WAVE OF PLASTIC

STUDENT INQUIRY OF PLASTIC WASTE AND ITS IMPACTS ON MARINE ECOSYSTEMS

A Meaningful Watershed Educational Experience

Grades 6-8

Through a series of five lessons, Wave of Plastic helps students make sense of the core ideas related to issues of plastic pollution (particularly those relevant to the Chesapeake Bay and its watershed) by engaging in authentic disciplinary practice culminating in comprehensive, student-driven, informed action projects.

This unit has been designed to support Next Generation Science Standards, Maryland Environmental Literacy Standards, Maryland Service-Learning Graduation Requirements, and the Student Outcome of the Environmental Literacy Goal of the 2014 Chesapeake Bay Watershed Agreement (Meaningful Watershed Educational Experiences).

Wave of Plastic represents a partnership between the University of Maryland Center for Environmental Science, and Calvert and St. Mary's County Public Schools. Funding support was provided by the NOAA Bay Watershed Education and Training (B-WET).

University of Maryland Center for Environmental Science

Calvert County Public Schools

St. Mary's County Public Schools

NOAA Chesapeake Bay

Wave of Plastic Leadership Team at University of Maryland Center for Environmental Science (UMCES):
Helen Bailey, PhD • Nicole Barbour • Sarah Brzezinski • Amy E. Green, PhD • Michael Gonsior, PhD
Jenna B. Linhart • Carys Mitchelmore, PhD • Cat Stylinski, PhD • Jamie Testa

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Setting the Context for Learning: Phenomena of Plastic Pollution & Marine Debris

Over the last several decades, plastics have come to dominate daily life. Their versatility, durability, and low production costs have made them a favored material for a wide variety of manufactured goods from eating utensils to medical equipment.

Some of the features that lead to the proliferation of plastics in everyday items also make them amongst the most ubiquitous environmental contaminants in the world today.

Every citizen can make a difference by making choices that reduce the use of plastics and its entry into our oceans.

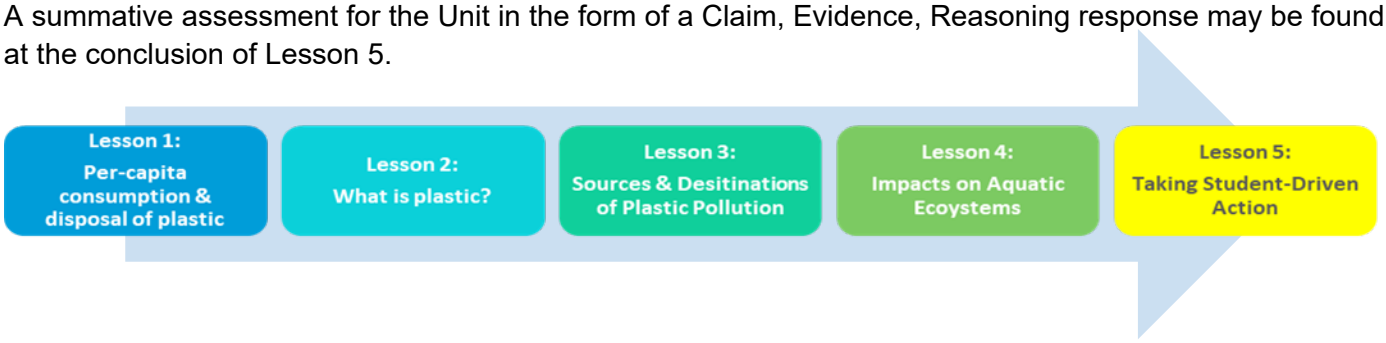
Wave of Plastic: Curricular Connections

The Wave of Plastic unit has been designed to meet Middle School NGSS Performance Expectations that are part of the scope of the curriculum for grades six (St. Mary's County Public Schools, MD) and eight (Calvert County Public Schools, MD). The lessons have been carefully developed to meet the needs of a broad range of grade level-appropriate and diverse learning needs.

Wave of Plastic helps students make sense of the core ideas related to issues of plastic pollution by engaging in authentic disciplinary practice culminating in comprehensive, student-driven, informed action projects.

In order to maximize the learning benefits for students, it is recommended that all five lessons in the unit be taught in sequence (note that some activities may extend across more than one lesson). If the unit must be abridged, it is recommended that Lessons 1, 3, and 5 be taught in order to continue to meet the requirements of the Next Generation Science Standards, the Maryland Service Learning and Environmental Literacy standards, and the Meaningful Watershed Educational Experience requirements of the Chesapeake Bay Watershed Agreement (see arrow figure below).

A summative assessment for the Unit in the form of a Claim, Evidence, Reasoning response may be found at the conclusion of Lesson 5.



Meaningful Watershed Educational Experiences (MWEEs) represent rigorous, student-centered, inquiry-based approaches to instruction designed to support student environmental literacy and stewardship.

MWEEs represent the Student Outcome of the Environmental Literacy Goal of the 2014 Chesapeake Bay Watershed Agreement, which commits school districts to support regional conservation and restoration efforts through high-quality environmental education. For more information, visit: www.BayBackpack.com.

Supporting Maryland State Department of Education (MSDE) Standards & Graduation Requirements

Next Generation Science Standards (NGSS)

Together, the 5 Wave of Plastic lessons support students' understanding of the Disciplinary Core Ideas, Scientific & Engineering Practices, and Crosscutting Concepts of the following Performance Expectations:

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.
★ Note: All lessons provide learning experiences in support of this Performance Expectation. The final CER assessment (at the conclusion of Lesson 5) addresses it in full.

MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
★ Note: This performance expectation is supported by Lesson 2.

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
★ Note: All lessons provide learning experiences in support of this Performance Expectation. The Student Action Project Summary assessment (at the conclusion of Lesson 5) addresses it in full.

MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
★ Note: This performance expectation is supported by Lesson 4.

Maryland Environmental Literacy Standards

Wave of Plastic supports student mastery of the following Maryland Environmental Literacy Standards:

Standard 1- Environmental Issues
Standard 5- Humans and Natural Resources
Standard 7- Environment and Society
Standard 8- Sustainability

Maryland Student Service Learning:

The Wave of Plastic Unit has been designed to meet all 7 Best Practices of Service-Learning in Maryland:

1. Meet a recognized need in the community.
2. Achieve curricular objectives through service-learning.
3. Reflect throughout the service-learning experience.
4. Develop student responsibility.
5. Establish community partnerships.
6. Plan ahead for service-learning.
7. Equip students with knowledge and skills needed for service.

Wave of Plastic Unit Standards-based Alignment

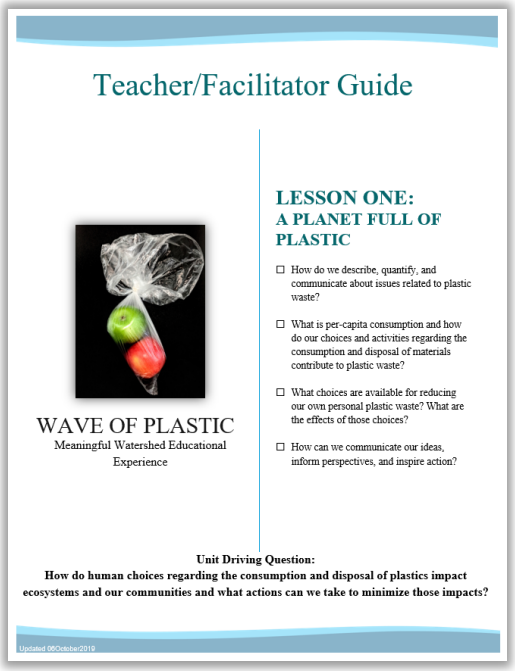
Lesson	NGSS Performance Expectations	Title	MWEE Elements	Maryland Environmental Literacy Standards
1.	☑ MS-ESS3-4 ☐ MS-PS1-3 ☐ MS-LS2-4 ☐ MS-ESS3-3	**A Planet Full of Plastic:** **Per-Capita Consumption & Disposal**	☑ Issue Definition ☑ Synthesis & Conclusions ☐Outdoor Field Experiences ☑ Student Action Projects	☑ Standard 1 – Environmental Issue (Investigation & Action) ☑ Standard 5 – Humans & Natural Resources ☑ Standard 7 – Environment & Society ☑ Standard 8 – Sustainability
2.	☑ MS-ESS3-4 ☑ MS-PS1-3 ☐ MS-LS2-4 ☐ MS-ESS3-3	**What is Plastic?**	☑ Issue Definition ☑ Synthesis & Conclusions ☐Outdoor Field Experiences ☑ Student Action Projects	
3.	☑ MS-ESS3-4 ☐ MS-PS1 ☐ MS-LS2-4 ☐ MS-ESS3-3	**From Hand, to Land, to Sea:** **Sources & Destinations of Plastic Pollution**	☑ Issue Definition ☑ Synthesis & Conclusions ☑Outdoor Field Experiences ☑ Student Action Projects	
4.	☑ MS-ESS3-4 ☐ MS-PS1-3 ☑ MS-LS2-4 ☑ MS-ESS3-3	**Impacts on Aquatic Ecosystems**	☑ Issue Definition ☑ Synthesis & Conclusions ☐Outdoor Field Experiences ☑ Student Action Projects	
5.	☑ MS-ESS3-4 ☐ MS-PS1-3 ☐ MS-LS2-4 ☑ MS-ESS3-3	**We Can Make a Difference:** **Minimizing the Effects of Plastic Waste**	☑ Issue Definition ☑ Synthesis & Conclusions ☐Outdoor Field Experiences ☑ Student Action Projects	

GUIDE TO READING THE LESSONS

Each lesson in the *Wave of Plastic* unit consists of four parts:

1. **Introduction:**
   - Students explore resources and engage in discussion to help build the foundational understandings that will support the lesson.
2. **Investigation:**
   - Students explore resources, engage in discussion, participate in investigations and activities in order to make sense of Core Ideas, Crosscutting Concepts, and Practices.
3. **Application:**
   - Students apply the understandings that they've constructed throughout the current and previous Wave of Plastic lessons through collaborative, informed actions designed to address aspects of problems related to plastic waste.
4. **Assessment:**
   - Students complete a constructed response based on the Claim, Evidence, Reasoning (CER) model to demonstrate their understandings of the NGSS core ideas, crosscutting concepts, and practices as a result of their participation in the lesson. A scoring rubric is included in each Teacher/Facilitator Guide as well as in the Student Workbooks, however teachers are invited to use the scoring system that best meets the needs of their students, school, and district.

*Each lesson begins with the NGSS Performance Expectations, the *Key Ideas* that are most relevant for the lesson, and a chart that describes each of the four parts of the lesson and lists the activities in which students will engage.


Teacher/Facilitator Guide

WAVE OF PLASTIC
Meaningful Watershed Educational Experience

LESSON ONE:
A PLANET FULL OF PLASTIC

- ☐ How do we describe, quantify, and communicate about issues related to plastic waste?
- ☐ What is per-capita consumption and how do our choices and activities regarding the consumption and disposal of materials contribute to plastic waste?
- ☐ What choices are available for reducing our own personal plastic waste? What are the effects of those choices?
- ☐ How can we communicate our ideas, inform perspectives, and inspire action?

Unit Driving Question:
How do human choices regarding the consumption and disposal of plastics impact ecosystems and our communities and what actions can we take to minimize those impacts?

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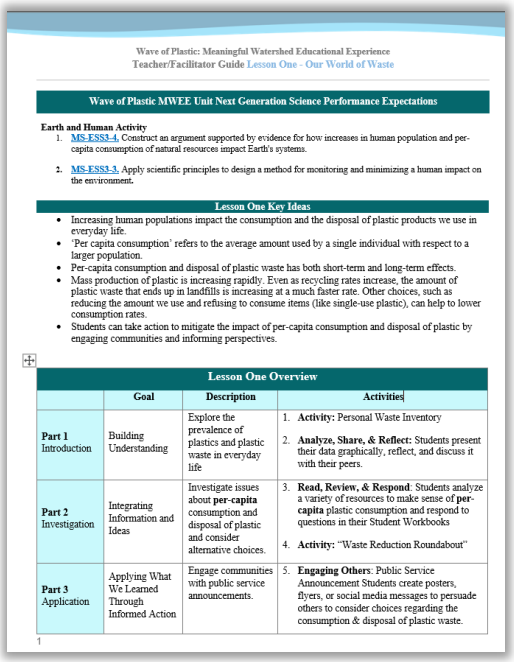
Wave of Plastic: Meaningful Watershed Educational Experience
Teacher/Facilitator Guide Lesson One - Our World of Waste

Wave of Plastic MWEE Unit Next Generation Science Performance Expectations

Earth and Human Activity

1. 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.
2. MS-ESS3-3, Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Lesson One Key Ideas

- Increasing human populations impact the consumption and the disposal of plastic products we use in everyday life.
- 'Per capita consumption' refers to the average amount used by a single individual with respect to a larger population.
- Per-capita consumption and disposal of plastic waste has both short-term and long-term effects.
- Mass production of plastic is increasing rapidly. Even as recycling rates increase, the amount of plastic waste that ends up in landfills is increasing at a much faster rate. Other choices, such as reducing the amount we use and refusing to consume items (like single-use plastic), can help to lower consumption rates.
- Students can take action to mitigate the impact of per-capita consumption and disposal of plastic by engaging communities and informing perspectives.

Lesson One Overview

	Goal	Description	Activities
Part 1 Introduction	Building Understanding	Explore the prevalence of plastics and plastic waste in everyday life	1. **Activity:** Personal Waste Inventory 2. **Analyze, Share, & Reflect:** Students present their data graphically, reflect, and discuss it with their peers.
Part 2 Investigation	Integrating Information and Ideas	Investigate issues about **per-capita** consumption and disposal of plastic and consider alternative choices.	3. **Read, Review, & Respond**: Students analyze a variety of resources to make sense of **per-capita** plastic consumption and respond to questions in their Student Workbooks 4. **Activity:** "Waste Reduction Roundabout"
Part 3 Application	Applying What We Learned Through Informed Action	Engage communities with public service announcements.	5. **Engaging Others**: Public Service Announcement Students create posters, flyers, or social media messages to persuade others to consider choices regarding the consumption & disposal of plastic waste.

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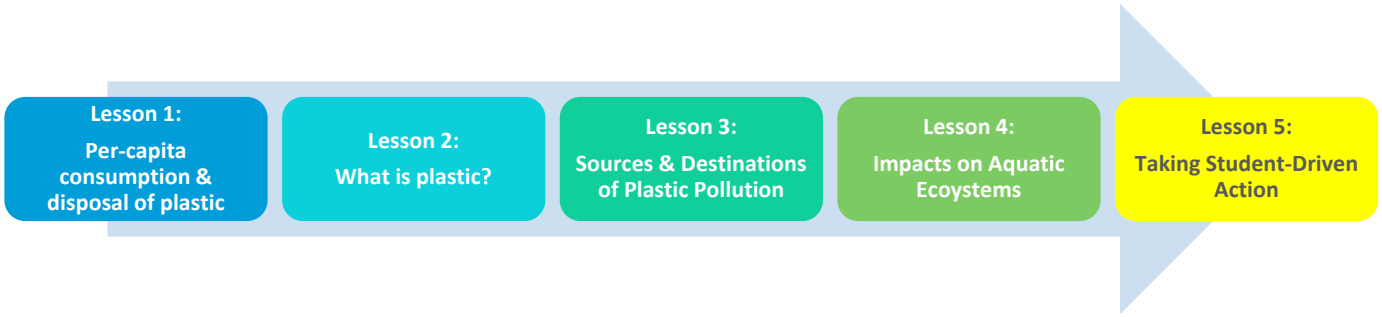
Wave of Plastic – Unit Overview

Lesson	Key Ideas	Lesson Components	
1. A Planet Full of Plastic	• Increasing human populations impact the consumption and the disposal of plastic products we use in everyday life. • 'Per capita consumption' refers to the average amount used by a single individual with respect to a larger population. • Mass production of plastic is increasing rapidly. Even as recycling rates increase, the amount of plastic waste that ends up in landfills is increasing at a much faster rate. • Students can take action to mitigate the impact of per-capita consumption and disposal of plastic by engaging communities and informing perspectives.	**Introduction**	1. **Personal Waste Inventory** 2. **Analyze, Share, & Reflect**
		Investigation	3. **Read, Review, & Respond** 4. **Activity**: "Waste Reduction Roundabout"
		Application	5. Engaging Others: Public Service Announcement
		Assessment	6. **CER**
2. What is Plastic?	• Plastic is a synthetic, human-made material derived from resources found in nature. • Plastic has many properties that make it a favored material for the manufacture of a wide variety of everyday items. • Items made from plastic may be easily broken *up* into smaller pieces but not easily broken *down* by decomposers. Thus, plastic remains and accumulates in the environment. • There are many factors that influence the individual choices that people make when it comes to using plastic. We can survey our communities to understand these choices and inspire behavior change.	**Introduction**	1. **Read, Review, & Respond**
		Investigation	2. **Read, Review, & Respond** 3. **Activity**: "Make Our Own Bio-Plastics" 4. **(OPTIONAL) Activity**: "What Happens to Our Waste" 5. **Analyze, Share, & Reflect**: Updating Our Personal Waste Inventories.
		Application	6. **Engaging Others:** Community Survey
		Assessment	7. **CER**
3. From Hand, to Land, to Sea:	• Human-caused pollution plays causal roles in changing Earth's systems. • Pollution refers to any substance or energy that is foreign to an environment and/or is present in quantities that cause harm to natural systems. • There are many properties of plastic that allow it to be easily transported by wind and rain runoff across land and into waterways, where it becomes pollution. • Plastic pollution harms living things and is accumulating in the environment because of increases in per-capita consumption and because plastic persists for very long periods of time. • Sharing information visually, such as through infographics, can be an effective way to inspire behavior change.	**Introduction**	1. **Read, Review, & Respond**
		Investigation	2. **Activity:** "Plastic Waste Sort!" 3. **Read, Review, & Respond** 4. **Outdoor Field Experience**- Runoff on School Grounds 5. **Outdoor Field Experience**- School Yard Plastic Pollution Survey 6. **(OPTIONAL) Outdoor Field Experience:** "Neighborhood Plastic Pollution Survey
		Application	7. **Engaging Others**: Community Infographic
		Assessment	8. **CER**
4. Impacts on Aquatic Ecosystems	• An ecosystem is a biological community of interacting organisms and their physical environment. • Disruptions to any physical or biological component of an ecosystem can have effects and outcomes and can lead to shifts in all populations of organisms within that ecosystems. • Plastic pollution can affect individuals and populations of animals within aquatic ecosystems.	**Introduction**	1. **Read, Review, & Respond**
		Investigation	2. **Read, Review, & Respond** 3. **Activity:** "You Are What You Eat!"
		Application	4. **Engaging Others**: Personal Pledge: "I Make a Difference!"
		Assessment	5. **CER**
5. We Can Make a Difference:	• "Stewardship" refers to the responsible use and conservation of the natural environment. • Students are critical stakeholders for supporting ecosystem resiliency and stability displaying behavior that consciously seeks to minimize the negative impacts of plastic pollution on Earth's systems. • There are many ways that students can take individual and collective action to mitigate the impacts of plastic waste.	**Introduction**	1. **Analyze, Share, Reflect** 2. **Activity:** "Preparing to Take Action"
		Investigation & Application	3. **Plan, Implement, and Evaluate Action**
		Assessment	4. **Student Action Plan Summary** (MS-ESS3-3). 5. **CER** (MS-ESS3-4).

