastic in the ocean.

____

____

____

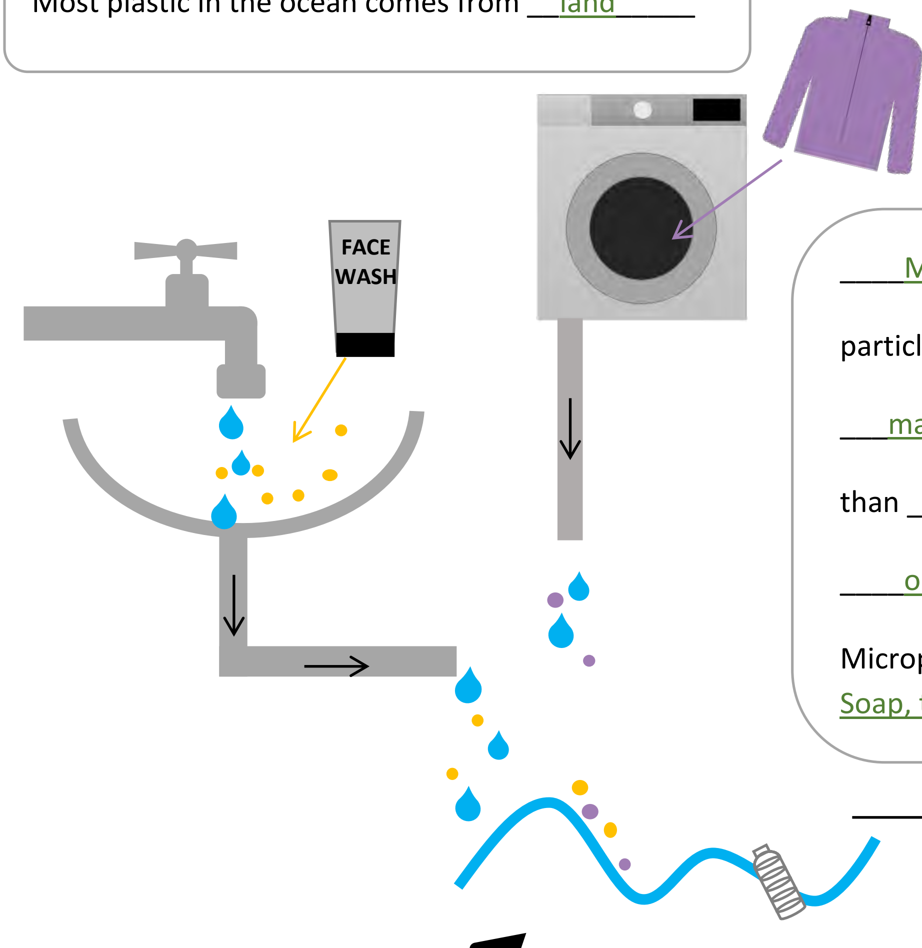
____

____

____

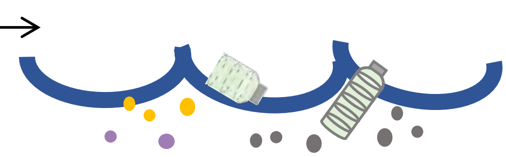
Sources of Microplastics:

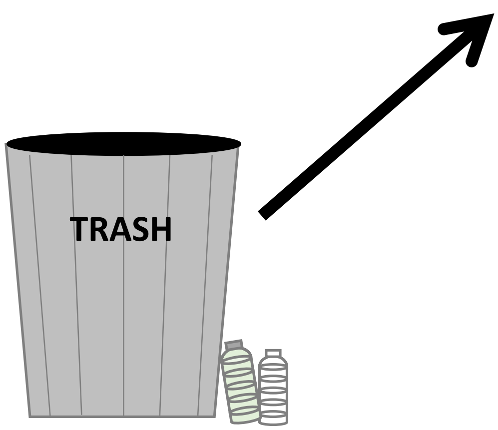
Most plastic in the ocean comes from __land_____



____Microplastics______ are small particles of ___plastic______ ___marine debris____ that are less than ___5 mm______ and end up in the _____ocean______.

