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LESSON

# Plastics in the Plankton, Plastics on Your Plate

Students investigate the impacts of plastics on marine organisms in different marine ecosystems. They construct a food web for an assigned ecosystem, using it to illustrate the principle of biomagnification visually. Students draw on evidence presented in this lesson and in the previous lesson, *Plastics, Plastics, Everywhere*, to justify an argument about whether plastic pollution affects humans as well. This lesson is part of the *Plastics: From Pollution to Solutions* unit.

**GRADES**

6 - 8

**SUBJECTS**

*Arts and Music, Biology, Ecology, Health, Chemistry, Conservation, English Language Arts, Storytelling*

**CONTENTS**

3 Activities

# In collaboration with

educurious
learning that connects

## ACTIVITY 1: UNDER THE SEA | 1 HR 40 MINS

## DIRECTIONS

***Plastics: From Pollution to Solutions* unit driving question**: *How can humans solve our plastic problem in the ocean?*

***Plastic in the Plankton, Plastic on Your Plate*** **lesson driving question**: *How do plastics affect ocean organisms and ecosystems?*

**1. Introduce students to the diversity of marine organisms.**

- Display the image of diverse marine organisms as silhouettes.
- Ask: *Which of these organisms can you identify?*
  - Possible responses: dolphins, sharks, swordfish, rays/skates, starfish, turtles, eels, snakes, seahorse, lionfish, crabs, jellyfish, octopus, clams, whelks, anemones, coral, seagrass, kelp
- Explain that life in the oceans is much more than just fish. In fact, much of the life in the oceans is microscopic. Marine microorganisms tend to fall in two broad categories:
  - Phytoplankton, including many types of algae, make their own food from sunlight and produce as much oxygen as land plants.
  - Zooplankton, including krill and many types of fish larvae, float in ocean currents and eat phytoplankton.
- Introduce the following new vocabulary words and add them to your word wall.
  - *Primary producer:* organisms, such as plants and phytoplankton, that can produce their own food through photosynthesis or chemosynthesis; also called autotrophs
  - *Primary consumer:* organism that eats producers; herbivores
  - *Secondary consumer:* organism that eats primary consumers; includes carnivores and omnivores
  - *Tertiary consumer:* carnivore that mostly eats other carnivores
  - *Apex predator:* species at the top of the food chain, with no predators of its own; also called an alpha predator or top predator
  - *Decomposers:* organisms that break down dead organic material; also sometimes referred to as detritivores
  - Trophic *level*: an organism's level on the food chain, whether producer, consumer, or decomposer
- Distribute the *Trophic Level Card Sort.* Instruct students to decide, in their groups, what trophic level each organism belongs to.
  - You may wish to hand out poster board, chart paper, or dry erase markers during this portion of the activity so that students can create a surface on which to organize and

label the six trophic levels.

  - Some of the organisms will be unfamiliar to students, and many groups may struggle to classify unfamiliar organisms. Remind students that they are not being graded in this activity on the correctness of their answers, and that they should use any available clues or reasonable guesses to guide their choices. There is also a category for *Other/Not Sure*.

- After groups have finished sorting, go over the answers using the *Trophic Level Card Sort Answer Key*.
- Then, ask if they can think of any organisms that are part of the marine environment but not featured in this card sort. Encourage students to think of organisms as well as their trophic level.

  - Possible responses:

    - Phytoplankton, including many types of algae, are producers.
    - Krill eat phytoplankton, so they are primary consumers.
    - Baleen whales, such as the blue whale, though very large, tend to eat krill, so they would be classified as secondary consumers.
    - Seabirds, such as seagulls and Laysan albatrosses, consume a variety of other organisms, including squid, fish, and crustaceans, so they would be considered tertiary consumers.
    - Many crabs are decomposers, as are many bacteria, fungi, and worms.

**2. Introduce the concepts of ingestion and entanglement.**

- Tell students that each of these organisms can be impacted by plastics in different ways. Have students work in their groups to brainstorm ways that plastics can impact different organisms.
- Rather than define the concepts of ingestion and entanglement directly, lead the following concept development activity.

  - Prepare chart paper or space on a whiteboard with three unlabeled columns.

    - The first column will represent ingestion impacts.
    - The second column will represent entanglement impacts.
    - The third column will represent other impacts.

- As student groups share their brainstormed lists of possible plastic impacts, record their responses in the appropriate column.

- After hearing from each group, ask: *Why are these responses grouped in three separate columns?*
  - The first column involves eating plastics; the second column involves getting trapped by plastics; and the third column is other impacts.
- Now ask students to help define the two new vocabulary words:
  - *Ingestion:* the act of eating or consuming
  - *Entanglement:* the state of being trapped or caught in something
- Add these entries to your class unit word wall and ask teams to create a sentence for their glossaries.
  - Encourage students to use other forms of both words, such as *ingested* or *entangled*, in their sentences.