Getting Started: An Introduction to the *Wave of Plastic* Unit

Wave of Plastic: Lesson & Topic Sequence



Throughout the course of the *Wave of Plastic* Unit, students will engage in authentic disciplinary practice as they make sense of the science ideas behind issues of plastic consumption and the disposal of plastic waste.

Teachers are encouraged to use the trailer, clips, or full version of the Documentary, ***A Plastic Ocean***, to introduce the unit and engage students in the topic.

Released in 2017*, A Plastic Ocean* is a feature length documentary made possible by a group of dedicated scientists, film-makers, social entrepreneurs, scholars, environmentalists and journalists and features Dr. Michael Gonsior, an analytical/environmental chemist with the University of Maryland Center for Environmental Science. The film explores the fragile state of our oceans and examines some of the consequences of society's increasing use and disposal of plastic.

The trailer may be found at http://www.aplasticocean.movie/ . For information about using the video clips and/or the full film, contact your school district science curriculum office.

After viewing the trailer, teachers are encouraged to share the lesson and topic sequence of the Wave of Plastic Unit. The unit culminates in student-driven action projects and teachers may find it productive to keep a running class list of potential ideas for the projects from the beginning of the unit.

Acknowledgements	
The Wave of Plastic Team would like to thank the following people for their contributions to the development, pilot, and implementation of this unit:	
Calvert County Public Schools	**St. Mary's County Public Schools**
Janel McPhillips, Supervisor of Science	**Jason Hayes, Supervisor of Science**
Alan Cook Chelsea Gallihugh Kristin Skiados Sarah Legge Carol Bosarge Elizabeth Megonigal	Andrea Kuehne Lee Musolino Mary Beth Hamm Amber Keesee Kari Koch Nennah Byle

Thank you for your commitment to learning, environmental literacy, stewardship, and conservation!

Teacher/Facilitator Guide

WAVE OF PLASTIC

Meaningful Watershed Educational Experience

LESSON ONE:
A PLANET FULL OF PLASTIC

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Unit Driving Question:

How do human choices regarding the consumption and disposal of plastics impact ecosystems and our communities and what actions can we take to minimize those impacts?

Wave of Plastic MWEE Unit Next Generation Science Performance Expectations

Earth and Human Activity

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Lesson One Key Ideas

- Increasing human populations impact the consumption and the disposal of plastic products we use in everyday life.
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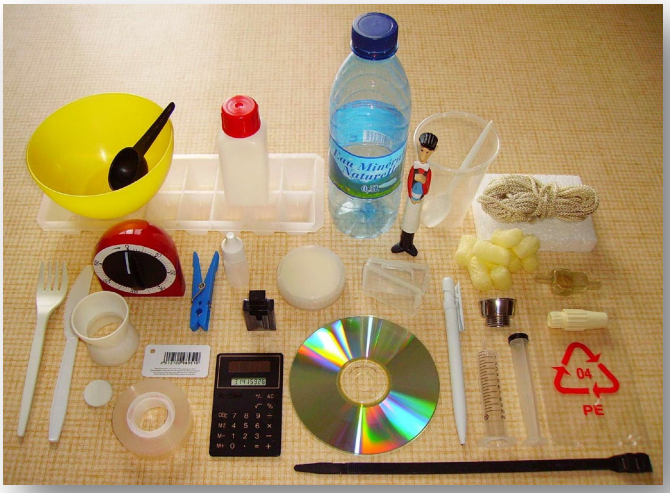
Part 3 Application	Applying What We Learned Through Informed Action	Engage communities with public service announcements.	5. **Engaging Others**: Public Service Announcement Students create posters, flyers, or social media messages to persuade others to consider choices regarding the consumption & disposal of plastic waste.

Part 4 Assessment	Demonstrating Our Understanding	Complete a constructed response using the *Claim, Evidence, Reasoning* model.	6. **Construct an argument supported by evidence:** Students describe the connections between the number of people in a society, the amount of plastic waste that they generate, and why it might be a problem.



Part 1- Introduction: Building Understanding

Objectives:

- We will ask questions and make observations about how our choices regarding the consumption and disposal of materials contribute to issues of plastic pollution.
- We will conduct inventories of the amount of waste we create in a given day.

1. Personal Waste Inventory

Students will:

☐ Collect an inventory of the waste they produce in one day *(suggested homework activity).*
☐ Respond to the *Personal Waste Inventory* questions in their Student Workbooks.

NOTE: You might find it productive to have students analyze and reflect on the **sample waste inventory that is provided in this lesson. Be sure to save the* Personal Waste Inventory *for a follow-up activity in Lesson 2.*

Whole Group Discussion Questions:

- Why do you think we are keeping track of the amount of trash we create?
- Use your prior experiences and what you know about cause and effect to predict the type of trash you think you and your classmates will produce the most.

Materials & Resources

- Lesson One: Student Workbook

2. Analyze, Share, & Reflect

Students will:

☐ Use the charts in their Student Workbooks to organize their waste data according to the type of material.
☐ Work with the teacher/facilitator to create a **class tally chart** to draw conclusions about how the amount of waste increases with the number of individuals.
☐ Present their data graphically, reflect, and discuss it with their peers.

**NOTE: You might choose to have students graph their own data, the class data, or both.*

☐ Students will reflect on the experience through whole-group discussion and written responses.

Whole Group Discussion Questions:

- *Review & Discuss the questions in the Student Workbook*

Materials & Resources

- *Optional*: Online graphing tools *(such as National Center for Educational Statistics' Create a Graph)*

SAMPLE Personal Waste Inventory

Name: Antonio **Day & Date:** Monday, April 13th, 2020

Items that I Discarded

Item	Why was it used?	From what type of material was it made?	What did I do with it when I was finished using it?	Notes
Chip bag	*food*	*Plastic and metal (foil)*	☑ Put it in a garbage bin ☐ Recycled it ☐ Reused it ☐ Composted it ☐ Other	
Soda can	food/snack	Metal	☐ Put it in a garbage bin ☑ Recycled it ☐ Reused it ☐ Composted it ☐ Other	I drank this in the school cafeteria and there was a recycling bin, so I put it the bin
Pudding cup	food/snack	Plastic	☑ Put it in a garbage bin ☐ Recycled it ☐ Reused it ☐ Composted it ☐ Other	I put it in the trash can because there wasn't a recycling bin nearby
Water bottle	food/drink	Plastic	☑ Put it in a garbage bin ☐ Recycled it ☐ Reused it ☐ Composted it ☐ Other	I drank this at basketball practice and there wasn't a recycling bin nearby, so I threw it in the trash can
Paper towel	food	paper	☑ Put it in a garbage bin ☐ Recycled it ☐ Reused it ☐ Composted it ☐ Other	
Old earbuds	fun/ entertainment	plastic and metal	☑ Put it in a garbage bin ☐ Recycled it ☐ Reused it ☐ Composted it ☐ Other	
Half of a sandwich	food	food	☑ Put it in a garbage bin ☐ Recycled it ☐ Reused it ☐ Composted it ☐ Other	
Straw	food/drink	plastic	☐Put it in a garbage bin ☐ Recycled it ☐ Reused it ☐ Composted it ☑ Other: **put it in my backpack**	
Cup	Food/drink	Styrofoam	☑ Put it in a garbage bin ☐ Recycled it ☐ Reused it ☐ Composted it ☐ Other	I don't know if I can recycle it
Total Number of Items: **9** ***Total Number of Plastic Items:*** **6**			***Number of Items I threw it in a garbage bin***: 8 ***Number of Items I recycled***: 2 ***Number of Items reused***: 0 ***Number of Items composted***: 0 ***Other***: 1	

Part 2- Investigation: Integrating Information & Ideas

Objectives:

- We will communicate scientific information and ideas about issues of plastic pollution orally, graphically, and textually.

3. Read, Review, & Respond

Students will:

- ☐ Analyze a variety of resources to make sense of per-capita plastic consumption
- ☐ Students will reflect on the experience through whole-group discussion and written responses

Whole Group Discussion Questions:

- *Review & Discuss the questions in the Student Workbook*

Materials & Resources

- **Online Article:** "Plastics: Material-Specific Data" (EPA)
  - Link: https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/plastics-material-specific-data
- **Website:** U.S. and World Population Clock. (US Census Bureau)
  - **Link:** https://www.census.gov/popclock/
- **Website:** Chesapeake Bay Program
  - **Link:** https://www.chesapeakebay.net/state/population
  Note: The website links to a spreadsheet that includes county population data over time.
- **Video:** "World Population" (populationeducation.org).
  - **Link:** https://populationeducation.org/curriculum-and-resources/world-population-video/
- **Web Map:** "Plastic Waste Generation Per Person 2010" (ourworldindata.org; University of Oxford).
  - **Link:** https://ourworldindata.org/grapher/plastic-waste-per-capita

4. Activity: "Waste Reduction Roundabout"

Students will:

- ☐ Explore alternative choices for the consumption and disposal of common plastic items through a musical-chairs inspired activity.

Whole Group Discussion Questions:

- Will each alternative waste reduction choice be appropriate for every item?
- What do these items have in common (besides that they are all made of plastic)?
- What are some short-term and long-term impacts these items could have on Earth's systems?
- How might changes in **per-capita** use of plastic items change these impacts?

Materials & Resources

- *Notecards or pieces of sturdy paper* (scrap paper will work too). Have at least one card for every student.
- *Marker or pen*
- A variety of *clean plastic waste.*

Activity: "Waste Reduction Roundabout"

Description: Students explore alternative choices for the consumption and disposal of common plastic items through an activity inspired by the game, 'musical chairs' Students will be prompted to critically, creatively, and collaboratively brainstorm and discuss choices for reducing plastic waste.

Materials:

- ☐ *Notecards or pieces of sturdy paper* (at least one card for every student)
- ☐ *Marker or pen*
- ☐ *A variety of clean plastic waste* (representing a variety of categories. For example, water bottles, plastic caps, plastic bags, food containers, to-go containers, to-go cups, plastic straws, food wrappers, product packaging, mailing packaging, etc.)

Prior to Beginning the Activity:

1. Divide the notecards into four piles. On one side of the card write either "***reduce***," "***reuse***," "***recycle,***" or "***refuse***," making sure that there are equal proportions of each. The other side of the card should be blank.
2. Spread the plastic waste around the classroom or other area with enough space for students to move around *(Note: this activity may also be done outside).*
3. Distribute the notecards around the room in proximity to the plastic waste items. This can be done randomly, or the facilitator can intentionally set certain "R" cards near certain items to create more challenging scenarios. Make sure that the blank side of the card is facing up.
4. Have music ready to play in the classroom. Alternatively, the lights of the classroom can be used to start and stop activity rounds instead of (or in addition to) music.

Procedures:

1. Explain that the mission is to explore alternative options to the plastic items in the room**.**
2. When the music is playing (or the lights are off), students should walk around the room. When the music stops (or lights come on), students should stop in place and pick up 1-2 plastic items and the nearest notecard. They should read the card to themselves and brainstorm ways that their item(s) could be recycled, re-used, reduced or refused depending the word written on their card. *(Note: this may be done individually, in pairs, or groups).*
3. Briefly engage students in discussions about the meaning of each choice for mitigating the harmful effects of plastic waste.
4. After everyone has had some time to privately brainstorm, allow a few students to share:
    a. The item
    b. The choice written on their card
    c. The alternative choices they brainstormed.
5. The activity may continue for several rounds.

Definitions

- **Reduce** - preventing something from becoming waste by reducing the need or use for it;
- **Refuse** - related to 'reduce', refusing to use items that you really don't need;
- **Reuse** – using an item again, delaying its entry into landfills, recycling centers, or ecosystems;
- **Recycle** - sending it to a facility where it may be converted back into reusable material;
- **Other ideas** – encourage students to discuss other choices (examples could include removing plastic waste from the environment, rallying others, redesigning products or lifestyle choices, etc.)

Facilitator Tips: To spark more engaging and thought-provoking discussion, once a student has shared their ideas, open the discussion for other students to contribute additional ideas, thought processes, etc. Additional questions for the group or individuals could include:

- *Does anyone else have ideas how this item could be 'r_____'?*
- *What if the card had been 'r____' instead?*
- *Are there any labels on the item to provide disposal instructions or other information?*
- *What purpose did this item have before it was trash?*
- *Do alternatives to this plastic item exist?*

Wrap-up and Making Connections:

The following are suggested discussion questions to conclude the activity:

- Will each alternative waste reduction choice be appropriate for every item?
- What do these items have in common (besides that they are all made of plastic)?
- Did you observe any trends while we discussed these options?
- What are some short-term and long-term impacts these items could have on Earth's systems?
- How might changes in *per-capita* use of plastic items change these impacts?

Extensions:

The plastic items used for this activity can also be collected by asking students to bring in a few items from their personal waste inventory. It is still recommended that the facilitator have some available to ensure that a variety of items are represented.

Part 3 – Application: Applying What We Learned Through Informed Action

Objectives:

- We will take action by engaging our communities with 'public service announcements' in the form of persuasive posters, flyers, or social media posts.

5. Engaging Others:

Students will:

☐ Create public service announcements in the form of posters, flyers, or social media messages to persuade others to consider choices regarding the consumption & disposal of plastic waste.

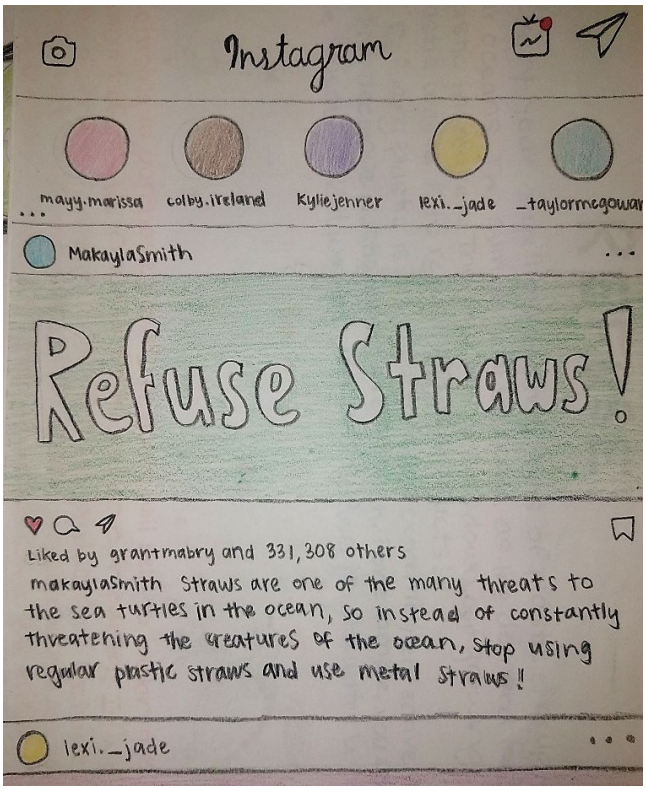
Whole Group Discussion Questions:

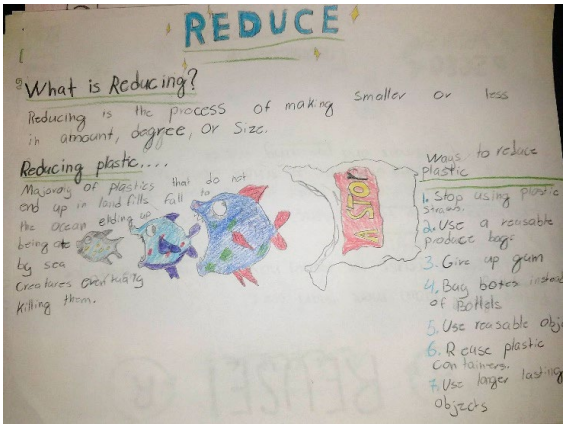
- Review the list of choices in your student workbook, do you agree with the order in which the choices are listed? (reduce, refuse, recycle, reuse, other). Why or why not? What changes would you make to the order of the choices?
- Specifically, why do you think the choice, 'recycling' was listed lower than some of the other choices?