Microplastics are found in:
Soap, toothpaste, laundry lint





___Marine debris______ is anything that ends up in the ocean or Great Lakes that doesn't belong there. Plastic marine debris _____fragments______ in the ocean.

Microplastics can also come from ____factories______ that use small plastic pellets to make their products. These pellets are called ___nurdles__. They are light in color and about this big

From the Field

Angel White

Name: Angel White

Career:
Researcher at Oregon State University

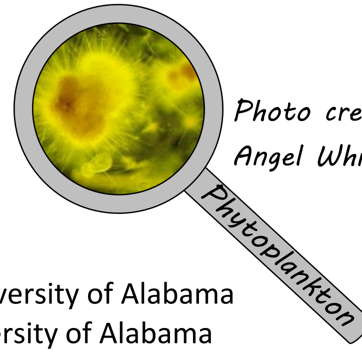
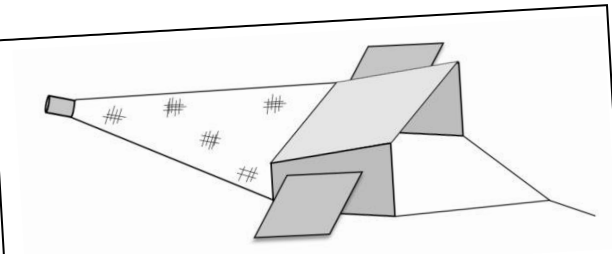


Photo credit: Angel White

Education:
Bachelor's degree in biology from University of Alabama
Master's degree in biology from University of Alabama
PhD in biological oceanography from Oregon State University

Research: phytoplankton, how materials move through ecosystems, harmful algal blooms

Notes:
In 2008, Angel had the chance to go on an expedition with other scientists to study the amount of plastic in the ocean. To do this research, Angel went with a team of scientists to the Pacific Ocean (shown by the star on the map below). Angel had heard that there were big patches of garbage in the middle of the ocean. However, when she went out on the expedition, she did not see piles of trash floating in the water. In fact, the water looked clean! She sampled the water using a **manta trawl**. A manta trawl is a large net with a bottle at the end that captures anything too big to fit through the net (like plastic in the water). Scientists pull the manta trawl behind a boat along the surface of the water, and then analyze what is caught in the net. Each time the net is dragged behind the boat, it is called a tow. Each tow filtered about 360 m^3 of water, which is about the size of a school swimming pool. The scientists separated the plastic from the net and counted the number of pieces in each sample. After looking at the data, Angel was surprised the plastic was so **dilute**, even though plastic can be found all over the ocean!



Manta trawl net

Small plastic that could get caught in a manta trawl net

The data in the table was collected by Angel and the other scientists on her expedition to the Pacific Ocean. Even though many researchers have found plastic in the ocean, people continue to study the amount of plastic in the ocean, where plastic can be found, and what type of plastic is in the ocean. This is important because people want to know how plastic in the ocean will affect living things.

Look at the table that shows Angel's data, then answer the questions.

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Plastics found in 10 tows in the Pacific Ocean

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6	281	358
7	901	361
8	543	360
9	1,334	360
10	515	360

1. Circle the *tow number* with the **largest** number of plastics found. What is the value? __1,334 plastics__
   Draw a box around the *tow number* with the **least** plastics. What is the value? __127 plastics__

2. How deep in the water were these microplastics found? Underline your evidence in the text.
   ___The microplastics came from the surface of the water.____________

3. What are two possible **sources** of the microplastics that Angel and the research team found?
   _____Two possible sources of the microplastics are laundry lint or fragmented large plastic debris (there are other possible answers).________

4. Angel had heard that she would find a large island of trash. What did she find instead?
   ___Angel said that the water looked clean, but when she towed the manta trawl, there were lots of very small plastics on the surface of the ocean.________

