All Waterways Lead to the Ocean

Sandy Shore - Grades 6-8

Learning Objectives

A) Students will explore their place in the watershed and model how activities upstream affect sandy shores downstream. Students will participate in a beach cleanup and record community science data for the Ocean Conservancy (Part 1).
B) Students will use basic statistics to categorize and analyze how much marine debris they find and possible sources of the debris (Part 2).
C) Students will use insight and data from parts 1 and 2 to develop possible complementary solutions to protect marine protected areas from marine debris (Part 3).

NGSS: DCI (Disciplinary Core Ideas):
MS-ESS2-2.
MS-ESS2-4.
MS-ESS3-3.
MS-ESS3-4.
MS-ETS1-1.

Time: Four to nine 50-minute class periods plus one and a half to two hour field trip

Materials for the Teacher
-Life in the Sand: Field Guide to Sandy Shores
-Plastic, paper, and other tiny scraps
-Vegetable oil
-Food coloring

Part 1: Data Collection

Background information:
(recommended one to six 50-minute class periods)
Sandy shores are dynamic habitats, constantly changing due to impacts from the ocean, wind, tides and people. One of the most challenging aspects of sandy shore conservation is connecting people who live far from the beach with this important habitat. In this lesson students will learn about watersheds and how all waterways lead to the ocean. Students will participate in a community science program collecting data about the impacts of activities upstream, including marine debris, to draw conclusions about how they can take steps to protect beaches.

Marine Protected Areas (MPAs)

We can think of marine protected areas, or MPAs, as underwater parks. Just like we have national, state, and regional parks on land, there are many different types of MPAs. Different parks allow different activities - same with MPAs! In some of them you can fish, while in others you can't. Some MPAs allow all kinds of activities (fishing, swimming, boating, etc.) while others are much stricter. By restricting what people can do and take in these underwater parks, we can protect California's natural resources.

California has 124 MPAs all along the coast. These MPAs protect many different habitats where many different animals live. MPAs give marine species a safe place to breed and grow. Animals inside of MPAs may be larger than those found outside of MPAs, allowing them to have more offspring than smaller animals. Offspring born within MPAs may also have access to more food, space, and other resources, allowing offspring to be healthier.

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MPAs also provide opportunities for people to see beautiful, protected ocean spaces through snorkeling, scuba diving, swimming, kayaking etc. Sometimes, people don't know that they are in an MPA and accidentally do something they aren't supposed to do. That's why it is important to understand what MPAs are, why we have them, and where they are - so you know if you are in one!

Also, have students start to think about the following now. We will discuss it more in-depth at the end off the lesson: Evidence suggests that MPAs may increase biodiversity and abundance by giving species a safe place to live, grow, and reproduce; however, this success is threatened by other activities such as marine debris/pollution. What are some complementary solutions that may be enacted to help reduce or eliminate the threat of marine debris to MPAs?

Materials for the Students

-Life in the Sand: Field Guide to Sandy Shores Student Edition
-Map of local watersheds
-One paint tray (preferably metal and reusable)
-Enough sponges or scraps of towel to fill width of paint tray
-Monopoly houses (3-10 per group usually works well)
-Water
-Natural materials such as dirt, rocks, sticks, leaves
-Trash bag or bucket (one per group)
-Gloves (two per person)
-Trash pickers (if available)
-Clipboard (one per group)
-Talking Trash data sheet (one per group; see appendix)
-Pen or pencil
-Poster board or butcher paper
-Markers
-Marine Debris Possible Solutions activity sheet (see appendix)

Sandy Shore

Sandy shores are areas where deposits of sand or other sediments cover the shoreline. To beachgoers, sandy shores often appear to be devoid of life, made up only of sand, shells, and the occasional piece of driftwood. But in reality, this dynamic habitat is home to a diversity of species, each specially adapted for life above or below the sand. These organisms must contend with pounding waves, changing tides, and constantly shifting sand particles - not to mention people who love to visit and develop beaches!