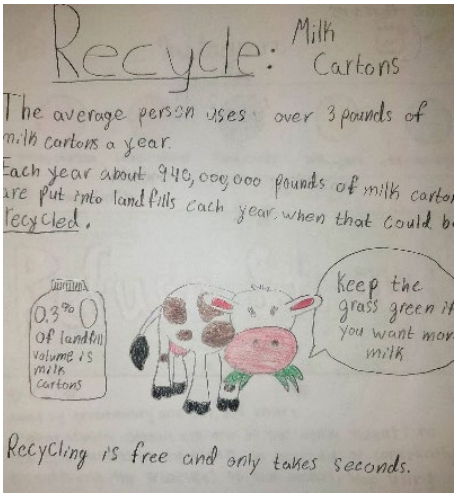
Materials & Resources

- *Optional*: Posters, paper, markers, art supplies, etc. for creating flyers and posters.

Sample Public Service Announcements:







Part 4- Assessment: Demonstrating Our Understandings

Objectives:

- Students will construct a convincing argument, supported with evidence, that supports or refutes claims for either explanations or solutions.
- Students describe a chain of reasoning that includes increases in the size of the human population, or the per-capita consumption of a given population cause increases in the consumption of resources, such as plastics.
- Students will describe choices and the impact of the disposal of plastics.

Claim/Evidence/Reasoning Writing Rubric				
	0	1	2	3
Claim – statement or conclusion that answers the original question/problem.	Does not make a claim.	Makes an inaccurate claim.	Makes an accurate but incomplete claim.	Makes an accurate and complete claim.
Evidence – scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence.	Only provides inappropriate evidence (Evidence that does not support the claim.).	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
Reasoning – justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence.	Does not provide reasoning	Only provides reasoning that does not link evidence to claim.	Repeats evidence and links it to some scientific principles, but not completely.	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles.

Use the Claim, Evidence, Reasoning model.

Construct an argument supported by evidence to describe the connections between the number of people in a society and the amount of plastic waste that they generate.

Teacher/Facilitator Guide

WAVE OF PLASTIC

Meaningful Watershed Educational Experience

LESSON TWO
WHAT IS PLASTIC?

- ☐ How do we describe, quantify, and communicate about the issue of plastic waste?
- ☐ What are some of the consequences of the manufacture, use, and disposal of plastic?
- ☐ What happens to plastic over time?
- ☐ What are some of the alternatives to plastic?
- ☐ What properties of plastic influence our everyday choices to use plastic?
- ☐ How can we communicate our ideas, inform perspectives, and inspire action?

Unit Driving Question:

How do human choices regarding the consumption and disposal of plastics impact ecosystems and our communities and what actions can we take to minimize those impacts?

Wave of Plastic MWEE Unit Next Generation Science Performance Expectations

Earth and Human Activity

- 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. Add evidence and clarification statements

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

Lesson 2: What is Plastic? Performance Expectation

Matter and its Interactions

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

Lesson Two Key Ideas

- Plastic is a synthetic, human-made material derived from natural resources (primarily "fossil fuels" like natural gas, oil, and petroleum).
- Plastic has many properties that make it a favored material for the manufacture of a wide variety of everyday items.
- Even though some of the ingredients to make the material for a plastic item may have been organic at one time, the manufacturing process changes the chemistry and structure so that the material becomes extremely difficult for decomposers to break apart. This means that items made from plastic may break *up* into smaller pieces but are not easily broken *down*. Thus, plastic remains and accumulates in the environment.
- There are many factors that influence the individual choices that people make for using plastic. We can survey our communities to understand these choices and inspire positive behavior change.

Lesson Two Overview

	Goal	Description	Activities
Part 1 Introduction	Building Understanding	Make sense of plastics as synthetic materials.	1. **Read, Review, & Respond**: Students will collect, organize, and synthesize information about the manufacture and properties of plastic.
Part 2 Investigation	Integrating Information and Ideas	Explore the properties of plastic that have positive and negative impacts on the environment and society.	2. **Read, Review, & Respond**: Students will read an article, "*Breaking Down Trash*," to make sense of what happens to waste over time and will respond to questions in their Student Workbooks. 3. **Activity: "Make Your Own Bio- Plastic."** Make plastics out of biodegradable substances. 4. **Analyze, Share, & Reflect: *Updating Our Personal Waste Inventories***. Students will return

			to their personal waste inventory to explore what happens to their waste over time. 5. **Activity: "What Happens to Our Waste?" OPTIONAL** Students investigate the degradability (including biodegradability) of a variety of waste materials over time.
Part 3 Application	Applying What We Learned Through Informed Action	Design and administer a 'plastic use' survey for the school community.	6. **Engaging Others**: Students will design and administer a survey for the school community to understand, inform, and influence people's choices regarding plastic use.
Part 4 Assessment	Demonstrating Our Understandings	Complete a constructed response using the *Claim, Evidence, Reasoning* model.	7. **Construct an argument supported by evidence:** Students describe what makes plastic a synthetic material, and how the properties of plastics impact society.

Part 1- Introduction: Building Understanding

Objectives:

- We will obtain, evaluate, and communicate information about the materials used to make plastics, how plastics are made, the changes that plastics undergo as they are used and discarded, and why the manufacture, use, and disposal of plastic can be problematic.

Supporting Questions:

- How do we describe, define, quantify, and communicate the issue of plastic waste?
- What are some of the consequences of the manufacture, use, and disposal of plastic?

1. Activity: Read, Review, & Respond

Students will:

- ☐ Collect, organize, and synthesize information about plastics as synthetic (man-made) materials that are derived from natural resources.
- ☐ Explore changes that plastics go through as they are made, used, and discarded.

Whole Group Discussion Questions:

- What are plastics?
- How are they made?
- How and why are they used?
- What happens to plastics over time?
- What are some of the positive and negative consequences for the manufacture, use, and disposal of plastic?

Materials & Resources

- **Lesson Two:** Student Workbook
- **Video:** "Plastics 101"
  - **Source**: National Geographic Society
  - **Description:** Once a completely natural product, much of today's plastic is man-made and largely dependent upon fossil fuels. From polymers to nurdles, learn how plastic is created and what we can do to slow the lasting repercussions this material will have on both our planet and our lives.
  - **Link**: https://video.nationalgeographic.com/video/101-videos/00000163-6503-de85-a16b-679316cc0000.
- **Infographic:** UMCES Plastic Watch Solomons Outdoor Sign #2
  - **Description**: How long does it take for plastics to break up into microplastics.
  - **Source**: UMCES Plastic Watch
  - **Link:** https://www.umces.edu/PlasticWatch

Part 2- Investigation: Integrating Information & Ideas

Objectives:

- We will gather and make sense of information to describe that everyday items that are made from plastic are synthetic materials made from natural resources and impact society
- We will investigate alternatives to plastic that may be used to manufacture everyday items.
- We will investigate how types of plastic polymers degrade over time

Supporting Questions:

- What happens to plastic over time?
- What are some of the alternatives to plastic?

2. Activity: Read, Review, & Respond

Read, Review, and Respond

Students will:

☐ Read and review resources to make sense of what happens to waste over time and will respond to questions in their Student Workbooks.

Whole Group Discussion Questions:

- *Review & discuss student responses to the questions in the Student Workbook as a whole group*

Materials & Resources

- **Article**: "*Breaking Down Trash*."
  - **Source:** Wave of Plastic UMCES team
  - **Description:** What do we mean by 'trash?' What is biodegradability? Why does it matter?
- **Web-based Article**: "Measuring Biodegradability"
  - **Source:** Science Learning Hub, (New Zealand government-supported science learning site)
  - **Description**: In nature, different materials biodegrade at different rates. This article explores the rates and processes by which different materials biodegrade.
  - **Link:** https://marinedebris.noaa.gov/discover-issue/types-and-sources
- **Online Dictionary**: "Biodegradable"
  - **Source:** Merriam-Webster.com
  - **Description**: Students can explore the etymology and definition of biodegradable
  - **Link:** https://www.merriam-webster.com/dictionary/biodegradable
- **Video**: "What are microplastics?"
  - **Description:** Microplastics are small plastic pieces less than five millimeters long which can be harmful to our ocean and aquatic life.
  - **Source:** NOAA National Ocean Service
  - **Link:** https://oceanservice.noaa.gov/facts/microplastics.html%5C
- **Sample Infographic:** "Plastics in the Ocean"
  - **Description:** Example of the use a creative visual to convey a pollution related concept
  - **Source:** NOAA Marine Debris Program (Office of Response and Restoration)
  - **Link:** https://marinedebris.noaa.gov/multimedia/infographics#prettyPhoto[field_image_image]/7/

Part 2: Investigation: Integrating Information & Ideas

3. Activity: "Make Our Own Bio-Plastic"

Students will:

- ☐ Work in teams to make their own bio-plastic that can be molded into usable items. They will consider and discuss the impact that bio-plastics could have on society and the environment.

Whole Group Discussion Questions:

- *Review & discuss student responses to the questions in the Student Workbook as a whole group*

Materials & Resources

☐ **Recipe 1**:
- *Plant based oils* (corn oil, and/or sesame oil, and/or vegetable oil)
- *Cornstarch* -1 tablespoon
- *Water* -1 tablespoon
- *Food coloring*
- *Measuring spoons*
- *Eyedroppers* (optional)
- *Wooden skewers or metal spoons* (to stir the bioplastic mixture)
- *Paper cup or small beaker*-1 per group (in which to heat and mix the bio-plastic)
- Access to a *microwave oven*

☐ **Recipe 2**:
- *Glycerin/Glycerol* -1 teaspoon (Glycerin is used as a plasticizer in this application. It can be found at local drugstores and supermarkets.)
- *Cornstarch* -1 tablespoon
- *Water* -4 tablespoons
- *Vinegar* -1 teaspoon
- *Food coloring*
- *Measuring spoons*
- *Eyedroppers* (optional)
- *Wooden skewers or metal spoons* (to stir the bioplastic mixture)
- 1 paper cup or small beaker per group (in which to heat and mix the bio-plastic)
- Access to a *microwave oven*

Activity: Make Our Own Bio-Plastic

Description: **"**Bio-plastics" are types of plastic made from renewable, biological materials like starches, cellulose, oils or proteins. They generally contain little or no petroleum and therefore are usually biodegradable. When bio-plastics are exposed to the environment (sunlight, heat, water, microorganisms) they break*down* into natural compounds like carbon dioxide and water.

In this activity, students will work in teams to make their own bio-plastic that can be molded into usable items. They will consider and discuss the impact that bio-plastics could have on society and the environment.

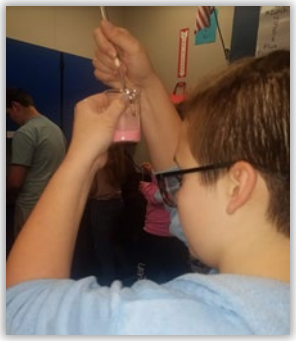
Materials

☐ **Recipe 1:**
- *Plant based oils* (corn oil, sesame oil, and/or vegetable oil)
- *Cornstarch* -1 tablespoon
- *Water* -1 tablespoon
- *Food coloring*
- *Measuring spoons*
- *Eyedroppers* (optional)
- *Wooden skewers or metal spoons* (to stir the bioplastic mixture)
- *Paper cup or small beaker*-1 per group (in which to heat and mix the bio-plastic)
- Access to a *microwave oven*

☐ **Recipe 2:**
- *Glycerin/Glycerol* -1 teaspoon
- *Cornstarch* -1 tablespoon
- *Water* -4 tablespoons
- *Vinegar* -1 teaspoon
- *Food coloring*
- *Measuring spoons*
- *Eyedroppers* (optional)
- *Wooden skewers or metal spoons* (to stir the bioplastic mixture)
- *1 paper cup or small beaker per group* (in which to heat and mix the bio-plastic)
- Access to a *microwave oven*

Procedures:

1. In a paper cup or beaker, mix all ingredients for Recipe 1 until combined.
2. Heat in a microwave oven for 20-25 seconds. Carefully remove the cup containing the mixture from the microwave and let it cool for a few minutes. While it is still warm, students can form the bioplastic mixture into a ball.
3. Encourage the students to try to mold the bioplastic into usable items (for example, cups, spoons, toys, etc.).
4. Repeat steps 1-3 for Bio-Plastic Recipe 2.
5. Allow the bioplastic to dry completely (this may take several hours).



4. Activity: Analyze, Share, & Reflect: Updating Our Personal Waste Inventories

Students will:

☐ Return to their personal waste inventory and will complete a supplementary chart that focuses on the amount of time it takes for each item to degrade and how it degrades (for example, does it break apart into smaller pieces, etc.). Students should begin with making a prediction of how long they think it will take for each item to degrade before conducting research to determine the amount of time it will actually take.

Whole Group Discussion Questions:

- *Review & discuss student responses to the questions in the Student Workbook as a whole group*

Materials & Resources

- *Access to the internet* or other resources that identify the length of time certain waste items take to break down or break up.

5. Activity: "What Happens to Our Waste?" *OPTIONAL*

Note that there is a separate student workbook for this activity

Students will:

☐ Investigate the degradability (including biodegradability) of a variety of waste materials over time.

Materials & Resources

- *Clear plastic bins/trays* with lids
- *Water* collected from one or more natural sources*
- *Soil*
- *Scale or balance* (to measure potential chances in mass over time)
- *Windowsill* or similar access to sunlight.
- A variety of objects and materials to represent waste. *There should be objects made from organic materials as well as plastic. Students may choose items from the Personal Waste Inventory they created in Lesson One, Our World of Waste.*

  Items may include:
  - Notebook Paper, napkins, paper towels
  - Glass bottle
  - Plastic bottle
  - Apple core, orange peel, banana peel
  - Fishing line
  - Food wrappers
  - Plastic Materials made in the "Make Our Own Bio-Plastic" Activity*.

Note: Samples from natural sources are necessary for there to be microorganisms present in the water to support biodegradation.

Activity: "What Happens to Our Waste?"

Note that this activity is optional and may extend beyond the time used to teach this lesson.
Note that there is a separate student workbook for this activity

Description: In this activity, students will plan and carry out an investigation to make sense of how different materials degrade over time. They will work in teams to determine and articulate the goal of the investigation, predict outcomes, and plan a course of action that will provide the best evidence to support their conclusions.

Objectives:

1. *Ask Questions, Define the Phenomenon, Make Predictions*: Students define and describe the processes of degradation that we will investigate. Then they use what they understand about biodegradability to make predictions about the effects that independent variables (such as water, soil, material type) will have on the dependent variables (mass and other observable features) for a variety of waste items.
2. *Plan and Conduct an Investigation*: Students will develop a plan for collecting, recording, and analyzing data that will answer the investigation questions about the degradability of different materials. They will identify and justify appropriate variables and determine the methodologies for collecting data.
3. *Analyze and Interpret Data*: Students will use the data collected in their investigations as evidence to support claims about the effects of independent variables (such as water, soil, material type) on the dependent variables (mass and other observable features) for a variety of waste items.
4. *Construct, Communicate, Refine Explanations*: Students will synthesize evidence from their investigations and apply their understandings of biodegradability to draw conclusions about the degradation of different waste materials.

Procedures:

1. Students will begin by describing degradation and the importance of biodegradation (the key processes that we will be investigating). *(Note: responses will vary but students should focus on the ideas that many things degrade, but some merely break apart into smaller and smaller pieces while others break down completely through biodegradation. Biodegradation is important for regulating the amount of waste that accumulates in ecosystems)*

What is Biodegradability?

Different materials break down in different ways. Biodegradability is the ability of materials to be broken down by microorganisms like fungi or bacteria that digest the materials and break it down into simple, inorganic substances such as water, carbon dioxide, and methane. Natural materials such as plants, animals and products made from plants and animals (for example, natural fabrics like cotton, silk, and wool; untreated wood; and paper) are considered biodegradable.