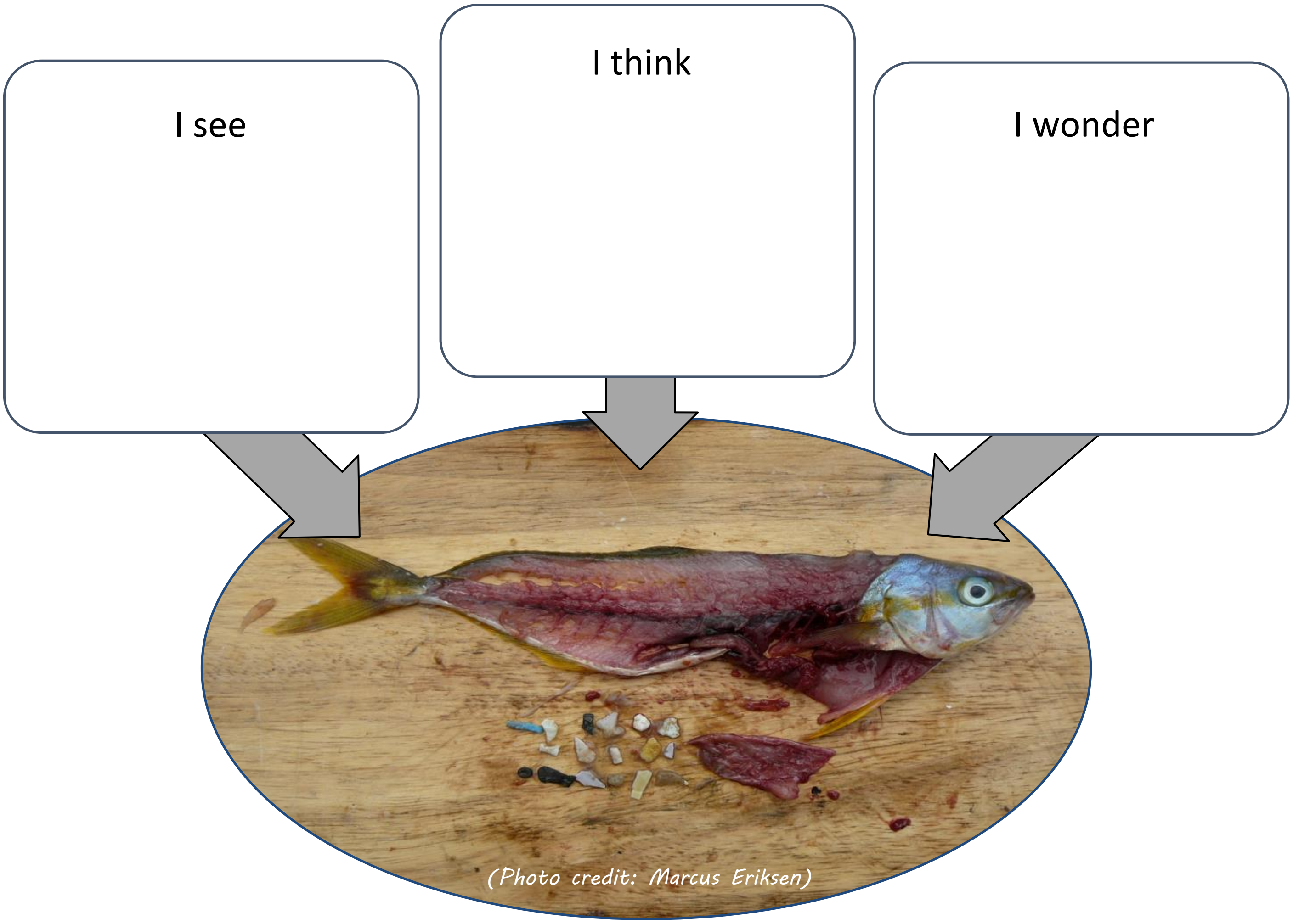
Another team with scientists from all over the world did a study on how much plastic was in the ocean. They collected data from net tows and visual surveys (scientists looked over the side of a boat and recorded all the trash they saw), and 92.3% of the tows had plastic in them. The scientists used the data to create a computer model that estimated how much plastic was in the ocean. The model showed that there should have been a lot more microplastics! Where are they going? Scientists aren't sure, and they will have to do more research to find out!

