Water Education For All
Lesson: Marine Debris

Time: 4 hours

Objectives:

- Define marine debris and its impacts on the ocean
- Identify common sources and types of marine debris
- Design a solution to mitigate pollution

Summary: In this lesson, students explore how human trash impacts the ocean. Through analyzing beach cleanup data and conducting waste audits, they connect how human habits affect the environment. After learning about how and why marine debris has become a global issue, they will design solutions to reduce waste in their lives.

Standards alignment:

NGSS Standards: Elementary School (3-5)
5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

ESS3.C: Human Impacts on Earth Systems. Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

NGSS Standards: Middle School (6-8)
MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

ESS3.C: Human Impacts on Earth Systems. Human activities have significantly altered the biosphere. 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.

NGSS Standards: High School
HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

ESS3.C: Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

Science Words:

biodegradable	marine debris	ocean gyre
decompose	marine pollution	plankton
entanglement	nurdles	plastic
food chain	North Pacific Gyre	pollution
ingestion	ocean current	recycle

Note: See the Glossary at the end of the lesson for definitions.

ENGAGE

1. THINK: Ask students to think about the question: What is pollution? Students can jot down ideas in their science notebooks. You may choose to show a photo example of pollution for them to look at while they're thinking.
2. PAIR: Once they've thought about the question for a minute, give them 2 minutes to share their ideas with a partner.
3. SHARE: Ask the class what ideas they or their partner discussed. Facilitate a conversation on what pollution means, including examples.
    a. What does "pollution" mean?
        i. Were their ideas about pollution similar or different from their partner? Did they think of any new ideas after talking to a partner?
        ii. According to National Geographic, pollution is "the introduction of harmful materials into the environment" (2011). How is this similar or different from the ideas they discussed?
    b. Where do you think most of the trash in the ocean comes from? From things we do on land (driving cars, visiting parks and beaches, etc) or things we do in the ocean (fishing, boating, etc)?
    c. If we find a piece of trash in the ocean, can we trace it back to the source? Why or why not?
        i. It is often difficult to identify where pollution came from. Point source pollution refers to pollution where we know where it came from (i.e. a broken sewer pipe). Non-point source pollution, on the other hand, can't be tracked back to an original source (i.e. a piece of trash in the water).
    d. Where have they experienced pollution in their own lives-- at the park, at school, at the beach, near a relative's home, etc?
    e. In what ways can pollution hurt the environment and people?

Background information

This information can be shared with the students, or individual topics may be assigned to teams of students to read and share with the rest of the class.

Marine Debris

The National Ocean Service (2020c) 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.” This includes a huge variety of debris, from derelict fishing boats to tiny pieces of plastic.

Plastic Facts

- According to UNESCO (2017), over 220 million tons of plastic are produced each year.
- Scientists have estimated that somewhere between 4.8 to 12.7 million metric tons of plastic enter the ocean each year (Jambeck et al., 2015).
- Plastics are useful because they provide lighter packaging and improve insulation. They are found in phones, computers, medical devices, and more, but are often not properly disposed of.
- Once discarded, plastics fragment into very small pieces becoming microplastics. Microplastics are less than 5mm in size (NOAA, 2020b). These microplastics, together with plastic pellets, are already found on most beaches around the world.
- Ocean currents, among other natural forces, create gyres. The circulation of these gyres causes a concentration of plastic and other debris in certain areas.Plastic is now found in all ocean gyres
- The Great Pacific Garbage Patch is found within the North Pacific Gyre. This is an accumulation of debris located between Hawaii and California. Some estimates have claimed that it is twice the size of Texas; because it is always moving with the ocean currents, it is difficult to estimate its true size (NOAA Office of Response and Restoration, 2019).

Plastic Sources

Plastics in the marine environment derive from two main sources:

1. Ocean-based sources, like trash and fishing gear from ships: **20%**
2. Land-based sources such as runoff, wastewater systems, and litter left on beaches: **80%** (Coe & Rogers, 1997).

Sizes

Plastic litter can be broadly divided into the following size categories (Lee et al., 2015; National Ocean Service, 2020b):

- Macroplastics (>25 mm)
- Mesoplastics (5-25 mm)
- Microplastics (<5 mm)

Some plastics enter the ocean already at the microplastic size, like plastic pellets; others enter the ocean as larger pieces and fragment into smaller microplastics over time (National Ocean Service, 2020c).

Where Does Litter Go?

Wind or water can move litter through rivers, canyons, streets, into storm drains, and into the ocean as runoff. It can travel many miles from the point it was discarded to reach the sea. Once it enters the ocean, some debris sinks, some floats, and some remains suspended in the water column. Ocean currents can move this debris thousands of miles away from its point of origin. In the ocean, debris may be ingested by marine life and be passed through the food chain as smaller animals are eaten by larger ones. Through this process, organisms at all levels of the food chain end up unintentionally eating marine debris, from the tiniest creatures to the largest (and yes, even us!).