2. Students will select waste items and, using what they've learned about biodegradability, make predictions about how they will degrade in given conditions over time.

3. Students will plan, implement, and evaluate an investigation that will generate data to provide evidence to support each of their claims. In their design, students will consider aspects of the investigation process:
    - Students should consider why we will be looking at mass as a dependent variable in this investigation. Other dependent variables (e.g. color or structure) may also be discussed. A dependent variable is one that is being studied and measured as data points. *(Note: responses may vary, but as microorganisms digest portions of the material in the biodegradation process, they will be converting components of the materials into separate compounds such as water and carbon dioxide. Thus, the original mass of the item will be reduced as biodegradation occurs. Changes in color or structure (e.g. becoming more brittle) may also occur.*
    - Students should identify the independent variables in their models and make predictions regarding the impacts of those variables on the dependent variables. *(Note: for example, the water and soil might contain microorganisms that could be involved in biodegradation, sunlight could contribute to photodegradation and changes in color, the type of materials that make up the plastic waste would determine if it could be biodegraded, etc.)*

What is Photodegradation?

Photodegradation is the alteration and/or breaking down of materials by exposure to light (usually sunlight) and air. This is the only natural process which breaks down plastic. Plastic is made up of long polymer chains, tangled together, making the object strong. Components of sunlight cause the long polymer chains to react with oxygen from the air and break down into shorter chains. As more of the plastic molecules react and break down, there are fewer long chains holding the object together- it becomes brittle and breaks into smaller and smaller pieces.

4. Students then plan and implement their investigation. They should collect data over several weeks and even months if possible, recording their dependent variable at regular intervals (e.g. weekly).
5. Students should describe the results of the investigations by reporting the effects they observed.
6. Students will then make claims about the effects of independent variable (such as water, soil, material type) on the dependent variables (mass and other observable features) of the waste items they observed.
7. Finally, students will make broader conclusions about the degradation of different types of waste.

Part 3 – Application: Applying What We Learned Through Informed Action

Objectives:

- We will describe that everyday items that are made from plastic are synthetic materials that come from natural resources and impact society
- We will design and administer a survey to collect information about the preferences and choices of people in your school community regarding plastic use.
- We will share what we've learned in the lesson investigations and from the survey results.

Supporting Questions:

- What properties of plastic influence our everyday choices to use plastic?
- How can we communicate our ideas, inform perspectives, and inspire action?

5. Activity: Engaging Others

Students will:

- ☐ Review the UMCES Plastic Watch Community Survey and brainstorm information about personal plastic use that they could collect from the community.
- ☐ Design their own survey and administer it to the school community.
- ☐ The teacher/facilitator may decide the medium through which the surveys will be designed and administered. For example, surveys may be electronic, designed using an online program such as Survey Monkey or Google Forms, or created in a word document.
- ☐ Students may work individually, in groups, or as a whole class.
- ☐ Analyze the results, summarize them, and share with the community.
- ☐ The results should include a discussion of the sources of plastics and alternatives to plastic.

(Note: The teacher/facilitator and/or students may decide how to share the information with the community. For example, the information may be shared in a flyer, brochure, poster, or newsletter)

Whole Group Discussion Questions:

- *Review & discuss student responses to the questions in the Student Workbook as a whole group*

Materials & Resources

- **UMCES Plastic Watch Survey**
  - **Link:** https://www.umces.edu/PlasticWatch/survey

  (Note: Available on pages 12-13 of this guide as well as in a separate PDF)
- **OPTIONAL:** Access to online survey design program
- **OPTIONAL:** Posters, paper, markers, art supplies, etc. for creating flyers and posters to share the results.

The *PlasticWatch* Project – Community Survey*

In the PlasticWatch project, the University of Maryland Center for Environmental Science (UMCES) Chesapeake Biological Laboratory partnered with local restaurants in Maryland to offer alternatives to single-use plastic products, such as biodegradable straws or the option of having no straw at all!

This survey is designed to find out how much plastic people use, what they think about alternative, biodegradable products, and their opinions on plastic in the environment. We will use the information we collect to identify how to most effectively switch from plastic products, including straws, cups and take-out containers, to biodegradable alternatives.

*This version of the survey has been modified from its original version for use in the *Wave of Plastic Meaningful Watershed Educational Experience*.

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1) How many plastic disposable straws do you use per week?

- ☐ None
- ☐ 1-3
- ☐ 4-7
- ☐ 8-10
- ☐ 10+

2) Are you willing to go without a straw in your drink?

- ☐ Yes
- ☐ No

3) How often do you recycle your plastic products and containers?

- ☐ Less than 25%
- ☐ 25-50%
- ☐ 50-75%
- ☐ 75-100%

4) Have you used a biodegradable paper straw or take-out container at a restaurant recently?

- ☐ Yes
- ☐ No

5) How satisfied were you with the biodegradable product?

- ☐ Very dissatisfied
- ☐ Slightly dissatisfied
- ☐ Neither dissatisfied or satisfied
- ☐ Slightly satisfied
- ☐ Very satisfied

6) How long do you think it takes a plastic straw to break up?

- ☐ 1 year
- ☐ 4 years
- ☐ 45 years
- ☐ 200 years
- ☐ 2000 years

7) What are some of the ways that plastic ends up in the rivers and ocean? Select all that apply.

- ☐ From boats
- ☐ Winds blowing trash out of a garbage can
- ☐ Releasing a balloon outside
- ☐ Throwing a plastic wrapper out of a car window

8) What are microplastics?

- ☐ Recycled plastic
- ☐ Tiny pieces of plastic
- ☐ A biodegradable plastic

Part 4- Assessment: Demonstrating Our Understandings

Objectives:

- Students will construct a convincing argument, supported with evidence, that supports or refutes claims for either explanations or solutions.
- Students describe a chain of reasoning that describes plastic as a synthetic material derived from natural resources that affects society in positive and negative ways.

Claim/Evidence/Reasoning Writing Rubric				
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Claim – statement or conclusion that answers the original question/problem.	Does not make a claim.	Makes an inaccurate claim.	Makes an accurate but incomplete claim.	Makes an accurate and complete claim.
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Use the Claim, Evidence, Reasoning model.

Describe what makes plastic a synthetic material, and describe how the properties of synthetic plastics impact society

Breaking Down Trash:

What is trash and what is biodegradation?

What is trash? Where does it go when we throw it away?

1. Trash is more important than many of us realize. In this article, we will explore what is meant by the word trash, the differences between natural and synthetic materials, and the properties that influence how trash changes over time.

2. How do you define the word "trash?" Many definitions of trash can be subjective or influenced by our own experiences and interpretations of information. The word "trash" is used to refer to items that we put into the garbage or recycling bin because we no longer want or need them. But what exactly is trash made up of? And if we are throwing trash away, where is "away?"

What types of materials make up trash?

3. Trash is all of the items that we discard. These items of trash are made of materials that originally came from nature, such as wood, minerals, coal, crude oil, and other fossil fuels. Although you may be able to observe an object and conclude that it came from nature (such as a wooden chair), there are many items that are made from materials that are difficult to identify through observation alone. A plastic bag, for example, is made from natural resources, but it isn't easy to know from which ones just by looking.

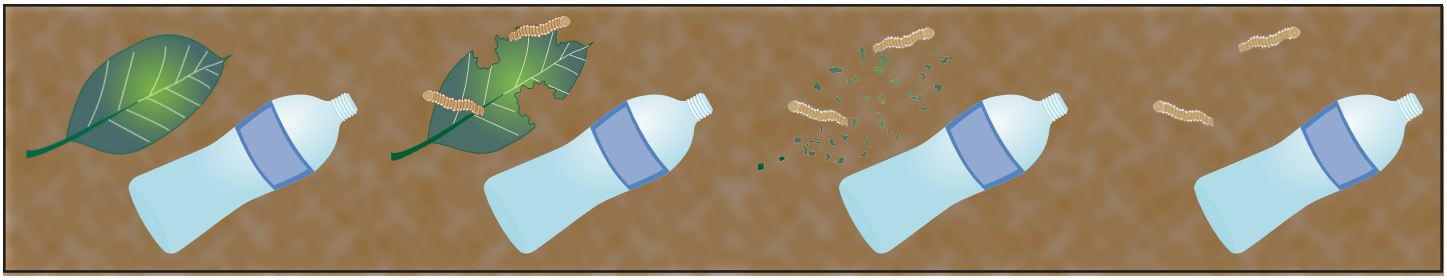
4. Some items can look very different from the materials they come from because they are either made of many different types of materials or the natural resources that made them were changed. Materials that are changed actually have a different chemical composition and are called "synthetic" materials. This is in contrast to "natural" materials, which have the same chemical composition and look similar to the natural materials they are made of (like a wooden chair). Both natural and synthetic materials are made into the items that we use in everyday life and eventually discard as trash.

Where does our trash go when we throw it "away"?

5. Trash that is properly contained in bags or trash cans is collected by local waste management companies in garbage trucks and taken to landfills. Landfills are large areas of land specifically set aside to store trash. Landfill operators usually try to confine the trash that is deposited in a landfill to as small an area as possible and modern landfills bury or cover waste with layers of soil.

6. Items that have been put in the recycling bin are typically collected by recycling waste management companies that sort the items, separate them into different types of materials, and send them to manufacturers who make new products from the materials. If items have been contaminated with food or other materials, they may not be able to be recycled and are sent to a landfill.

7. Sometimes, trash is not discarded into containers where it can be taken to a landfill or to a recycling facility. Instead, it enters the natural environment where it becomes pollution. This can happen when people do not put their trash in cans or bins, or when dumpsters or trash cans are overfilled. It can also happen when garbage bags are ripped, or trash is not properly contained. In all of these cases, trash can be carried by wind or water across land and into waterways.



What happens to natural waste materials over time?

8. Whether trash is made from materials that were once living will determine what happens to it over time. Organic materials come from either the waste products of living things or their remains. Organic materials are biodegradable. This means that specialized organisms called decomposers (like bacteria, fungi, and earthworms) can feed on the material and break it into simple elements and nutrients. This process of decomposers breaking organic materials down into usable nutrients is called biodegradation.

9. Biodegradation is an important process in nature because it allows the elements and nutrients contained in one organism to be cycled back into the ecosystem for other organisms to utilize. One example found in nature is the cycle of trees losing their leaves in the autumn. Leaves are organic and therefore they biodegrade quickly and easily. When leaves fall off trees, decomposers break down the structure of the leaves as they digest them. Decomposers help to prevent materials from building up, or accumulating in the environment. Without decomposers to digest and break down the leaves that fall from trees, for example, there would eventually be piles of leaves taller than the trees themselves!

10. Some materials, like clay, stone, and minerals like aluminum and sodium, are found naturally in the environment, but they are not organic, meaning they have never been a part of materials that were once living. They are not broken down to be used as nutrients by decomposers.

What happens to synthetic materials over time?

11. Many of the items that we use in everyday life are not natural and are not organic. These items are made from synthetic, human-made materials such as fibers, medicines, and plastics. While some of the ingredients used to make these materials may have been natural or organic at one time, the process to turn them into the synthetic materials during manufacturing changes their structure, which can result in the materials being much more difficult to break down through biodegradation.

12. Plastic, for example, is a synthetic material that is made from natural materials like crude oil and natural gas. The manufacturing process changes the chemistry of these original liquid and gas materials to a solid that is very difficult for decomposers to break down in order to extract nutrients. This means that items made out of plastic (like plastic bags) may be broken up into smaller pieces over time , but not easily broken down through biodegradation. Scientists estimate that it will take considerable amounts of time (even hundreds of years) for plastics to be broken down into tiny pieces. Thus, pieces of synthetic materials like plastic remain and accumulate in ecosystems, where they can pollute the air, water and soil and cause harm to living things for years and years.

What can you do to help?

13. Humans are using more and more plastic items every day and enormous amounts of plastic trash are entering ecosystems. Think about the choices that you make when it comes to using items and discarding them as trash. Are there things you can do to help reduce the amount of trash and its harmful impacts in our natural environments?

PLASTICS BREAK UP INTO MICROPLASTICS. HOW LONG DOES IT TAKE?

PLASTIC WATER BOTTLE
450 YEARS

PLASTIC UTENSIL
200 YEARS

PLASTIC BAG
20 YEARS

PLASTIC STRAW
200 YEARS

FOAM PLASTIC CUP
50 YEARS

PLASTIC BEVERAGE HOLDER
400 YEARS

MICROPLASTICS

Microplastics are small plastic pieces less than five millimeters long which can be harmful to our aquatic life.

Decomposition rates will vary depending on product material and environmental conditions

WHAT CAN YOU DO?

- **Skip the straws, plastic bags, and plastic take-out items!**
- **Reduce, Reuse, and Recycle...or just Refuse to Use!**
- **Participate in beach and community greenspace cleanups!**

PLASTICWATCH

Visit our website to learn more
www.umces.edu/plasticwatch

University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
CHESAPEAKE BIOLOGICAL LABORATORY

The PlasticWatch project is funded using federal funds under award number NA16NOS4190170 from NOAA, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce."

Teacher/Facilitator Guide

WAVE OF PLASTIC

Meaningful Watershed Educational Experience

LESSON THREE:

FROM HAND, TO LAND, TO SEA

Sources and destinations of plastic pollution

- ☐ How do we describe, quantify, and communicate about issues related to plastic waste?
- ☐ What are the causes and effects of pollution?
- ☐ What are the sources of plastic pollution?
- ☐ How and why does plastic pollution enter our waterways?
- ☐ How can we communicate our ideas, inform perspectives, and inspire action?

Unit Driving Question:

How do human choices regarding the consumption and disposal of plastics impact ecosystems and our communities and what actions can we take to minimize those impacts?

Wave of Plastic: Meaningful Watershed Educational Experience

Teacher/Facilitator Guide Lesson Three -From Hand, To Land, To Sea

Wave of Plastic MWEE Unit Next Generation Science Performance Expectations

Earth and Human Activity

1. 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. Add evidence and clarification statements

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

Lesson Three Key Ideas

- Human-caused pollution plays causal roles in changing Earth's systems.
- Pollution refers to any substance or energy (for example, heat and light) that is foreign to an environment, and/or is present in quantities that cause harm to natural systems and the living things within them.
- Plastic items become pollution when they enter natural environments.
- There are many properties of plastic that allow it to be easily transported by wind and rain runoff across land and into waterways.
- Plastic pollution harms living things and is accumulating in the environment because of increases in per-capita consumption and because plastic persists for very long periods of time.
- Sharing information visually, such as through infographics, can be an effective way to reach and engage diverse audiences and inspire behavior change.

Lesson Three Overview			
	Goal	**Description**	**Activities**
Part 1 Introduction	Building Understanding	Make sense of pollution as any substance that is foreign to an environment, and/or any substance or energy that is present in quantities that cause harm to natural systems and the living things within them.	1. **Read, Review, & Respond**: Students analyze a resources to make sense of pollution, participate in a "jigsaw" activity to organize information, and respond to questions in their Student Workbooks
Part 2 Investigation	Integrating Information and Ideas	Investigate the properties of plastic that allow it to be easily moved across land and into waterways. Engage in **outdoor field investigations** to determine how runoff will move waste across local surfaces. Collect data about plastic pollution within local	2. **Activity: "Plastic Waste Sort!"** Students sort plastic items first by properties of their choice and then by properties that they think contribute to its ability to travel across landscapes and waterways. 3. **Read, Review, & Respond**: Students analyze a variety of resources to make

		communities and make predictions about how and where the pollution might be transported (for example to storm drains, then local streams, to rivers, and the Chesapeake Bay).	sense of plastic pollution and respond to questions in their Student Workbooks 4. **Outdoor Field Experience A: *How Does Water (Runoff) Move Across Our School Grounds?*** Students will explore and map ways that water moves across the surfaces of their school grounds 5. **Outdoor Field Experience B: *What Plastic Pollution Do We Observe on Our School Grounds?*** Students will survey the plastic pollution found on their school grounds and make predictions about where and how it might travel to other destinations. 6. **Outdoor Field Experience C: *What Plastic Pollution Do We Observe in Our Neighborhoods?* (OPTIONAL)** Students will survey the plastic pollution found in their neighborhoods and make predictions about where and how it might travel to other destinations.
Part 3 Application	Applying What We Learned Through Informed Action	Engage communities by designing conceptual models to represent the sources and destinations of plastic pollution in our community.	7. **Read, Review, & Respond:** Students will review and discuss: o NGSS Science & Engineering Practice, Developing and Using Models. o A variety of infographics related to plastic pollution 8. **Engaging Others**: Students will work individually or in teams to develop a model in the form of an infographic that represents the possible sources, movement, and destinations of plastic pollution in their communities.
Part 4 Assessment	Demonstrating Our Understanding	Complete a constructed response using the *Claim, Evidence, Reasoning* model.	9. **Construct an argument supported by evidence:** Students describe how plastic pollution can enter an environment and how it might travel to other environments.