5. After reading about this worldwide research about plastic in the ocean, was Angel's data unusual or does it fit in with this data? How do you know?
   ____Angel's data does fit in with this data. She also found microplastics on the surface of the ocean, although we cannot compare the abundance of microplastics the two studies found.

Eriksen, M., Lebreton, L. C. M., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., Galgani, F., Ryan, P. G., & Reisser, J. (2014). Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. *PLOSone, 9*(12).

See-Think-Wonder

Study the picture and describe what you see, what you think about it, and what you wonder about the image.



(Photo credit: Marcus Eriksen)

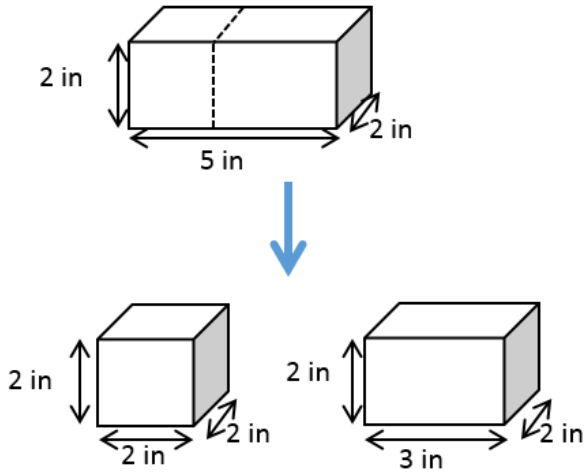
Plastics in the environment

Anything that doesn't belong in the ocean is **marine debris**. Plastic marine debris comes in many shapes, sizes, and colors. It ends up on beaches, floating at the surface, sinking to the bottom, and many places in between. Plastics in the ocean are exposed to waves, wind, and sunlight, which causes them to break into smaller and smaller pieces over time, or **fragment**. This is one way that plastic marine debris becomes **microplastics**.

Like the fish pictured above, debris like microplastics can be eaten by animals. The animals *might* mistake the plastic pieces for prey, or they might be filter feeders, which means they take in whatever is in the water. Sometimes, microplastics can get stuck in the guts of animals and cause problems. Another possible problem with microplastics is that the plastic attracts **toxins** from the water that stick to the surface of the plastic. Researchers have also found that **microbes**, very small organisms, form colonies (groups) on the surface of plastic marine debris. These are all **impacts**, or effects. Scientists do not know all the impacts of microplastics in the ocean. Researchers are working to understand these impacts.

What happens when plastic fragments in the ocean?

Example:



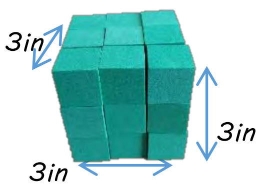
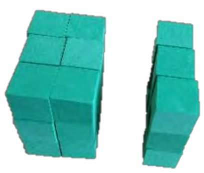
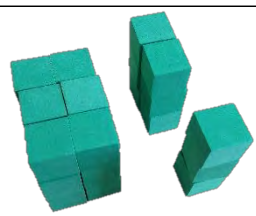
$(2\ in \times 2\ in) \times 2 = 8\ in^2$
$(2\ in \times 5\ in) \times 4 = 40\ in^2$
*$SA = 8\ in^2 + 40\ in^2 =$ **$48\ in^2$***

$6 \times 2\ in^2 = 6 \times 4\ in^2 = 24\ in^2$

$(2\ in \times 2\ in) \times 2 = 8\ in^2$
$(2\ in \times 3\ in) \times 4 = 24\ in^2$
$8\ in^2 + 24\ in^2 = 32\ in^2$

*Total $SA = 24\ in^2 + 32\ in^2 =$ **$56\ in^2$***

Record how your marine debris fragments in the table below.