Community Science

Community science (also known as citizen science) involves members of the general public (that's you and me!) collecting data that can then be used in scientific research. Anyone can participate in community science. It's a great way for people to help out professional scientists!

There are many different types of community science. Some involve using an app on your phone to take pictures or measurements that are then sent to professional scientists. Today, we are going to do a type of community science that involves taking notes about what you see.

Ocean Conservancy Fighting for Trash Free Seas

From the Ocean Conservancy:

"Ocean trash affects the health of wildlife, people and local economies. Trash in the water and on the shore can be mistaken as food by wildlife, or entangle animals with lethal consequences. Plastic also attracts and concentrates other pollutants from surrounding seawater, posing a contamination risk to those species that then eat it. Scientists are studying the impacts of that contamination on fish and shellfish as well as the possible impact it may have on human health as well.

From plankton to whales, animals across ocean ecosystems have been contaminated by plastic. Plastic has been found in 59% of sea birds like albatross and pelicans, in 100% of sea turtle species, and more than 25% of fish sampled from seafood markets around the world.

Marine debris isn't an ocean problem—it's a people problem. That means people are the solution. Ocean Conservancy is committed to keeping our beaches and ocean trash free. For more than 30 years we have organized the International Coastal Cleanup, where nearly 12 million volunteers from 153 countries have worked together to collect more than 220 million pounds of trash. And we're not the only ones who care about ocean trash: Every day, all over the world, concerned people take the problem into their own hands by cleaning up their local waterways.

Tackling the problem of plastic in the ocean begins on land. Reduction in plastics use, especially of single-use disposable products, and the collection and recycling of plastics in developing countries can help to reduce the amount of plastic waste that enters the ocean."For this activity students will be participating in the Ocean Conservancy's Trash Frees Seas community science program to collect marine debris from a local beach, analyze what they find, and explore the impact on local ecosystems and wildlife.

Vocabulary

-Marine Protected Area (MPA): MPAs are areas in or near the ocean made to protect or conserve marine life and habitat, safeguard cultural sites, and provide enhanced recreational opportunities.

-Take: To hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill any natural resources.

-Community (or citizen) Science: The collection and/or analysis of scientific data by everyday people.

-Marine Debris: Human-created waste that has deliberately or accidentally been released in a lake, sea, ocean, or waterway.

-Watershed: An area of land that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean.

-Main stem (watershed): the major river all the water drains into.

Our Place in the Watershed

Most people, including most or all of your students depending on your school, live far upstream from a sandy shore. Far too often there is a disconnect between what one does upstream and the impact it has in the ocean. This lesson will explore the idea that all watersheds lead to the ocean and create a connection between students, wherever they may be in the watershed, and the beach.

Watersheds in San Diego

San Diego County is home to eleven westward draining watersheds (see map in appendix for full list). Most of these empty to the ocean adjacent to a sandy shore. Three San Diego County watersheds end in an MPA:

-Carlsbad Watershed: Swami's State Marine Conservation Area (Cardiff State Beach)

-Peñasquitos: Matlahuayl State Marine Reserve (La Jolla Shores)

-Tijuana Watershed: Tijuana River Mouth State Marine Conservation Area

Activity: Map Your Watershed

1) Pull up a map of your local watershed.

2) Have students identify where their school is located within the watershed.

3) Have students identify the parts of their watershed: the main stem, tributaries, headwaters, and mouth (make sure to point out any sandy shores located around the mouth).

a. **Main stem**: the major river all the water drains into

b. **Tributaries**: smaller rivers that flow into a larger river

c. **Headwaters**: the beginning of the river

d. **Mouth**: where it empties into the ocean, often surrounded by sandy shores (beaches)

4) Ask students: Is our school located in the headwaters, along the main stem, along a tributary, at the mouth?

5) Have students identify the main human communities (i.e. cities) in the watershed.