Part 1- Introduction: Building Understanding

Objectives:

- We will obtain, evaluate, and communicate information about the types of pollution and the negative impacts it can have on the environment and living things.

1. Activity: Read, Review, & Respond

Students will:

- ☐ Review a resource about pollution and how it can negatively impact and alter many of Earth's systems including the atmosphere, land, waterbodies, and living things.
- ☐ Participate in a team "jigsaw" activity in which each member of the team focuses on understanding one type of pollution and shares that information with the group.
- ☐ Use the pages in the Student Workbook to collect, organize, and synthesize information.

Whole Group Discussion Questions:

- *Review & discuss student responses to the questions in the Student Workbook as a whole group*

Materials & Resources

- ☐ Lesson One: Student Workbook
- ☐ **Article:** "*What is Pollution*"
  - **Source:** UMCES Wave of Plastic
  - **Description:** What pollution is, the different types, and what its effects are.

Photos courtesy of Jenna B. Linhart

Part 2- Investigation: Integrating Information & Ideas

Objectives:

- We will explore the different properties of plastics by sorting plastic waste items.
- We will read informational text about how plastic pollution moves across land and into water.
- We will investigate how water (runoff) moves across our school grounds.
- We will conduct a survey of the plastic pollution found on our schoolgrounds and in our neighborhoods.

2 . Activity: Plastic Waste Sort!

Students will:

☐ Sort plastic items first by properties of their choice and then by properties that they think contribute to its ability to travel across landscapes.
☐ Students discuss their observations and reasoning for their selections.

Whole Group Discussion Questions:

- How did each of you choose to sort items?
- What observations were you able to make about the sorted items and their properties?

Materials & Resources

☐ A variety of plastic waste items.

Activity: "Plastic Waste Sort!"

Description: Students sort plastic items first by properties of their choice and then by properties that they think contribute to plastic's ability to travel across landscapes and waterways. Students discuss their observations and reasoning for their selections. This activity should take 10-15 minutes, with discussion. *(Note: may need to discuss that properties are distinguishing qualities of an object made of matter, such as its color, shape, weight, size or temperature).*

Prior to Beginning the Activity:

1. Bins of plastic trash/waste should be available throughout this unit. The collection can be the material the group has collected or items that the teacher has provided. *(Note: it will be beneficial to be able to access these bins during discussion questions and activities).*

Procedures:

1. Invite students to observe different items of plastic waste and ask them to sort the plastics based on their properties. *(Note: Students should choose the properties- for example. color, weight, etc.)*
2. Engage in a second sort specifically focusing on properties that allow plastics to travel easily. Ask students to think about where they have seen plastic trash and what properties allowed it to travel to that place (for example, it may be lightweight, durable, buoyant, sturdy, resistant to corrosion).
3. "Share your Sort." Students share their sort categories with the class.

Wrap Up and Making Connections:

- How did each of you choose to sort items?
- What observations were you able to make about the sorted items and their properties?

3. Read, Review, and Respond

Students will:

☐ Analyze a variety of resources to make sense of plastic pollution and respond to questions in their Student Workbooks

Whole Group Discussion Questions:

- *Review & discuss student responses to the questions in the Student Workbook as a whole group*
- **Additional Discussion Question:** Why you think the authors decided to title the article, "From Hand, to Land, to Sea**?"**

Materials & Resources

☐ **Article:** "***From Hand, to Land, to Sea***"
- **Source**: UMCES Wave of Plastic Team
- **Description**: Sources and Destinations of Plastic Pollution

- **Video**: "What are microplastics" **(2 min, 6 sec)**
  - **Source**: NOAA National Ocean Service
  - **Description**: Microplastics are small plastic pieces less than five millimeters long which can be harmful to our ocean and aquatic life..
  - **Link**: https://oceanservice.noaa.gov/facts/microplastics.html%5C

☐ **Sample Infographic**: "Rains can lead to an increased amount of marine debris."
- **Source:** NOAA Marine Debris Program (Office of Response and Restoration)
- **Description:** Example of the use a creative visual to convey a pollution related concept
- **Link:** https://marinedebris.noaa.gov/multimedia/infographics#prettyPhoto[field_image_image]/5/

☐ **Sample Infographic**: "Microplastics on National Park Beaches"
- **Source:** NOAA Marine Debris Program (Office of Response and Restoration)
- **Description:** Example of the use a creative visual to convey a pollution related concept
- **Link:** https://marinedebris.noaa.gov/multimedia/infographics#prettyPhoto[field_image_image]/2/

4. Outdoor Field Experience A
How Does Water (Runoff) Move Across Our School Grounds?

**Note:* *This may be a separate outdoor experience or may immediately precede the next investigation, Plastic Pollution Survey.*

Students will:

☐ Sketch a map of their school grounds, make predictions about water flow, and then test their predictions on their school grounds.

Whole Group Discussion Questions:

- What features of the land seem to influence the direction that water flows? Do those features seem to be natural or man-made? Why do you think that is?

Materials & Resources

☐ *Map* of the school grounds and surrounding areas
Note: the map should indicate local waterways, landforms, and anthropogenic features.

☐ *Containers (cups, buckets, bottles) of water*

Outdoor Field Experience A
"How Does Water (Runoff) Move Across Our School Grounds?"

Description: Students will sketch a map of their school grounds and make predictions about the way that water will flow. They will test their predictions by pouring water in strategically chosen places on the school grounds and update their maps accordingly.

Procedures:

1. Display electronic and/or satellite imaging of the school grounds and ask the students to sketch the site in their Lesson 3 Student Workbooks. Students should attend to the closest waterway (stream, river) as well as natural and manmade features such as shrubbery, pavement, etc.
2. As a group, discuss predictions as to how water will move in the form of runoff (direction, flow, speed) on the school grounds. Ask students to consider and identify the factors might influence the way runoff moves across the site. (*For example, paved surfaces might be intentionally sloped toward storm drains, grassy areas might absorb water and thus limit runoff, etc.*).
3. Chose a site on the school grounds for the students to explore. Ask the students to bring containers of water with them. They will use the water to make observations and test their predictions for how runoff will move across your school grounds.
4. Once outside, work with students to locate the storm drains on the property and add them to your map. Make any other adjustments that might be necessary.
5. Ask the students to continue to make predictions about how runoff will flow at particular points on the site, using the natural and manmade features of the land as evidence to support their predictions.
6. Invite students to pour water onto the ground to test their predictions about the direction that runoff flows. *(Note: the students will be limited in the amount of water they are able to bring with them, thus decisions about where to test should be strategic).*
7. Students should share their results with the class and once again update their maps, this time using arrows to indicate the direction that runoff will flow on your school grounds map

Wrap Up and Making Connections:

The following are suggested discussion questions as whole group:

- What features of the land seem to influence the direction that water flows? Do those features seem to be natural or man-made? Why do you think that is?
- What did you notice about the location of storm drains on our school grounds?
- What are some of the advantages of runoff traveling to and entering storm drains?
- What are some of the negative effects of runoff traveling to and entering storm drains?
- How do you think the ways that water flows may influence the locations and types of waste that we will observe in our plastic pollution survey?
- What other factors might influence the locations and types of waste that we will observe in our plastic pollution survey?

5. Outdoor Field Experience B What Plastic Pollution Do We Observe On Our School Grounds?	
***NOTE:** This may be a separate outdoor experience or may immediately follow the first investigation into runoff.* ***NOTE:** Students should not pick up the waste they observe unless directed. If they are to pick up the waste, they should use gloves and/or tongs.* **Students will:** ☐ Students will conduct surveys of the plastic pollution on their school and use what they've learned to draw conclusions about the movement and destinations of plastic waste.	**Materials & Resources** ☐ *Plastic Pollution Survey* data collection sheet (found in the Lesson 3 Student Workbooks) ☐ *"Types of Plastic Trash" handout* (also found in the Lesson 3 Student Workbooks) ☐ *Gloves, tongs* (if plastic waste will be collected)
Whole Group Discussion Questions: • How do you think the amount of plastic waste we observed compares to other schools? How about to other neighborhoods and communities? • How would you describe the amount of plastic waste that enters our local waterways (*considering all the sources in our area*)? • Considering the *per-capita* amounts generated, why is plastic waste harmful to ecosystems?	

Outdoor Field Experience B

"What Plastic Pollution Do We Observe On Our School Grounds?"

Description: Students will conduct surveys of the plastic pollution that they observe on their school grounds (and, optionally, in their neighborhoods – *See Outdoor Field Experience C).* Students will use what they've learned about the properties of plastic and the ways that runoff moves across land and into waterways to draw conclusions about the movement and destinations of plastic waste.

Procedures- Part A, School Grounds Pollution Survey:

1. Review the Plastic Pollution Survey in the Lesson 3 Student Workbooks.

2. Display & discuss the "Types of Plastic Trash" handout. Ask students what other kinds of plastic items they might find that are not listed on the chart. Students should predict what kinds of plastic trash they are most likely to find and why. Students should use what they learned about the ways that water runoff flows on their school grounds as evidence to support their predictions.

3. Discuss the current weather as well as recent weather conditions that may influence the types and locations of plastic pollution that might be observed. For example, recent rain events may have already carried plastic pollution to storm drains or moved it from the places where it was originally discarded.

Procedures- Part B, Neighborhood Pollution Survey:

1. Review the *Neighborhood Trash Survey.* Point out that they will be doing the same survey they just conducted on the school grounds in the area near their homes.

2. Ask students to make predictions regarding how their neighborhood survey might differ from their school survey.

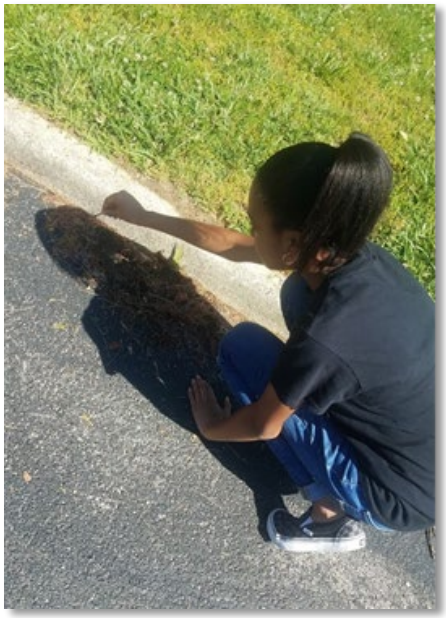
Wrap Up and Making Connections:

The following are suggested discussion questions:

- How do you think the amount of plastic waste we observed compares to other schools? How about to other neighborhoods and communities?
- How would you describe the amount of plastic waste that enters our local waterways (*considering all the sources in our area*)?
- Considering the *per-capita* amounts generated, why is plastic waste harmful to ecosystems?

Extension:

- Students may create graphs of the data that they collected in the schoolyard survey. This may be done individually or in groups with *graph paper or using electronic graphing resources.*



6. Outdoor Field Experience C (OPTIONAL)
What Plastic Pollution Do We Observe in Our Neighborhoods?

Students will:

- ☐ Conduct a plastic pollution survey in their neighborhood.

Whole Group Discussion Questions:

- How did your neighborhood survey compare to the schoolyard survey? Why?

Materials & Resources

- ☐ Plastic Pollution Survey data collection sheet *(*found in the Lesson 3 Student Workbooks)
- ☐ "Types of Plastic Trash" handout (also found in the Lesson 3 Student Workbooks)

Part 3 – Application: Applying What We Learned Through Informed Action

Objectives:

- We will explore how conceptual models are used in science.
- We will review examples of conceptual models in the form of infographics that explain concepts related to plastic pollution
- We will work individually or in teams to develop a model in the form of an infographic that represents the possible sources, movement, and destinations of plastic pollution in our communities.

7. Activity: Read, Review, & Respond

Read, Review, & Respond

Students will:

- ☐ Review and discuss the Science & Engineering Practice, Developing and using models.
- ☐ Review sample infographics and answer a set of questions to demonstrate their understanding of how to create an effective infographic.
- ☐ Students will review and discuss the infographic on the sources and destinations of plastic pollution on Solomons Island, Maryland, that was created through the *PlasticWatch* project. This will serve as inspiration for their own models.

Materials & Resources

- ☐ **Video: "**NGSS Practice 2, Developing and Using Models"
  - **Source:** Bozeman Science (8m 21sec)
  - **Description**: How scientists use models.
  - **Link:** http://www.bozemanscience.com/ngs-developing-using-models
- ☐ **Infographic**: "How Do Plastics Get into the Chesapeake Bay?"
  - **Source:** UMCES CBL PlasticWatch Project
  - **Description:** Sources of plastic pollution that enter the Chesapeake.
  - **Link:** https://www.umces.edu/plasticwatch
- ☐ **Sample Infographic**: "Threats to Coral Reefs, Land-based Sources of Pollution"
  - **Source:** NOAA
  - **Description:** How sources of pollution from land enter waterways, how they cause harm and how you can help.
  - **Link:** https://oceanservice.noaa.gov/facts/coral-pollution.html
- ☐ **Sample Infographic**: "Plastics in the Ocean"
  - **Source:** NOAA Marine Debris Program (Office of Response and Restoration)

Whole Group Discussion Questions:

- How and why do we use models in science?
- What are examples of models?
- What are infographics?
- What makes infographics effective and/or ineffective? If appropriate, students may review online resources that discuss effective infographics.

- **Description:** Example of the use a creative visual to convey a pollution related concept.
- **Link:** https://marinedebris.noaa.gov/multimedia/infographics#prettyPhoto[field_image_image]/7/

☐ **Sample Infographic**: "Microplastics on National Park Beaches"

- **Source:** NOAA Marine Debris Program (Office of Response and Restoration)
- **Description:** Example of the use a creative visual to convey a pollution related concept.
- **Link:** https://marinedebris.noaa.gov/multimedia/infographics#prettyPhoto[field_image_image]/2/

8. Engaging Others

Students will:

☐ Develop models in the form of an infographic that demonstrates the possible sources and destinations of plastic pollution in their communities.

Whole Group Discussion Questions:

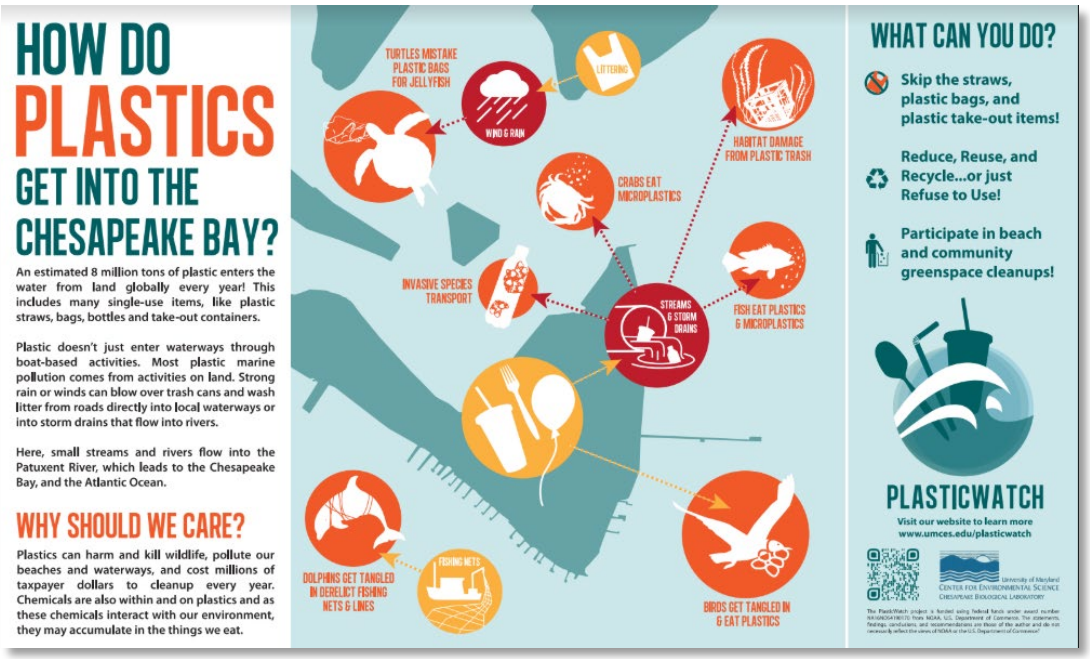
- *Review & discuss student responses to the questions in the Student Workbook as a whole group*

Materials & Resources

- *Online software programs* such as Canva.com, Microsoft Publisher, or https://piktochart.com/, Google Slides, Wixie
- *Posters, paper, markers, and other art supplies* for creating flyers and posters
- *Action/Infographic/Optional Infographic Websites*:
  - *Easel.ly*: a fairly easy way to create an infographic, a visual depiction of information. The tool offers set themes that can be dragged onto a blank canvas to give students somewhere to start. It won't do the work for you, and it forces students to represent what they know at the end of a research project, while giving some creative license.
  - *Infogr.am*: another tool to visually represent information. It has templates that allow you to throw in your facts and build beautiful charts to represent the information.