Number of pieces	Work	Total Surface Area
1	 Surface Area $= (3\ in \times 3\ in) \times 6$ $= 9\ in^2 \times 6 = 54\ in^2$	$= 54\ in^2$
2	 $4(2in \times 3in) + 2(3in \times 3in) = 42in^2$ $4(1in \times 3in) + 2(3in \times 3in) = 30in^2$ $42in^2 + 30in^2 = 72\ in^2$	$=72\ in^2$
3	 $4(2in \times 3in) + 2(3in \times 3in) = 42in^2$ $2(1in \times 3in) + 2(1in \times 2in) + 2(3in \times 2in) = 22in^2$ $4(1in \times 3in) + 2(1in \times 1in) = 14in^2$ $42in^2 + 22in^2 + 14in^2 = 78\ in^2$	$=78\ in^2$
5	 $4(2in \times 3in) + 2(3in \times 3in) = 42in^2$ $2(1in \times 3in) + 2(1in \times 2in) + 2(3in \times 2in) = 22in^2$ $3[6(1in \times 1in)] = 18in^2$ $42in^2 + 22in^2 + 18in^2 = 82\ in^2$	$=82\ in^2$

Questions

1. When did this marine debris have the **smallest** surface area? The **biggest** surface area?
   The marine debris had the smallest surface area when it was one large piece. It had the biggest surface area when it was broken up into smaller pieces.
2. When more surface area is exposed to water, there is more space for toxins or microbes to attach. Does marine debris hold more toxins when it is big, or when it is fragmented into microplastics? Why?
   Marine debris holds more toxins when it is fragmented into microplastics, because microplastics have more total surface area.

Read the text and look at the data table below, then answer the questions.

From the Field

Laurie Weitkamp

Name: Laurie Weitkamp

Career: Fisheries biologist with NOAA (National Oceanic and Atmospheric Administration)

Education: Bachelor's degree in zoology from University of Washington
Master's degree in fisheries from University of Washington
PhD in aquatic and fisheries science from University of Washington

Research: Pacific salmon and factors that affect their survival

(Photo credit: NOAA)

Notes: Laurie and her team wanted to find out what juvenile salmon in the Columbia River were eating. They wanted to understand their biology and wondered if they get food from the marshes that people have been restored nearby. Salmon mostly eat small animals such as insects. The scientists looked inside the salmons' stomachs, and some of them had plastic inside. The plastic pieces were about the same size as the insects, but were found in many different colors (white, red, blue, and black). The scientists recorded when they saw plastic, but not how much or what kind. Sometimes scientists make observations and record data on something completely different from the focus of their work!

Laurie Weitkamp's Data: Juvenile salmon diets in the Columbia River Estuary			
Species	***Total number of fish***	***Number with plastic in their stomachs***	***Percent of fish with plastic in their stomachs***
Chinook	1,009	28	3%
Coho	174	12	7%
Steelhead	219	3	1%

1. How many steelhead had plastic in their stomachs?

   ___3______

2. Which species had the highest percentage of fish with plastic in their stomachs? ______Coho______

Wild Juvenile Steelhead
(Photo credit: Laurie Weitkamp)

3. What does this data tell you about what juvenile salmon in the Columbia River Estuary are eating? Support your statement from #3 with specific evidence from the data table.
_____This data tells me that juvenile salmon in the Columbia River Estuary are eating plastic in the water. I know that there is plastic in the estuary because there were fish with plastics found in their stomachs.____

4. Do you think it is acceptable for these juvenile salmon to have plastic in their stomachs? Why or why not?
This is an opinion question; answers will vary.______________________________________
____
____
____

Dried microbeads

5. A student named Sara looked at Laurie's data and said, "These fish are eating plastic because they look like bugs!" Is this a claim she can make from the data *shown in the table*? If it is, state the evidence from the table. If it isn't, correct her statement.
_____This is not a claim that Sara can make about the data because the data in the table shows that the fish have plastic in their stomachs, but not *why* they have ingested the plastic._______

6. List two impacts of microplastics on the ocean.

Impact
1. Microplastics can get eaten by small animals and stuck in their gut.
2. Microplastics can attract toxins, which might hurt animals if they are eaten.