What are the main impacts of plastic debris in the ocean?
Plastic becomes brittle and breaks into increasingly smaller pieces after exposure to environmental factors such as ultraviolet sunlight, oxidation by the air, hydrolysis by seawater, and physical abrasion. This "breakdown" is not the same as "degradation;" rather, the polymer simply breaks into smaller polymer pieces. These smaller pieces are still plastic and will not truly decompose in the natural environment (Stevenson, 2011).

- **Ecological Impacts**:
    - **Ingestion**: When an animal eats debris.
        - Plastic debris causes the deaths of more than a million seabirds every year, as well as more than 100,000 marine mammals. Plastic isn't digestible, so accumulates in an animal's stomach and never goes away. Animals die from starvation with a full stomach of plastic. This ingested plastic has severe consequences for the health of the bird and negatively impacts survival and reproduction.
        - Roughly 95% of fulmars (a type of seabird) in the North Sea area have plastic in their stomachs, ranging from plastic twine to candy wrappers (Avery-Gomm et al., 2012).. One bird in this study was found with 454 pieces of plastic in its stomach (Avery-Gomm et al., 2012).
    - **Entanglement:** When an animal gets tangled in debris.
    - **Bioaccumulation**
        - Studies found that plastics can release or attract chemicals floating in seawater, which can have potentially toxic, carcinogenic, and hormone-disturbing effects for animals (Rochman, 2015).
- **Economic Impacts:** Marine debris incurs costs through the damage of fishing gear and facilities, losses to fishery operations, and cleaning costs. This pollution costs the fishing and shipping industry millions of dollars.
    - Discarded plastic bags get caught in boat propellers and cooling intakes, damaging engines.
    - Marine debris is increasingly impairing the ocean's capacity to provide food and other services. The extinction of fish species could lead to starvation or under-nourishment of other species.
    - Ghost fishing that occurs when discarded fishing nets entangle marine life indiscriminately, reducing fishers' revenues from lost catch.
- **Social Impacts**: Reductions in aesthetic and recreational value, risks to public health and safety.

EXPLORE

Activity: How Long Does It Take to Break Down?

Different materials decompose at different rates. How long does it take for these common types of trash to break down? Match the decomposition rates (time) with materials found in the ocean (marine debris). Download our matching game and try it out!

Activity: Top 10 Types of Marine Debris

Can you guess the top 10 trash items found during San Diego beach cleanups each year? Try ranking the list below from most collected to least collected. Then, check your results against our 2019 beach cleanup data.

- plastic bottles
- cigarette butts
- paper bags
- Styrofoam
- plastic caps & lids
- food wrappers & containers
- glass beverages bottles
- cell phones
- straws
- plastic bags
- beverage cans
- plastic cups, plates, forks, knives, spoons

Afterwards, write a brief reflection on what you found:

- Did anything surprise you?
- How did these items get to the ocean?

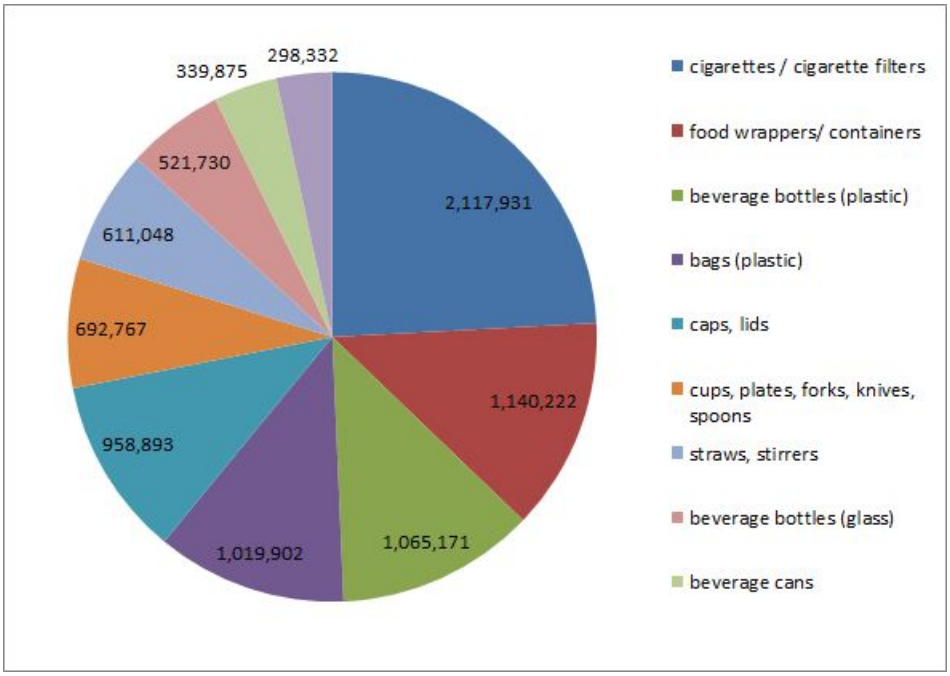
Extension: Research beach cleanup reports from San Diego Coastkeeper or International Coastal Cleanup Day for the last 3-5 years. Were there any changes in the top 10 items over the years? What might be some reasons for the changes (legal bans on items, education campaigns, etc)?