The following resources discuss the effectiveness of infographics and give students information on the power of information visualizations:

- The beauty of data visualization - TED Talk by David McCandless
- Infographics in Education
- 10 Tips for (journalists) Designing Infographics
- *Link*: https://piktochart.com/blog/using-infographics-classroom/



Part 4- Assessment: Demonstrating Our Understanding

Objectives:

- Students describe how plastic pollution can enter an environment and how it might travel to other environments.

Claim/Evidence/Reasoning Writing Rubric				
	0	1	2	3
Claim – statement or conclusion that answers the original question/problem.	Does not make a claim.	Makes an inaccurate claim.	Makes an accurate but incomplete claim.	Makes an accurate and complete claim.
Evidence – scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence.	Only provides inappropriate evidence (Evidence that does not support the claim.).	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
Reasoning – justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence.	Does not provide reasoning	Only provides reasoning that does not link evidence to claim.	Repeats evidence and links it to some scientific principles, but not completely.	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles.

Use the Claim, Evidence, Reasoning model.

Construct an argument supported by evidence to describe how plastic pollution can enter an environment and how it might travel to other environments.

What is Pollution?

Types and environmental impacts

What is Pollution

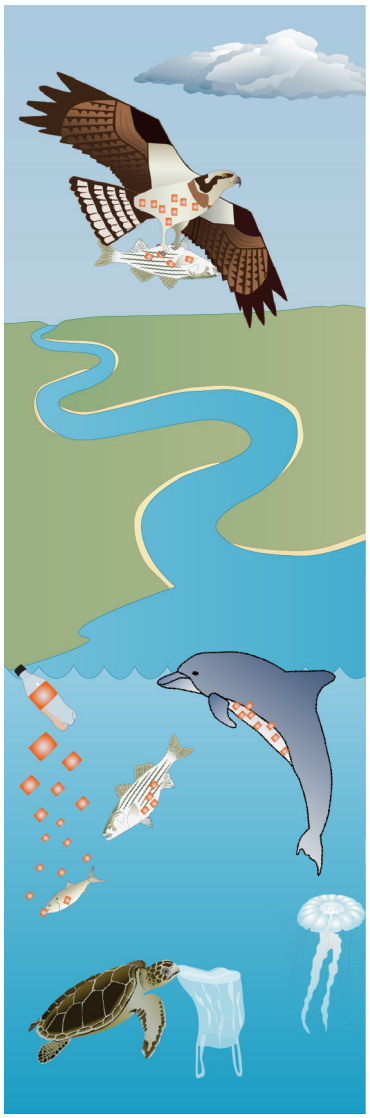
1. Pollution is the introduction of substances or energy (such as light or heat) into the natural environment in amounts or concentrations that can be harmful for humans, animals, and plants.
2. Pollution can reduce the health of ecosystems by harming or even causing death to the living things that call those ecosystems home. The negative effects of pollution can range in severity depending on what the pollutant is, the characteristics of the pollutant, and where the pollutant is located.
3. Pollution is most often composed of synthetic, or human-made substances (like plastic, for example), although even natural substances like sediment, nutrients, and carbon dioxide can become pollutants when they exceed a particular level. If natural substances exceed healthy levels, however, it is very likely the result of human activities.
4. The way in which pollution is categorized, studied, and managed depends on what Earth system is affected. Parts of Earth's systems that can be affected by pollution include land, waterways (such as ground-water, rivers, lakes, bays, and oceans), air, and climate.

What are some different types of pollution?

5. Water, air, and land pollution are three major categories of pollution. Sometimes pollution is easy to detect and is obvious to see, like an oil spill from a ship in the ocean. However, pollution can also be hard to see, like in the case of many types of air pollution. Specific pollutants can also contaminate more than one system at a time. For example, spilled chemicals may contaminate soil at the spill site (land pollution), and rain water may carry the chemicals and some of the contaminated soil into waterways (water pollution).
6. Land pollution can be anything from litter on the streets to spilled chemicals, such as gasoline in a gas station parking lot. A large portion of land pollution comes from industrial waste, which is generated from manufacturers or factories. It can also come from commercial waste produced by businesses, such as plastic food wrappers.
7. Another common source of land pollution is solid waste, such as household garbage. The garbage, or trash, that we generate includes things like food packaging, food waste, personal care products, and other unwanted items.
8. Land pollution can become water or air pollution. In fact, most of the pollution in the ocean comes from sources on land! One major way that this happens is through runoff, when rain or wind washes pollutants off the land and into storm drains or waterways. As the runoff travels, it picks up any pollutants in its path like trash and chemicals. Once in storm drains, the polluted runoff can then enter streams, rivers, and eventually bays and the ocean.

9. Air Pollution is a mixture of gases and solid particles in the air. Air pollution comes from the exhaust that cars and trucks produce when they burn gasoline for fuel, chemicals from factories, dust, mold, smog, and other sources. Air pollution can reach harmful concentrations both outside and indoors.

10. Water pollution can occur when pollutants are introduced into groundwater, rivers, lakes, ponds, and oceans. Sources of water pollution include synthetic materials like plastics, chemicals, pesticides, and fertilizers, and natural materials like nutrients and sediments. These pollutants often accumulate or build up as they flow downstream. They often eventually end up in bays and oceans, since all of these waterways are connected.



What are the effects of pollution on the environment and living things?

11. Pollution harms the environment by making it less suitable for living things. Sometimes a pollutant is toxic or dangerous and can directly cause living things to die. However, lower amounts of a pollutant or different types of pollutants may make a living thing sick, cause injury, or reduce its ability to find good habitat or food.

12. Pollutants can be especially dangerous when they accumulate, or build up, in an ecosystem and reach high, toxic concentrations. Plants and animals can absorb or ingest toxins from pollution, which can be damaging to their own health. As organisms eat each other, toxins from the pollution can then be passed from organism to organism up the food chain, increasing in concentration each time until they are at such high levels that they can cause death or serious health problems to the organism. Air pollution can be very dangerous to the animals and humans who breathe it in. It can cause short-term issues such as sneezing or coughing as well as long-term problems such as disease and even death.

What is plastic pollution?

13. Much of the solid waste that becomes land and water pollution is made of plastic. There are many properties of plastic pollution that make it dangerous to natural environments. Items made of plastic (like plastic bags and bottles) are lightweight and float, which makes it easy for them to travel by wind and water into the environment. Because plastic is very durable and it can withstand damage, plastics can remain in ecosystems for years and years. As pollution, plastic can injure animals if they become entangled in it (for example, if an animal gets tangled in an abandoned plastic nylon fishing net) or if animals ingest plastic because they mistake it for food.

What can you do to help?

14. Pollution can cause a variety of negative changes to the environment and the living things that call it home (including us). Can you think of ways you could prevent different types of pollution in your environment and beyond?

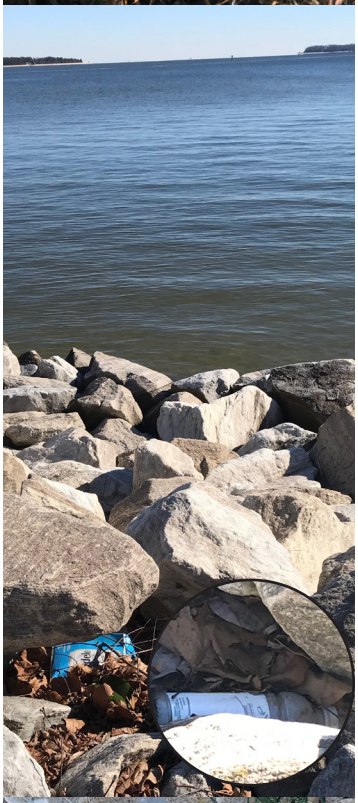
Symbols courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/).

From Hand to Land to Sea:
Sources and Destinations of Plastic Pollution

What are the Sources of Pollution?

1. The majority of pollution comes from human activities. Pollution is defined as any substance or energy that is foreign to a particular environment or is present in high enough quantities to cause harm to humans, animals, and plants.

2. Pollution can enter the environment in direct ways. For example, some factories discharge polluted wastewater through pipes directly into nearby lakes or rivers. Pollution can also get into the environment through indirect ways. Runoff can happen when rain or melting snow moves across the surface of the land without being absorbed. As runoff water travels it picks up pollutants like trash and chemicals and carries them into streams or rivers, or into storm drains which lead directly into the nearest water body, ultimately flowing into the ocean. This means that trash, such as drink bottles, can travel from our neighborhoods to the Chesapeake Bay and eventually the ocean! This also means that the source of the pollution can be very far from the environment where it ends up.



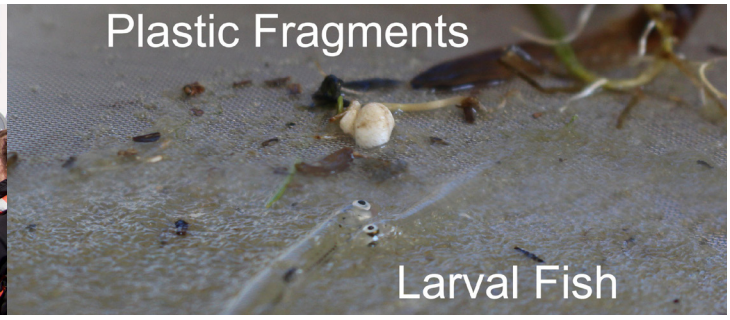
What about plastic pollution?

3. Most of the plastic pollution in the ocean comes from the land and is carried there by runoff. Our per-capita use of plastics - in other words, the amount of plastic that each person in the growing population uses - keeps increasing, which means the chance of it becoming pollution are also increasing. Plastic items can become pollution when they are either intentionally put into the natural environment or when they accidentally get there, such as if the wind blows a trashcan over.

4. There are multiple properties of plastic that make it easy for plastic waste items to be carried by wind and runoff into natural environments. Plastic is lightweight and buoyant (meaning it can float), and because of this, plastic items can be easily carried by wind and water, traveling from your hand, to the land, to streams and rivers, and finally into bays and the ocean.

5. Some plastics easily **break *up*** into smaller pieces over time, but those pieces do not easily **break *down*** in the ways that natural materials do. The majority of plastic pollution in the ocean is made up of microplastics. Microplastics are small bits of plastics that are less than 5 millimeters long (about the length of a red ant). Microplastics are plastics that were once larger items (such as plastic forks, children's toys, or microfibers from clothes) that broke apart into smaller pieces or that were originally very small, such as plastic microbeads and glitter. Microplastics are easily carried by the wind and rain because they are lightweight and buoyant, but their tiny size makes their transport through landscapes and waterways even faster. Microplastics are so small in fact that they can be difficult to see and can be very challenging to filter from water, sediments and soil.

Scientists sample the Patuxent River for microplastics



Microplastics were found in all Patuxent River samples

What does pollution do to aquatic systems?

6. Pollution can cause a wide range of problems to living things by negatively affecting the function and stability of the ecosystem. For example, an ecosystem that is affected by pollution may not be able to provide the services it normally does, like clean water, fresh air, or access to food. This can then harm the living things in the ecosystem that depend on those services by causing illness, injury, or even death.

7. Plastic pollution that gets into the environment breaks up into smaller pieces or microplastics over time. When plastic is in the environment, it can also release harmful chemicals that contaminate the air, water, and soil. If living things mistake microplastics for food and ingest them, these harmful chemicals can also be released into their bodies and cause illness or death.

8. Once plastic enters the food chain, it can accumulate in the bodies of organisms either when a living thing directly ingests plastic or when one organism eats another organism that has plastic in its body. Fish, oysters, dolphins, birds, whales and sea turtles have all been found with stomachs full of plastic! These large amounts of plastic prevent these animals from being able to digest real food and will often cause them to eventually die of starvation. Plastic can also accumulate in the environment, reducing the amount of suitable habitat for plants and other organisms by blocking space and sunlight.

9. Large pieces of plastic pollution, like plastic fishing line or soda can rings, can also entangle or wrap around the bodies, fins or limbs of organisms, preventing them from being able to hunt for food or even move. This eventually can lead to suffocation, starvation, or even death for entangled individuals.

What can we do to help?

10. There are many different actions that cities, organizations, and individuals (you!) can take to prevent pollution, especially plastic pollution. The best way to prevent pollution is by reducing the amount we use and waste we produce. For example, you can select foods with little or no plastic packaging or choose to use reusable items instead of single-use ones. You can spread this action to your community by acting as an example and telling them what you have learned about pollution and where it comes from.

11. As citizens and voters, we can also propose and support efforts to make laws that require businesses, factories, and communities to reduce the pollution they produce.

12. Having local cleanups to pick up trash can stop pollution from getting into important habitats and help raise awareness about the problem. People also tend to be less likely to litter in a cleaner environment.

13. Finally, proper disposal of waste items is very important to prevent them from getting picked up by wind and rain and carried to the ocean. Make sure that waste items are contained in trash bags or cans with lids and that they are not overfilled. For plastic waste, check the bottom of the plastic item for the recycling code number and find out if your city will let you recycle it (make sure it's clean first!).

14. **What actions do you plan on taking to prevent pollution in your community?**

Photos by the UMCES Wave of Plastic Leadership Team & members of the year one cohort

HOW DO PLASTICS GET INTO THE CHESAPEAKE BAY?

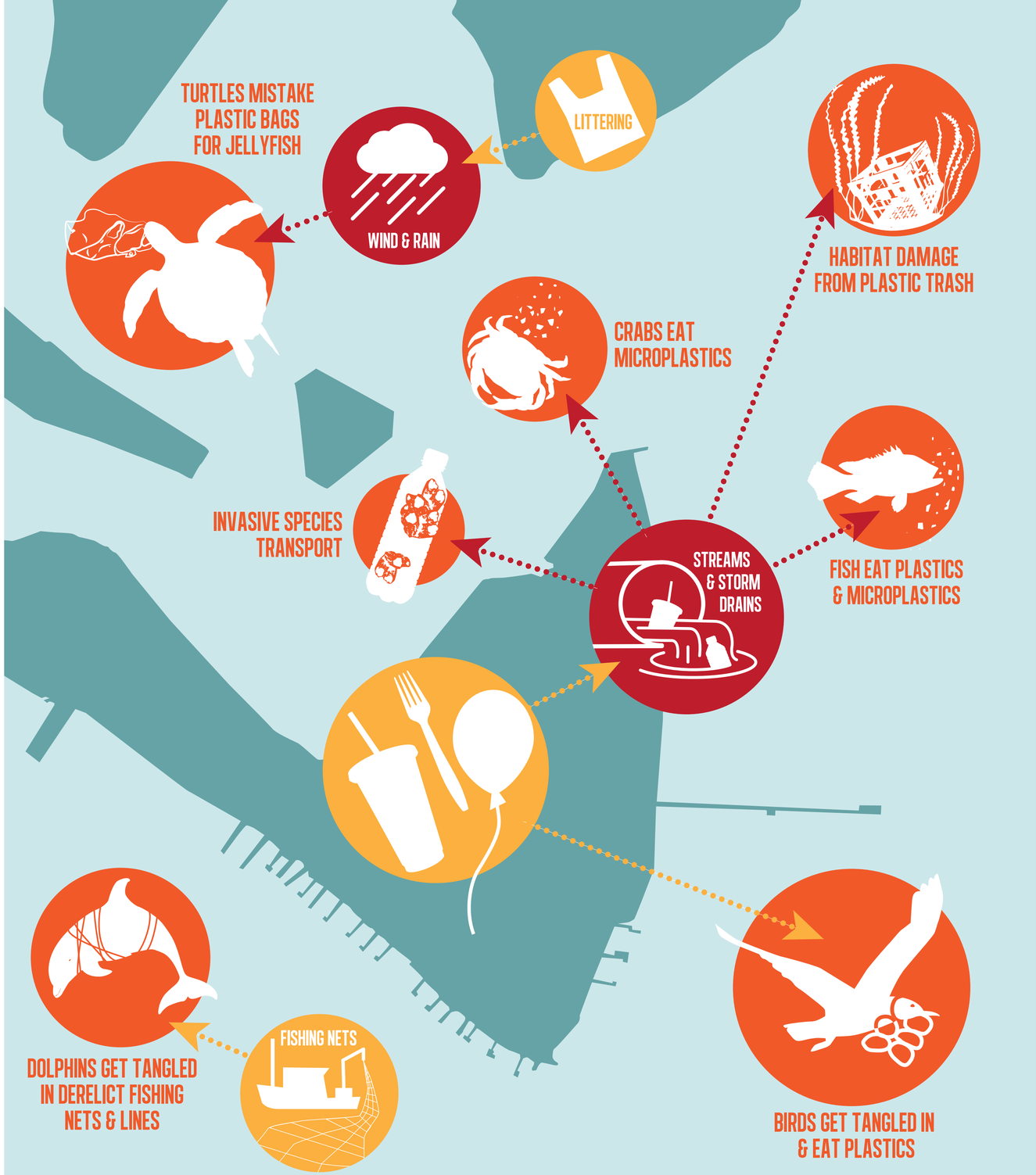
An estimated 8 million tons of plastic enters the water from land globally every year! This includes many single-use items, like plastic straws, bags, bottles and take-out containers.