6) Have students identify any MPAs within your watershed or into which

your watershed empties.

7) If your school is not located in the same watershed where you will be holding your cleanup, also have students map that watershed and make sure to identify the beach where you will be.

8) Ask students to think about the following questions: How might people affect the ecosystems and wildlife within the watershed? Sandy shores tend to accumulate trash more so than some other parts of the watershed – why might this be?

Activity: Watershed in a Pan

In this activity students will use science and engineering to design and construct a watershed model that effectively protects human communities while reducing pollution of the watershed and marine protected areas downstream. It is recommended that this activity take place outside where students may dig in the dirt. The Carlsbad Watershed will be used in the example below.

9) Divide students into research teams of approximately four people. They will stay in these teams for the remainder of the lesson.

10) Each group will need:

a. One paint tray (preferably metal and reusable)
b. Enough sponges or scraps of towel to fill width of paint tray
c. Monopoly houses (3-10 per group usually works well)
d. Water
e. Natural materials such as dirt, rocks, sticks, leaves
f. Plastic, paper, and other tiny scraps to simulate litter
g. Vegetable oil to simulate motor oil
h. Food coloring to represent other pollution

11) In the classroom explain the following:

a. Each research group will be building a model of their watershed. The model should be of the watershed which includes the sandy beach where you will do your clean up.

b. The deep end of the paint tray, where the paint would normally go, represents the MPA. For the Carlsbad Watershed this would represent Swami's State Marine Reserve.

c. The sponges or scraps of towel will be used to separate the paint well (the MPA) from the rest of the tray. This represents the wetland separating the rest of the watershed from the ocean. In the Carlsbad Watershed this is the San Elijo Lagoon State Marine Conservation Area (also an MPA!).

d. Once outside students will use natural materials (i.e. dirt, rocks, sticks, leaves) to fill in the remaining part of their paint tray. Students must also place at least three houses in their watershed. They may place more if desired. Have each research team discuss a strategy and draw out a plan before leaving the classroom

12) Take students into the field. Give them boundaries and instructions on which plants not to pick and then tell them to begin building their watersheds. This typically takes about 20 minutes for the first round.

13) Once teams finish building their watershed models call them all

- *Tributaries (watershed)*: smaller rivers that flow into a larger river.
- *Headwaters (watershed)*: the beginning of the river.
- *Mouth (watershed)*: where it empties into the ocean, often surrounded by sandy shores (beaches).

California Department of Fish and Wildlife Key Messages:

-MPAs protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.
-MPAs help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.
-MPAs improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and manage

together and complete the following:

a. Fill the paint well with enough water to get the sponges/towels just a little wet. Remind them that this represents the wetland and MPA.

b. Ask students if humans put anything in to the environment. If so, what? (Common answers, trash/litter, pollution, etc.)

c. Tell students you will be representing pollution using scraps of paper and plastic for litter, vegetable oil for motor oil, and food dye for other pollution. Have students sprinkle the paper and plastic scraps around the houses. Pour about one capful of vegetable oil around the houses. Place five drops of food dye in front of each house. Note: you can add more types of pollution if you wish. Examples include chocolate sprinkles for dog poop, coffee grounds for top soil, etc.

d. Make it rain! Using a watering can (or bottles of water) pour water along the topmost part

of the watershed model. Pour in just enough that the water saturates the soil and runs through the watershed, but not enough to completely submerge everything in the model.

e. Have students evaluate how their model did. Did all the houses survive? Did any of the pollution make it to the wetland? The ocean? Where did each type of pollution accumulate? Did what happened upstream impact the sandy shore? How so? Did what happened upstream impact the MPA(s)? How so?

Suggested procedure:

Teacher Prep

1) Read pages 26-29 of Ocean Conservancy and NOAA Marine Debris' Talking Trash and Taking Action Instructor's Guide.