EXPLAIN

Activity: Beach Cleanup Math

Using the data you researched above, make a pie chart or infographic that shows the top 10 items found in beach cleanups and their percentage of the overall items collected.

Example: Top 10 Marine Debris Types from 2011 Coastal Cleanup Day



ELABORATE

Activity: Waste Audit

Students will prepare a T-table to keep a tally of the trash they produce daily during a 7, 14, or 30-day period. The T-table could be created in Google docs spreadsheet or science notebook (see example table below). Once the students have finished their waste audit, they should graph their results and share with the class. As an extension to the project, students can implement waste prevention strategies and compare the total waste before and after the habit change.

Research Questions

- Assuming these amounts remain the same, how much waste would you generate in a year? Calculate your results.
- What was the item you used the most? What could you do to reduce your use of that item? If you cut back by 50% or stopped using that product altogether, how would that affect the amount of waste you generate in a year?
- Based on your numbers, propose a solution that would reduce the most waste in your daily habits. Use data to justify your reasoning.

Item	Day 1 # used	Day 2 # used	Day 3 # used	Day 4 # used	Day 5 # used	Day 6 # used	Day 7 # used	Week 1 Total
Milk container		1				1		2
Napkin	2	1	1	1	2	1	1	9
Paper plate	1	1	1	1	1	1	1	7
Plastic sandwich bag	1	1	1	1	1			5
Plastic wrapper	1	1	1			1	1	5
Styrofoam container	1				1			2
Plastic utensils	1		1		1	1	1	5

Activity: Solutions to Pollution

What can you do to reduce the pollution problem? Choose one (or more!) of the options below to get students thinking about how they can make a difference.

- Research laws that ban single-use items like straws and plastic bags. Are any of these already in place in your city or state? What are the pros and cons? How effective are these laws at reducing single-use items?
- Compare and contrast two months of different habits. During one month, use reusable materials and recycle the waste you create. The next month, collect the waste you normally throw away or recycle, and watch it add up. How big is your trash footprint after a month in the two different scenarios? (Don't forget to recycle all recyclable materials at the end of the experiment!)
- Share what you learn with your friends, family, and community. Spread the word about how we can reduce the amount of common waste products by changing our daily habits. Create a YouTube video, social media campaign, art piece, blog, infographic or brochure that highlights ways to reduce pollution.

EVALUATE

Students can be assessed in a variety of ways. Students can:

- Develop a hypothesis about how human activities impact the ocean environment.
- Identify common sources of pollution in their region and suggest ways to minimize that pollution.
- Describe the most common marine debris found in beach cleanups and use scientific studies or reports to demonstrate the effect on local beaches.
- Share their solutions to reduce or prevent pollution. This can include actions like hosting school or beach cleanups, conducting a school waste audit, implementing an education campaign, and more.

Glossary

Biodegradable (*biodegradable*): Capable of being broken down by the action of microorganisms. A piece of fruit is biodegradable; a piece of plastic is not.

Decompose (*descomposición*): To decay or break down.

Entanglement *(enredado)*: The condition of being caught in something. Many items of marine debris, such as abandoned fishing equipment, pose an entanglement risk to marine life.

Food chain (*cadena alimentaria*): The transfer of energy from organism to organism in the form of food.

Ingestion (*ingestión*): Consumption of a substance by an animal. Typically of a food, but pollutants and trash can also be ingested.

Marine debris (*basura marina*): 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 (National Ocean Service, 2020c).

Microplastics (*microplásticos*): small plastic pieces less than five millimeters long (National Ocean Service, 2020b).

North Pacific Gyre: An area of the North Pacific Ocean where currents have trapped huge amounts of debris, mostly plastic. Some believe it is twice the size of Texas, but the size is difficult to measure or estimate.

Ocean current (*Corrientes marinas*): The continuous movement of seawater as it circulates through the ocean.

Ocean gyre: a large system of rotating ocean currents (NOAA, 2020a).

Plankton (*plancton*): Tiny aquatic organisms that drift with the currents. They make up the base of the ocean food chain. Phytoplankton are plant-like in that they photosynthesize. Zooplankton are tiny protozoans and animals and do not photosynthesize.

Plastic (*plástico*): A variety of synthetic and semi-synthetic materials derived primarily from fossil fuels. Plastics do not biodegrade, and make up the majority of debris found in the ocean.

Pollution (*Contaminación*; *polución*): the introduction of harmful materials into the environment (National Geographic, 2011).

Recycle (*Reciclaje*): A process by which waste products are converted into useful raw materials and reintroduced into the production cycle.

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