Plastic doesn't just enter waterways through boat-based activities. Most plastic marine pollution comes from activities on land. Strong rain or winds can blow over trash cans and wash litter from roads directly into local waterways or into storm drains that flow into rivers.

Here, small streams and rivers flow into the Patuxent River, which leads to the Chesapeake Bay, and the Atlantic Ocean.

WHY SHOULD WE CARE?

Plastics can harm and kill wildlife, pollute our beaches and waterways, and cost millions of taxpayer dollars to cleanup every year. Chemicals are also within and on plastics and as these chemicals interact with our environment, they may accumulate in the things we eat.



WHAT CAN YOU DO?

- **Skip the straws, plastic bags, and plastic take-out items!**
- **Reduce, Reuse, and Recycle...or just Refuse to Use!**
- **Participate in beach and community greenspace cleanups!**

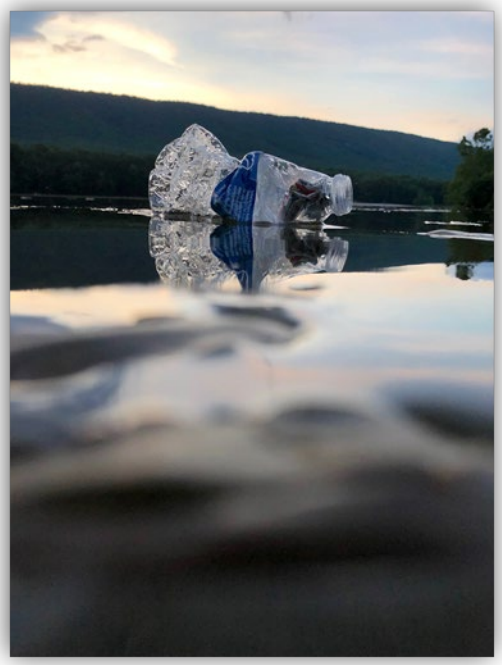
PLASTICWATCH

Visit our website to learn more
www.umces.edu/plasticwatch

University of Maryland
Center for Environmental Science
Chesapeake Biological Laboratory

The PlasticWatch project is funded using federal funds under award number NA16NOS4190170 from NOAA, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce."

Teacher/Facilitator Guide



WAVE OF PLASTIC

Meaningful Watershed Educational Experience

LESSON FOUR:
IMPACTS ON AQUATIC SYSTEMS

- ☐ How do we describe, quantify, and communicate about issues related to plastic waste?
- ☐ What causes disruptions to the stability of ecosystems?
- ☐ How can we use models to make predictions about the impacts of plastic pollution on ecosystems?
- ☐ How can personal choices and behaviors reduce the impacts of plastic pollution on ecosystems?

Unit Driving Question:
How do human choices regarding the consumption and disposal of plastics impact ecosystems and our communities and what actions can we take to minimize those impacts?

Wave of Plastic MWEE Unit Next Generation Science Performance Expectations

Earth and Human Activity

- 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-ESS3-3. Earth and Human Activity Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment**.**

Lesson 4: Impacts of Plastic on Ecosystems Performance Expectation

Ecosystems: Interactions, Energy, and Dynamics

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

Lesson Four Key Ideas

The Wave of Plastic Unit explores phenomena related to plastic waste. Lesson Four specifically focuses on the following Key Ideas:

- An ecosystem is a biological community of interacting organisms and their physical environment. Disruptions to any physical or biological component of an ecosystem can have effects and outcomes and can lead to shifts in all populations of organisms within that ecosystems.
- Plastic pollution can have multiple effects on individuals and populations of animals within aquatic ecosystems. For example:
    - Entanglement: Plastic pollution can directly kill or harm animals if they become entangled in it.
    - Ingestion: Plastic pollution can directly kill or harm animals when they mistake it for food and eat it.
    - Bioaccumulation: Plastics can bioaccumulate over time within an individual as they continue to eat more plastic.
    - Biomagnification: Predators feeding on individuals containing plastics can suffer from biomagnification as the concentration of plastic increases up the food web.

Lesson Four Overview			
	Goal	**Description**	**Activities**
Part 1 Introduction	Building Understanding	Make sense of how the abiotic and biotic components of a system exist and rely on each other in complex, interconnected relationships.	1. **Read, Review, & Respond**: Students analyze a variety of resources about ecosystems as biological communities of interacting organisms and their physical environments. Students respond to questions in their Student Workbooks
Part 2 Investigation	Integrating Information and Ideas	Investigate how plastic pollution disrupts and/or compromises elements of ecosystems. Students will read and answer questions about plastic ingestion and entanglement and the impact on organisms. Students will also engage in activities to model the impacts of plastics on organisms' abilities to grow and survive.	2. **Read, Review, & Respond**: Students analyze a variety of resources to understand the ways that plastic pollution contributes to marine debris and respond to questions in their Student Workbooks 3. **Activity:** "You Are What You Eat!" Students will model how plastic pollution can impact the extent to which different organisms are able to get the nutrition they need to grow, survive, and reproduce.
Part 3 Application	Applying What We Learned Through Informed Action	Make and share personal pledges to reduce the impacts of per-capita consumption and plastic pollution on ecosystems.	4. **Activity:** "I Make a Difference"
Part 4 Assessment	Demonstrating Our Understanding	Complete a constructed response using the *Claim, Evidence, Reasoning* model.	5. **Construct an argument supported by evidence:** Students describe how plastic pollution can cause changes to physical or biological components of an ecosystem.

Part 1- Introduction: Building Understanding

Objectives:

- We will obtain, evaluate, and communicate information about ecosystems as biological communities of interacting organisms and their physical environments.

1. Activity: Read, Review, & Respond

Students will:

- ☐ Review a variety of resources about ecosystems as biological communities of interacting organisms and their physical environments.
- ☐ Use the pages in the Student Workbook to collect, organize, and synthesize information.

Whole Group Discussion Questions:

- What are ecosystems?
- What does it mean for an ecosystem to be healthy and stable?
- Why do you think that scientists use an ecosystem's biodiversity as one of the measures of the health and stability of that ecosystem?
- What sorts of things can cause disruptions to the stability of ecosystems? Explain the possible effects of those disruptions on the health of that ecosystem.

Materials & Resources

- **Video**: "Ecosystem biodiversity" (4m, 13 sec)
  - **Source:** Khan Academy; Video by California Academy of Sciences.
  - **Description**: This video explores regional ecosystems as having their own assemblages of species and contributing uniquely to global biodiversity. Explore why ecosystem diversity is important for conservation decisions.
  - **Link:** https://www.khanacademy.org/science/high-school-biology/hs-ecology/hs-community-ecology/v/ecosystem-biodiversity

- **Video:** "Exploring Ecosystems: Coastal Food Webs?" (4min, 14sec)
  - **Source:** California Academy of Sciences
  - **Description:** How do changes in the ecosystem effect the community? Enter an underwater forest of kelp and explore the various threads that connect species together that help maintain diversity and balance in food webs.
  - **Link:** https://www.youtube.com/watch?v=LVJ5BKcAhAg

- **Article:** "Ecosystem" Encyclopedia Entry
  - **Source:** National Geographic Society
  - **Description:** Descriptions and definitions of ecosystems
  - **Link:** https://www.nationalgeographic.org/encyclopedia/ecosystem/

Part 2- Investigation: Integrating Information & Ideas

Objectives:

- We will model and describe how plastic pollution in ecosystems affects organisms.

2. Activity: Read, Review, & Respond

Students will:

- ☐ Analyze a variety of resources to understand the ways that plastic pollution contributes to marine debris.
- ☐ Respond to questions in their Student Workbooks

Whole Group Discussion Questions:

- How might plastic pollution enter an ecosystem?
- What are some ways that plastic pollution might impact ecosystems?

Materials & Resources

- **Video**: NOAA Marine Debris Program: "Trash Talk Video: What is marine debris" (2 min, 6 sec)
  - **Source**: NOAA.gov
  - **Description**: An introduction to marine debris.
  - **Link**: https://oceantoday.noaa.gov/trashtalk_whatismarinedebris/welcome.html

- **Video**: "What is marine debris" (1 min, 55 sec)
  - **Topic**: Marine debris
  - **Source**: Pew Trust
  - **Description**: An introduction to marine debris
  - **Link:** https://www.pewtrusts.org/en/research-and-analysis/video/2016/what-is-marine-debris-a-cartoon-crash-course

- **Video**: NOAA Marine Debris Program: "Trash Talk Video: How does marine debris impact the ocean, animals, and me?" (1 min, 33 sec)
  - **Source:** NOAA.gov
  - **Description**: Discussion of how plastic pollution and marine debris affect organisms and their habitats.
  - **Link:** https://oceantoday.noaa.gov/trashtalk_impacts/

3. Activity: "You Are What You Eat!"

Students will:

☐ Model how plastic pollution can impact the extent to which different organisms are able to get the nutrition that they need to grow, survive, and reproduce.

Whole Group Discussion Questions:

- What are some ways that plastic pollution can impact the overall health and stability of an ecosystem?
- What are some actions that people can take to help prevent plastic from harming individuals and populations of animals?
- Describe the effect that plastic pollution had on your food intake (and therefore the amount of nutrition each organism was able to extract from its habitat).
- Describe the effect of being entangled in plastic AND ingesting plastic pieces on the food intake of each species. (For example, did those who were entangled have to work harder to collect food items?)

Materials & Resources

- A tray/shoebox for each group of students (to represent the organisms' habitat)
- *Small cups/paper bags for each student* (to represent the organisms' stomachs)
- *Rubber bands* (to represent the effect of entanglement)
- *4 different colored beans/beads- 10 of each color/per kid* (one to represent uncontaminated food items, three to represent items of plastic pollution)
- *Data tables* (in the Student Workbooks)
- *Optional: Picture of food web* (if extensions to food webs will be made)
- *Optional: A tool such a spoon or tweezers* (to remove the 'food' from the habitat)

. Activity: "You Are What You Eat"

Description: Students will model how plastic pollution can affect individuals and populations of animals within aquatic ecosystems.

- ☐ Students work in groups that represent an organism from the food web. Depending on the number of students, there should be enough groups to represent at least one predator-prey relationship (e.g. for a group 9 students, 3 represent horseshoe crabs, 3 represent turtles, and 3 represent clams). All students within each group will represent the same species.
- ☐ Trays or shoeboxes with different-colored beads or beans in them will represent sources of nutrition within the ecosystem habitat.
- ☐ Different colored beans/beads will represent both food sources and plastic pollution that *resembles* food (for example, painted/colored beans may represent items of uncontaminated food and white beans may represent pieces of plastic pollution).
- ☐ The nutrition obtained will be determined by the number of beads/beans representing uncontaminated food items that each student is able to collect. Beads/beans representing plastic particles will have no nutritional value and will limit the amount of nutritional food an organism can ingest.
- ☐ Students model obtaining food from their habitats by using their fingers (or another tool such as spoons or tweezers) to remove beans/beads from the trays. *(Note: make sure that students are only removing one item at a time).*
- ☐ Rubber bands wrapped around the fingers of some students will model "entanglement" in plastic debris.
- ☐ Some students will experience *aggregate* effects by suffering from two effects of plastic pollution at once: ingestion of plastics (beads/beans representing plastic particles in their tray) and entanglement in plastics.
- ☐ *Do not tell students which color represents plastic until the end of the all three rounds.*
- ☐ Students record data from their simulation in their *Student Workbooks* and then draw conclusions from their experience.

Prior to Beginning the Activity:

1. Separate the students into groups that represent organisms in the food web.
2. Fill each of the trays/shoeboxes (one for each group) with four different colored beans/beads. Trays should include a mixture of different colored beans (equal proportion of each color for each tray, e.g. a handful of each color) that represent pieces of plastic pollution and uncontaminated food (each round the teacher decides which color is plastic without telling the students).
3. Each group should have one rubber band in which one student (an organism) will become entangled.
4. Make sure that each student has a cup/paper bag (to represent the organism's stomachs) and the data table from their Workbook.

Procedures – Basic Version, 3 Rounds:

1. Review and discuss the relationships between living things in a given food web.

2. Explain to students:
    - Each of the groups represent organisms of one species (in other words, a population).
    - During the activity, one individual in the group will wrap a rubber band around his/her fingers to restrict movement, simulating *entanglement* in plastic pollution. *(Note: The individual who is entangled will remain entangled throughout all three rounds.)*
3. Introduce the goals of the activity to the students:
    - Have students write down the color names of their beans/beads (e.g. "red", "white", "blue")
    - Students will have *30 seconds* to pick food items from the group's tray habitat *one at a time* and put them in their cup/bag 'stomach.' The more food items, the higher nutrition your animal was able to get and the healthier it is!
    - When time is up, each student/organism *counts* the number of 'food items' of each color that they were able to 'consume' (collect) and record the data in the Round 1, 2, or 3 row of their table, as applicable. Then students add up the *total* number of items consumed in the round and record the number to their data table. *(Note: at this point, the students do not know which color beans represent food and which represent plastic pollution.)*
    - Have students repeat this step for two more rounds.
4. Have students add up the total number of pieces of each color that they consumed in all rounds. Record this number for each color in the "Total Consumed" row (A).
5. Choose which color represents plastic pollution. Students should copy the total number of pieces that they 'consumed' (collected) of that color into the box titled "Total Plastic" (box B).
6. Students should subtract the total number of plastic pieces (box B) from the number of food items they were able to 'consume'(collect) (box A) in order to determine the amount of nutrition that they obtained from their food or the "Total Food" (box C).
7. Have students put their beans back into their species' group trays habitats.
8. At the end of three rounds, all student-organisms who were able to collect 30* or more pieces of uncontaminated food items have survived! The others have (unfortunately) perished. *(*Note: teachers may decide to adjust the number of food items according to the needs and abilities of the students)*.

Wrap Up and Making Connections:

The following are suggested discussion questions to conclude the activity with the whole group:

- What do you think would happen if a predator species (such as a sea turtle) ate a prey species (such as the horseshoe crab) that had plastic in its body? What do you think would happen if this sea turtle ate *many* horseshoe crabs that had plastic in their bodies?
- What are some ways that plastic pollution can impact the overall health and stability of an ecosystem?
- What are some actions that people can take to help prevent plastic from harming individuals and populations of animals?

Extensions:

- Represent *bioaccumulation* by having students collect new food and subtracting the number of pieces they got for this round AND the last round from their total (key point: plastic persists in their individual's body and is not digested like natural food items)
- Represent *biomagnification* by having predator species subtract both the number of plastic pieces obtained by their prey species and the number of plastic pieces they collected from their own food item totals.
- Implement "rescue actions" into a round, such as "cleaning up" the plastic from the environment, disentangling some animals, etc.

Part 3 – Application: Applying What We Learned Through Informed Action

Objectives:

- We will discuss how small changes in one part of a system might cause large changes in another part.
- We will apply what we've learned about per-capita consumption, plastic pollution, and the effects on ecosystems to develop a personal pledge for behavior change.

Activity: "I Make a Difference!"

Students will:

☐ Develop individual pledges that they share with their peers and communities and encourage others to pledge to make change as well.

Whole Group Discussion Questions:

- What is an example of something happening to one species/organism or in one place that affects something else or another place(s)?
- Consider our own individual choices when it comes to using and discarding plastic. How might our choices affect other aspects of Earth's systems?

Materials & Resources

- "I Make A Difference" Brainstorm Guide & Pledge Worksheet (located in the Lesson Four Student Workbook)
- Individual student waste inventories from Lesson 1
- *Optional:* Art paper/poster board for finished pledges

- *Supporting Resources for Student Pledge Research*
  - National Geographic Society:
    - Planet or Plastic Personal Pledge: https://www.nationalgeographic.com/environment/plasticpledge/
    - "You Can Help Turn the Tide on Plastic. Here's How" .https://www.nationalgeographic.com/magazine/2018/06/plastic-planet-solutions-waste-pollution/
  - Baltimore Beyond Plastic:
    - Personal Pledge: http://www.bmorebeyondplastic.org/pledge.html
  - #OneLessBottle.org:
    - Personal Pledge https://www.onelessbottle.org/pledge/

Activity: "I Make a Difference"

Description: Students extend their understanding of the impacts of plastics on ecosystems by examining their own choices and pledging to make a change. Students develop individual pledges that they share with their peers and communities and encourage others to pledge to make changes as well.

Procedures:

1. Engage students in a whole group discussion around the following ideas:
   - The world we live in is a complex and ever-changing connected system made up of smaller inter-connected systems.
   - What happens in one place, whether it's good or bad, can have effects on many other parts of the system.
   - What we each do in our daily lives impacts many other things and depending on our choices and behaviors, these impacts can be positive or negative.
2. Using the supporting resources from this lesson, past lessons, other resources, and students' *Personal Waste Inventory* (from Lesson 1) for inspiration, have students complete the personal pledge brainstorm worksheet in their workbooks. See prompt below.
   - Space on the right side of the Personal Pledge worksheet is provided for each student to trace their hand representing personal ownership of their pledges.
   - Pledges may be hung in the classroom, in a public space at the school, taken home or displayed at other locations.

Prompt:

I _____, pledge to protect ecosystems from the harmful effects of plastic pollution by _____.