2) Gather clean up materials

   a. Trash bag or bucket (one per group)
   b. Gloves (two per person)
   c. Trash pickers (if available)
   d. Clipboard (one per group)
   e. Talking Trash data sheet (one per group)
   f. Pen or pencil

3) It is recommended that you visit the site ahead of time to determine meeting locations, boundaries, and meet with lifeguards to discuss clean up plan if possible.

Student Prep

1) In class go over MPAs,….to be filled in from field guide once it's done

Field Trip *(recommended 1.5-2 hours in the field)*

1) This activity could take place at any beach open to the public. We recommend Cardiff State Beach within the Swami's State Marine Conservation Area.

2) For this activity students will be working in their small research teams from the previous activity.

these uses in a manner consistent with protecting biodiversity.
-MPAs protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic values.

Connections:
Art, science, engineering

Ocean Literacy Connection:
-The ocean supports a great diversity of life and ecosystems.
-The ocean and humans are inextricably interconnected.

Suggested extensions:
-Omit the field trip portion and substitute a clean up of a more local waterway (i.e. riverbank, lake or reservoir) or even a cleanup in your own schoolyard. If doing a cleanup in the schoolyard note proximity to any drains

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3) Go over safety items:
   a. Boundaries
   b. Meeting spot for emergencies (make sure to leave a chaperone at the meeting spot at all times) and at end of project
   c. End time
   d. Stay in groups
   e. Wear gloves
   f. Do not touch sharp or hazardous material; alert adult of dangerous item(s)
   g. Always watch the tide
4) Give each team:
   a. Trash bag or bucket (one per group)
   b. Gloves (two per person)
   c. Trash pickers (if available)
   d. Clipboard (one per group)
   e. Talking Trash data sheet (one per group)
   f. Pen or pencil
5) Take a before photo of your group and the beach!
6) Give students instructions for clean up
   a. Follow all safety instructions
   b. Pick up any trash and debris, record it on the data sheet (instruct students to use tick marks, words like “lots” and “many” are not useful for analysis), and put it in the bag (make sure to wear gloves whenever handling trash!)
   c. Take pictures of interesting finds!
   d. Record any animals you see on the back of the datasheet. Note if they are interacting with the marine debris in any way.
   e. Return full bags to the meeting spot.
   f. At the designated stop time collect all bags and weigh them if possible. Fish scales work well for this, if you do not have a fish scale assume 15lb per standard trash bag.
   g. Collect all data sheets. Make sure students record how many people worked on each sheet.
   h. Take an after picture with students, all their trash, and the clean beach!
   i. E-mail completed data sheets to cleanup@oceanconservancy.org

More instructions and tips may be found on pages 26-29 of Ocean Conservancy and NOAA Marine Debris’ Talking Trash and Taking Action Instructor’s Guide.

Supplemental resources for Talking Trash and Taking Action may be found at: https://oceanconservancy.org/trash-free-seas/outreach-education/

and discuss where drains go. Data analysis may be done of the data students collect, just make sure to tie it in to the sandy shore by asking questions such as “If we had not picked this up, where might it have ended up?” “Is it possible that the items you found would have ü ended up at the beach?”
-Have students collect trash from two sites (i.e. near river mouth away from river mouth, high tide line vs water’s edge, etc.) and compare quantity and origin of trash between sites.
-Create an Excel file with your findings and complete Parts 2 and 3 of this lesson plan on a computer.
-Mix and match the six lessons and various activities in Life in the Sand: Field Guide to Sandy Shores to meet classroom needs.
-Allow students to conduct a separate inquiry project using the datasets they produce.

PART 2: Data Analysis

(recommended two 50-minute class periods)

Categories of Trash

1) Compile data from all sheets to create a master list of debris found.
2) In small groups have students go over the data and look for ways to categorize where the trash likely came from. For example, beach/shoreline recreation, ocean/waterway activities, smoking-related activities, etc.
3) Come back together as a class and write the students' suggestions on the board. Look for commonalities and discuss to decide on a master list of categories. Any items that do not fit into a logical category may be placed in a category called "Other."
4) Next, have students calculate the percentage of trash that came from each of the categories upon which the group decided. Create a pie chart of this data.