7. Microplastics do not just impact animals! They also impact people. How might microplastics impact people?
______There are many possible responses. Microplastics can impact recreation (for example, the cleanliness of beaches or water), fisheries, seafood, and other services that we get from the ocean.
____

Lesson 3

Designing Solutions to Microplastics

Use the information in your notebook and the scientific data to develop a possible solution to microplastics. Think about the plan's costs and benefits as well as its feasibility (whether or not it's possible).
Answer the questions in the graphic organizer below, then put all your ideas together.

Chinook Salmon
(Photo Credit: Laurie Weitkamp)

The Problem		
What are microplastics? Microplastics are plastic marine debris less than 5mm.	*How do microplastics get in the ocean?* Directly, when small plastics like microbeads in personal care products are washed down the drain; or indirectly, when large plastic marine debris breaks down in the marine environment.	*What is the problem with microplastics?*

Our Solution	
What solution did your group decide on?	*What made you decide on this solution?*

Evidence to Support our Solution	
What evidence supports your solution? *Use evidence from student notebooks, the "student solutions guide," or other informational sources.	*What evidence does not support your solution?*

Costs and Benefits	
Costs of your solution:	*Benefits of your solution*

Glossary

Dilute – Less concentrated because water has been added to it

Degradation – The process of objects breaking down, in the case of microplastics, by UV waves (photodegradation)

Ecosystem – All the living organisms and non-living things in an environment

Estuary – An area where freshwater and salt water mix

Fragment – To break into smaller pieces

Impacts – The effects of something, either positive or negative

Manta trawl – A net with floats and a bottle at the end to capture small particles at the surface of the ocean

Marine Debris – Any trash or other solid material that ends up in the ocean or the Great Lakes without a purpose.

Microbes – Tiny organisms that live everywhere on Earth

Microbeads – Tiny plastic particles added to many types of personal care products

Microplastics – Plastic marine debris that is less than 5 mm

Nurdles – Small, pre-manufacture plastic pellets

Plastic – Manufactured, long chains of hydrocarbons, often derived from natural gas or petroleum

Polyethylene – The most common type of plastics, with a wide variety of uses, including packaging, shopping bags, and clothes

Prey – An animal that is eaten for food

Organism – A living animal, plant, or single-celled creature

Sink – Where something ends up

Surface Area – The area of the outermost layer of an object

Toxin – Poisonous substance

Weathering – Mechanical weathering is the process of breaking down materials into smaller pieces

Oregon coast

Name: ________________________

Bags, Bottles, and Beads: Sources of Microplastics Assessment

Directions: Read each question carefully and answer completely. For multiple-choice items, choose ***one*** *answer.*

Objective: Define marine debris and microplastics

1. What is marine debris?

____

____

2. If all of the following items were found floating in the ocean, which would be described as microplastics?

   a. Plastic bag

   b. Seed 

   c. Bottle cap 

   d. Plastic nurdles 

   Explain your answer.

____

____

Objective: Explain sources of microplastics

3. What are two ways microplastics can get into the ocean?
   a. ____
   b. ____

4. List two possible sources of microplastics.
   a. ____
   b. ____

5. What is one possible source of microplastics in your classroom now? ___________________________

6. Circle the statement that accurately describes the abundance of microplastics.
   a. Microplastics are found only near beaches
   b. Microplastics are found all over the world
   c. Microplastics are found only in the middle of the ocean
   d. Microplastics are found only in rivers

   Explain your answer.

____

____

7. What do you think happens to microplastics in the ocean?

____

____

____

Name: ________________________

Small Plastics, Big Problem Assessment
Directions: Read each question carefully and answer completely.

Objective: Articulate at least two impacts of microplastics on the marine environment

1. List two impacts of microplastics on the ocean.

1.
2.

Objective: Describe how surface area changes when an object fragments

2. What happens to the total surface area of an object when it fragments into smaller pieces?

____

____

____

Dried microbeads

3. Can more microbes live on marine debris when it is whole, or when it is broken down into small pieces? Explain your answer.

____

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