My actions matter because _____.

Wrap Up and Making Connections:

- *Communicate with others:* Once students have identified their pledges, encourage them to share their pledges with their friends, families, and communities. Encourage students to be creative in the ways that they share their pledges *(For example, sharing through videos, infographics, flyers, t-shirts, essays,* etc.)

Extensions:

Encourage students to monitor the impact of their pledges. Students could consider the following:

- How can we monitor our progress on keeping our pledges?
- How can we encourage others to make their own pledges to take action?

Part 4- Assessment: Demonstrating Our Understanding

Objectives:

- Students describe how plastic pollution can cause changes to physical and biological components of an ecosystem.

Claim/Evidence/Reasoning Writing Rubric				
	0	1	2	3
Claim – statement or conclusion that answers the original question/problem.	Does not make a claim.	Makes an inaccurate claim.	Makes an accurate but incomplete claim.	Makes an accurate and complete claim.
Evidence – scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence.	Only provides inappropriate evidence (Evidence that does not support the claim.).	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
Reasoning – justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence.	Does not provide reasoning	Only provides reasoning that does not link evidence to claim.	Repeats evidence and links it to some scientific principles, but not completely.	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles.

Use the Claim, Evidence, Reasoning model.

Construct an argument supported by evidence to describe how plastic pollution can cause changes to physical and biological components of an ecosystem.

Teacher/Facilitator Guide

WAVE OF PLASTIC

Meaningful Watershed Educational Experience

LESSON FIVE:
WE CAN MAKE A DIFFERENCE

- ☐ How do we describe, quantify, and communicate about issues related to plastic waste?
- ☐ What is environmental stewardship?
- ☐ How are students and other citizens engaging in informed action to address issues of plastic pollution?
- ☐ What can we do?

Unit Driving Question:
How do human choices regarding the consumption and disposal of plastics impact ecosystems and our communities and what actions can we take to minimize those impacts?

Wave of Plastic MWEE Unit Next Generation Science Performance Expectations

Earth and Human Activity

1. 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. Add evidence and clarification statements
2. MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Lesson Five Key Ideas

- "Stewardship" refers to the responsible use and conservation of the natural environment.
- Students are critical stakeholders for supporting ecosystem resiliency and stability and displaying behavior that consciously seeks to minimize the negative impacts of plastic pollution on Earth's systems.
- There are many ways that students can take individual and collective action to mitigate the impacts of plastic pollution.

Lesson Five Overview

	Goal	Description	Activities
Part 1 Introduction	Building Understanding	Review and reflect on issues related to plastic pollution and how they affect the Chesapeake. Explore four types of action projects.	1. **Analyze, Share, & Reflect:** Students reflect on what they've learned in prior Wave of Plastic lessons and explore the four categories of informed action. 2. **Activity: Preparing to Take Action** Students explore and discuss examples of different types or categories of informed action and brainstorm ideas for their own action projects.
Part 2 Investigation	Integrating Information and Ideas	Use *Wave of Plastic Student Action Journal* to organize, plan, implement, and evaluate stewardship action projects.	3. **Plan, Implement, and Evaluate Action** ▪ Ask questions. ▪ Collect information & draw conclusions. ▪ Develop a claim and identify solutions. ▪ Design a plan and take informed action. ▪ Evaluate and reflect.
Part 3 Application	Applying What We Learned Through Informed Action		
Part 4 Assessment	Demonstrating Our Understanding	Summarize and reflect on Lesson 5 *and* on the entire *Wave of Plastic* Unit.	4. **Part 1: Student Action Project Summary** Students summarize the experience and respond to the NGSS Performance Expectation (MS-ESS3-3) *Note: The Action Project Summary draws on student learning in all Wave of Plastic lessons, but specifically assesses students' understanding*

			of the key ideas in Lesson 5 according to the Performance Expectation MS-ESS3-3. 5. **Part 2: CER.** Students respond to the NGSS Performance Expectation (MS-ESS3-4) *Note: This final CER draws on student learning in* all Wave of Plastic lessons *and specifically assesses students' understanding according to the Performance Expectation MS-ESS3-4.*

Part 1- Introduction: Building Understanding

Objectives:

- We will ask questions and make observations about how our choices and activities regarding the consumption and disposal of materials contribute to issues of plastic pollution.
- We will explore ways that we can take informed action to address issues related to plastic pollution.
- We will integrate and interpret information presented in different media or formats to develop a coherent understanding of a topic or issue.

1. Analyze, Share, & Reflect:

Students will:

- ☐ Review and reflect on issues related to plastic pollution and how they affect the Chesapeake.
- ☐ Review and reflect on the actions taken in previous Wave of Plastic Lessons.
- ☐ Explore stewardship definitions and the four different types of action projects promoted by the Chesapeake Bay Program for Meaningful Watershed Educational Experiences (MWEE): watershed restoration and protection, civic action, community engagement, and everyday choices.

Whole Group Discussion Questions:

- How can we describe issues related to plastic waste?
- How can issues related to plastic waste affect the Chesapeake Bay and its watershed?
- What were the actions that we took in the previous Wave of Plastic lessons to address issues of plastic waste?
- What was the intended impact of each action? (What did we hope it would achieve?)
- What was the actual impact of each action?
- How can we classify each action?
- What other types of action are there?

Materials & Resources:

- **Video:** "Bay 101: Restoring the Chesapeake Watershed" (4min, 52 sec)
  - **Source:** Chesapeake Bay Program
  - **Description:** What does it take to restore a 64,000-square-mile watershed?
- **Website**: "Bay 101"
  - **Source:** Chesapeake Bay Program
  - **Description**: A collection of videos about some of the critters that live in the Chesapeake and the issues that affect Bay restoration.
  - **Link:** https://www.chesapeakebay.net/discover/bay-101
- **Website**: "Stewardship definitions: Educating people in environmental stewardship practices"
  - **Source:** National Oceanic and Atmospheric Administration (NOAA).
  - **Description**: a framework and examples about different types of stewardship actions you can be used in education programming.
  - **Link:** https://www.noaa.gov/resource-collections/common-measures-definitions/stewardship-definitions

2. Activity: Preparing to Take Action

Students will:

- ☐ Explore actions that others are taking to address issues related to plastic pollution.
- ☐ Brainstorm problems they've noticed with plastic pollution or the use of plastic products

Whole Group Discussion Questions:

- What was the specific problem (or aspect of the problem) that each action is intended to address?
- What steps were taken to address the issue?
- What was the impact of the action? How do we know if they action is successful?
- How is the action being shared with the broader community?

- What are some issues related to plastic pollution that we've observed in our community?
- What are some ways we could take action to address them? What impact do we think those actions could have?

Materials & Resources:

- **Video:** "Kids Take Action Against Ocean Plastic"
  - **Source:** National Geographic (4min 14 sec)
  - **Description:** *This resource was chosen for its format (a video or PSA), representing community engagement. Children and adults address the negative impacts of plastic pollution, students are recorded presenting these thoughts on stage for their schoolmates.*
  - **Link:** https://edpuzzle.com/media/5d51bd93afdf65412d16f568

- **Letter**: "From the House of Commons, London to the Chief Executive of Tesco Plc. requesting the elimination of plastic packaging from brand products"
  - **Source:** Chesapeake Bay Program
  - **Description**: This resource was chosen for its format (a letter) and representation of a civic action project. Also, the letter references entanglement and ingestion which connects to previous lessons.
  - **Link:** pbs.twimg.com/media/DT5s4i0XUAAhT1c.jpg

- **Website & Infographic**: "Less Plastic: 9 Reasons to Refuse Single-Use Plastic"
  - **Source:** Less Plastic UK
  - **Description**: This resource was chosen for its format (an infographic). It represents an everyday choices project. The infographic is very clear and concise in its message of how single-use plastics affect the world.
  - **Link:** https://lessplastic.co.uk/9-reasons-refuse-single-use-plastic/

Activity: "Preparing to Take Action"

Description: Students will explore and discuss examples of different types or categories of informed action and brainstorm ideas for their own action projects.

Prior to Beginning the Activity:

1. Review key ideas from previous Wave of Plastic lessons and the impacts of actions that the students have previously taken.

2. Introduce the goal of this lesson:
   Using what you've learned about plastic and its effects on the environment, design and implement an action project to minimize the negative impacts of plastic pollution. Monitor the project's progress and evaluate its success.

Procedures:

1. Share the visual, "Types of Action Projects" (found in the *An Educator's Guide for Meaningful Watershed Educational Experiences*). Discuss potential examples of each type of action. Are their examples of actions that could fall into more than one category?

3. In teams, students explore ways that others are taking action to address the causes and negative effects of plastic waste. Teachers may choose to have students review the resources listed above (online or via printed copies) and/or locate their own examples of action projects.
4. For each project, teams should identify:
   a. The specific problem that the action is intended to address (for example, overuse of single-use plastics, entanglement and ingestion by aquatic animals, etc.)
   b. The steps that were taken to address the issue
   c. The impact of the action
   d. How the action was shared with the broader community

Wrap Up and Making Connections:

The following are suggested discussion questions to conclude the activity:

- Engage students in small and/or whole group discussions of the actions they explored (see whole group discussion questions above).
- Brainstorm plastic issues in their local community (note, you may have kept a running list of action projects throughout the unit. If so, refer to this list and add to it as needed.
- What are some action projects that we could plan and implement to address these issues?

Extensions:

Present the following discussion topic. "Social scientists often define specific periods in human history by the material or technology that most impacted society at that time. The Stone Age, Bronze Age, and Iron Age were named based on artifacts found at various, dated archaeological sites. Some believe that the present time period will become known as the Plastic Age. Is that justifiable? Using what you know about plastic, discuss this with classmates and defend judgements based on evidence learned." Students share their thoughts with the whole group, including problems they've noticed with plastic pollution or the unnecessary use of plastic products that may eventually end up as pollution.

Part 2- Investigation: Integrating Information & Ideas
Part 3 – Application: Applying What We Learned Through Informed Action

Objectives:

- We will use our *Student Action Journals* to plan, implement, and evaluate solutions for addressing issues related to plastic waste in our communities.

Plan, Implement, Evaluate Action:

Students will:

☐ Use *Wave of Plastic Student Action Journals* to organize, plan, implement, and evaluate stewardship action projects.

Whole Group Discussion Questions:

- How can we describe issues related to plastic waste?
- How can issues related to plastic waste affect the Chesapeake Bay and its watershed?
- What are some issues related to plastic pollution that we've observed in our community?
- What are some ways we could take action to address them? What impact do we think those actions could have?

Materials & Resources

- *Student Action Journals*
- Other materials as needed

Part 4- Assessment: Demonstrating Our Understanding

Objectives:

- Part 1: Students will respond to the Performance Expectation, **MS-ESS3-3.** *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment,* in a Student Action Project Summary**.**

- Part 2: Students will respond to the Performance Expectation, **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.*

Part 1: Student Action Project Summary.

- Students will respond to the Performance Expectation, **MS-ESS3-3.** *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment,* in a Student Action Project Summary**.**

Observable features of the student performance by the end of the course:		
1	Using scientific knowledge to generate design solutions	
	a.	Given a problem related to human impact on the environment, students use scientific information and principles to generate a design solution that:
		i. Addresses the results of the particular human activity. ii. Incorporates technologies that can be used to monitor and minimize negative effects that human activities have on the environment.
		ii. Incorporates technologies that can be used to monitor and minimize negative effects that human activities have on the environment.
	b.	Students identify relationships between the human activity and the negative environmental impact based on scientific principles, and distinguish between causal and correlational relationships to facilitate the design of the solution.
2	Describing* criteria and constraints, including quantification when appropriate	
	a	Students define and quantify, when appropriate, criteria and constraints for the solution, including:
		i. Individual or societal needs and desires.
		ii. Constraints imposed by economic conditions (e.g., costs of building and maintaining the solution).
3	Evaluating potential solutions	
	a	Students describe* how well the solution meets the criteria and constraints, including monitoring or minimizing a human impact based on the causal relationships between relevant scientific principles June 2015 Page 1 of 2 about the processes that occur in, as well as among, Earth systems and the human impact on the environment
	b	Students identify limitations of the use of technologies employed by the solution.

Student Action Project Summary

Use the chart below to summarize and reflect on your action plan.

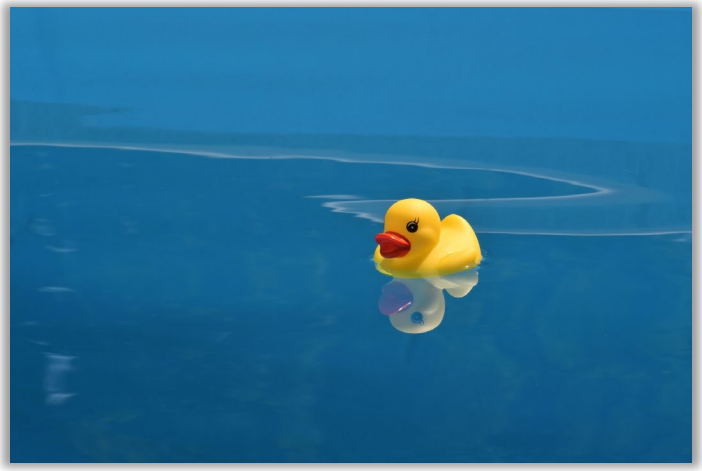
☑ **The problem that we addressed:**
☑ **Our solution:**
☑ **The scientific principles that informed our solution:**
☑ **The impact of our solution:**
☑ **Advice for others working to address this problem:**

Part 2: Claim Evidence Reasoning Response (Wave of Plastic Unit Summative Assessment)

- Students will respond to the Performance Expectation, **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.*

Observable features of the student performance by the end of the course:		
1	Supported claims	
	a	Students make a claim, to be supported by evidence, to support or refute an explanation or model for a given phenomenon. Students include the following idea in their claim: that increases in the size of the human population and per-capita consumption of natural resources affect Earth systems
2	Identifying scientific evidence	
	a	Students identify evidence to support the claim from the given materials, including:
		i. Changes in the size of human population(s) in a given region or ecosystem over a given timespan.
		ii. Per-capita consumption of resources by humans in a given region or ecosystem over a given timespan.
		iii. Changes in Earth systems in a given region or ecosystem over a given timespan
		iv. The ways engineered solutions have altered the effects of human activities on Earth's systems.
3	Evaluating and critiquing evidence	
	a	Students evaluate the evidence for its necessity and sufficiency for supporting the claim.
	b	Students determine whether the evidence is sufficient to determine causal relationships between consumption of natural resources and the impact on Earth systems.
	c	Students consider alternative interpretations of the evidence and describe* why the evidence supports the claim they are making, as opposed to any alternative claims.
4	Reasoning and synthesis	
	a	Students use reasoning to connect the evidence and evaluation to the claim. In their arguments, students describe* a chain of reasoning that includes:
		i. Increases in the size of the human population or in the per-capita consumption of a given population cause increases in the consumption of natural resources.
		ii. Natural resource consumption causes changes in Earth systems.
		iii. Because human population growth affects natural resource consumption and natural resource consumption has an effect on Earth systems, changes in human populations have a causal role in changing Earth systems.
		iv. Engineered solutions alter the effects of human populations on Earth systems by changing the rate of natural resource consumption or mitigating the effects of changes in Earth systems.

**Unless otherwise specified, "descriptions" references in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.*



Claim/Evidence/Reasoning Writing Rubric				
	0	1	2	3
Claim – statement or conclusion that answers the original question/problem.	Does not make a claim.	Makes an inaccurate claim.	Makes an accurate but incomplete claim.	Makes an accurate and complete claim.
Evidence – scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence.	Only provides inappropriate evidence (Evidence that does not support the claim.).	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
Reasoning – justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence.	Does not provide reasoning	Only provides reasoning that does not link evidence to claim.	Repeats evidence and links it to some scientific principles, but not completely.	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles.

Use the Claim, Evidence, Reasoning model.

Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

REDUCING PLASTIC POLLUTION IN THE CHESAPEAKE BAY

7 THINGS YOU CAN DO

BRING YOUR OWN SHOPPING BAG

USE A REUSABLE WATER BOTTLE OR MUG

SAY NO TO STRAWS & PLASTIC UTENSILS

PACK YOUR LUNCH IN REUSABLE CONTAINERS

PROOF ONLY

PARTICIPATE IN BEACH & COMMUNITY CLEANUPS!

REDUCE, REUSE, AND RECYCLE... OR JUST REFUSE TO USE!

SHARE THESE TIPS WITH YOUR FRIENDS. TOGETHER WE ALL MAKE A DIFFERENCE!

PLASTICWATCH

Billions of pounds of plastic pollution enter the ocean every year.

Where does it come from? Much of it comes from single-use disposable items, such as plastic straws, cups, bags and bottles. These plastics may be eaten by animals or they can become entangled causing them harm and even death.

Scientists at the University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, are working with businesses on a project called "PlasticWatch" to reduce the use of single-use plastics in our community.

Visit our website to learn more
www.umces.edu/plasticwatch

University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
CHESAPEAKE BIOLOGICAL LABORATORY

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