Mean, Median, and Mode

1) Now that we know which proportion of trash is coming from where, it is helpful to know how much trash each category accounts for. We figure this out by calculating the mean, median, and mode for each of the categories.
2) Teacher's choice: Have students calculate the mean, median, and mode for how many pieces of trash were found for each category. You could have each research team do this for their own datasheet or have the class do it together off the master list of debris.
3) Ask students which is more important: the number of items found, the type of debris (i.e. plastic, paper, Styrofoam, etc), the weight?
4) As a fun addition, students may look up the approximate weight of each item to calculate how many pounds they found for each category.

PART 3: Drawing Conclusions

(recommended one to two 50-minute class periods; adapted from 5Gyres Institute Plastic Site Sampling Curriculum)

Class Discussion

Have each research group discuss the following:

1) What do your findings tell us?
a. How did these items get here?
b. Why were they made and what will happen to them?
c. What are potential sources for the items that you found?
d. Were the items found from packaging and do you think this packaging was necessary?
e. What other questions, thoughts, or ideas come up for you?
2) What story do your findings tell? Draw your story on butcher paper and share with the class.
3) What organisms did you observe during your clean up? What were their adaptations for living at a sandy shore?
4) Evidence suggests that MPAs may increase biodiversity and abundance by giving species a safe place to live, grow, and reproduce; however, this

success is threatened by other activities such as marine debris. What are some complementary solutions that may be enacted to help reduce or eliminate the threat of marine debris/pollution to MPAs?

Activity

Distribute a copy of the Protecting Sandy Shores Solutions Worksheet (see appendix) to each student. Have them evaluate how feasible and effective each of the solutions are for protecting sandy shores, especially those in marine protected areas, from pollution. Consider factors such as how well the solution helps prevent the problem, human behavior changes needed, and monetary costs. After evaluating the benefits and the challenges rank the following solutions from least to most effective (8 = least effective and 1 = most effective). You may add solutions if you wish. Be prepared to share your ranking with your class.

Engage: Map your watershed and build a model before heading out into the field.
Explore: Conduct a beach clean up at a local sandy shore.
Explain: Explain possible sources of trash and how we use math to categorize it.
Elaborate: Have students calculate the proportions and averages of where the trash came from.
Evaluate: Ask the students questions relating to what they have learned (more questions may be found in Part 3 of this lesson plan).
Q1: What do your finding tell us?
Q2: What story/stories do your findings tell?
Q3: What organisms did you find at the sandy shore? What were some of their adaptations for living there?
Q4: What are some complementary solutions that may be enacted to help protect MPAs from marine debris/trash?

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NGSS Alignment

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying times and spatial scales.
MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.
MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Science and Engineering Practices

Asking Questions: Ask questions that arise from examining models or a theory to clarify and/or seek additional information to determine relationships, including quantitative relationships between independent and dependent variables, and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the sustainability of a design.
Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution, apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data, and evaluate the impact of new data on a working explanation and/or model.
Using Mathematics and Computational Thinking: Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Engaging in Argument from Evidence: Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence and make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge.

Crosscutting Concepts

Systems and system models: Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.

Online Resources

Watersheds of San Diego County:
https://www.sandiegocounty.gov/content/sdc/dpw/watersheds/Watersheds.html
Supplemental resources for Talking Trash and Taking Action may be found at:
https://oceanconservancy.org/trash-free-seas/outreach-education/

Appendices

See next page

Talking Trash & Taking Action
Cleanup Data Form

Dear Marine Debris Explorers,

Today you are a scientist! As a scientist, collecting data is very important. Data help answer questions, develop solutions and inform future actions. The data you collect today will not only tell a story of what items you are finding locally. They will also be compiled with data from around the world to create a global picture of the marine debris problem.

Here's how to collect great data:

1 GROUP UP

Working in pairs or small groups makes collecting data safe and simple; switch off collecting trash and recording data.

2 GRAB A DATA FORM

Each group needs a data form and pen/pencil before heading out to cleanup

3 TICK & TOTAL

Make tick marks next to the corresponding items as trash is collected. Words like "lots" aren't helpful. Total each item's tick marks at the end of the Cleanup

4 GIVE IT LOCAL FLAIR

Fill out the local information below: Where are you? How many scientists joined you? How far did you go? How much do your finds weigh?

Cleanup Site Information:

Site Name:

Nearest Crossroad or Landmark:

County:

State:

Country:

Miles Cleaned (check one): ☐ 1/4 ☐ 1/2 ☐ 3/4 ☐ 1 Other: ____

Total Weight of Trash Collected: ____ lbs.

Site Type (check one of the boxes): ☐ Inland (no water) ☐ Freshwater (river, lake) ☐ Saltwater (beach, estuary)

Number of Scientists Working on This Card: ____ Scientists (Youth) ____ Senior Scientists (Adults)

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Talking Trash & Taking Action
Cleanup Data Form

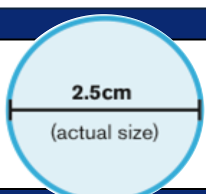
MOST LIKELY TO FIND ITEMS:

Cigarette Butts:	=	Beverage Bottles (Plastic)	=
Food Wrappers (candy, chips, etc.):	=	Beverage Bottles (Glass):	=
Take Out/Away Containers (Plastic):	=	Beverage Cans:	=
Take Out/Away Containers (Foam):	=	Grocery Bags (Plastic):	=
Bottle Caps (Plastic):	=	Other Plastic Bags:	=
Bottle Caps (Metal):	=	Paper Bags:	=
Lids (Plastic):	=	Cups & Plates (Paper):	=
Straws/Stirrers:	=	Cups & Plates (Plastic):	=
Forks, Knives, Spoons:	=	Cups & Plates (Foam):	=

FISHING GEAR:		PACKAGING MATERIALS:	
Fishing Line (1 yard/meter = 1 piece):	=	Other Plastic/Foam Packaging:	=
Rope (1 yard/meter = 1 piece):	=	Other Plastic Bottles (milk, bleach, etc.):	=

OTHER TRASH:		CRAZY FINDS:
Balloons:	=	Crazy Item 1:____________________
Clothing & Towels:	=	Crazy Item 2:____________________
Toys:	=	Crazy Item 3:____________________

TINY TRASH LESS THAN 2.5CM:



Foam Pieces	=
Glass Pieces	=
Plastic Pieces	=

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Protecting Sandy Shores Solutions Worksheet

Evaluate how feasible and effective each of the solutions are for protecting sandy shores, especially those in marine protected areas, from pollution. Consider factors such as how well the solution helps prevent the problem, human behavior changes needed, and monetary costs. After evaluating the benefits and the challenges rank the following solutions from least to most effective *(8 = least effective and 1 = most effective)*. You may add solutions if you wish.

Solution	Benefits	Challenges	Ranking
Trash Clean Ups			
Recycling			
Circular Economy How can products be produced with their end-of-life in mind? (Designing products so they can be infinitely reused, with little or no waste created)			
Incineration Burning trash.			
Extended Producer Responsibility Making the manufacturers of products responsible for the waste created by them (i.e. producer needs to have a plan for how to dispose of or re-use a product before creating it).			
Bioplastics A type of biodegradable plastic made from plants and/or microorganisms rather than from petroleum (often difficult to compost or recycle).			
Grassroots movements Community members or school groups raising awareness and impacting policy changes.			
Policy Change Enacting policies at the local, state, or federal level.			