**3. Facilitate a jigsaw activity about the varied ways plastics affect organisms at different trophic levels.**

- Explain that to learn more about how different kinds of plastics affect different kinds of organisms, publishing teams will split up for a jigsaw activity and then reassemble at the end of class to share what they learned. Each jigsaw group will become experts on one group of organisms, from primary consumers to decomposers, which they will then teach their publishing team about when they reunite.
  - Note that producers are not included in this jigsaw because they do not ingest plastics. However, new research suggests that plastics do have a variety of impacts on phytoplankton, including adhering to their surfaces and altering their rates of growth and photosynthesis.
- Divide the class into their jigsaw groups. Distribute one of the following four *Plastic Impacts* handouts to each group (multiple groups can focus on the same topic as needed).
  - *Plastic Impacts: Primary Consumers*
  - *Plastic Impacts: Secondary and Tertiary Consumers*
  - *Plastic Impacts: Apex Predators*
  - *Plastic Impacts: Decomposers*
- Provide instructions for the jigsaw:

  - Point out that the first question on each handout asks students to create a list of organisms in their assigned trophic level. Then, students will read the resources provided and answer the related questions.
  - Advise students that they may not need to read the entire article, but can skim for key information based on the questions.
  - Some articles may not explicitly state how ingestion and/or entanglement affect specific organisms. In these cases, push students to formulate reasonable hypotheses, and to confront the very real uncertainties that plague researchers and policymakers.
  - When they finish, groups should fill in their assigned row on the back of their *Plastic Impacts* handout in preparation to share information with their project group.

- Assess student learning before students return to their publishing teams to ensure they share accurate information. Use the *Plastic Impacts Answer Key* as a guide while observing the jigsaw groups and/or reviewing their responses.
- Finally, bring students back into their publishing teams. Instruct them to take turns sharing the information they learned in their jigsaw groups and fill in the rest of the table on the back of their handouts.

**4. Conclude the activity by summarizing and connecting it to the unit project.**

- On an exit ticket, ask students the following summarizing questions:

  - *Which marine trophic level is the most impacted by plastics? Explain why.*
  - *Which type of plastic impact is the most harmful for marine organisms? Explain why.*

- Tell students that in their final project, they must include a profile of a unique marine organism. It can be any organism, but it must be unique: It should not be one of the organisms profiled in this activity, and it should not be an organism shared by another project group. In their profile, they must include basic information about the organism and how it is impacted by plastics.
- Direct students to spend any remaining class time discussing which organism to choose for this focal profile.

# Informal Assessment

Students' participation in the trophic level card sorting discussion and their exit tickets provide insights into students' developing understanding and ideas about the cycling of matter in marine ecosystems; these should be collected by the teacher. Their completion of the *Plastic Impacts* handouts demonstrates their ability to determine the main ideas in scientific texts; these should be kept in the publishing teams' project folders.

# Extending the Learning

Consider using these related encyclopedic entries to build a deeper understanding of each trophic level and different roles in the food web.

- *carnivores*
- *consumers*
- *decomposers*
- *herbivores*
- *omnivores*
- *producers*

# OBJECTIVES

## Subjects & Disciplines

**Biology**
  - Ecology
- Conservation

## Learning Objectives

Students will:

- Differentiate between producers, primary consumers, secondary consumers, tertiary consumers, apex predators, and decomposers in marine ecosystems.
- Describe how ingestion and entanglement impact organisms at each level of the food web.

## Teaching Approach

- Project-based learning

## Teaching Methods

- Cooperative learning

- Jigsaw
- Reading

# Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
- 21st Century Themes
  - Environmental Literacy
- Science and Engineering Practices
  - Obtaining, evaluating, and communicating information

# National Standards, Principles, and Practices

## NATIONAL GEOGRAPHY STANDARDS

• **Standard 8:**
The characteristics and spatial distribution of ecosystems and biomes on Earth's surface 

## NEXT GENERATION SCIENCE STANDARDS

• **LS2.B Cycles of Matter and Energy Transfer in Ecosystems:**
Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

**Preparation**

# BACKGROUND & VOCABULARY

## Background Information

Nearly 250,000 species are known to live in the oceans. Meanwhile, as many as 91 percent of ocean species still have not been classified, and 95 percent of the oceans remain unexplored. Ocean food webs, therefore, are complex and difficult to study. In some ways, they seem like a bizarre mirror image of terrestrial food webs. Stationary creatures, like coral, seem like plants, but are actually consumers (although they live symbiotically with photosynthetic algae called zooxanthellae). Huge animals, such as the whale shark, subsist primarily on plankton, while tiny creatures, such as seahorses, are predators. The water column contains so much detritus, known as marine snow, that many filter-feeding animals that eat plankton could also be considered decomposers. Adding to the confusion, many marine animals are opportunistic feeders that will take advantage of almost any available food source, so they could be considered to occupy more than one trophic level. This confusion may become apparent to some of the students as they learn more about the marine food web. Nevertheless, understanding how organisms in different habitats and niches interact with plastics of different sizes allows students to appreciate both the beauty of the ocean ecosystem and the complexity of dealing with the problem of plastics.

## Prior Knowledge

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## Recommended Prior Activities

- Autopsy of an Albatross
- Follow the Friendly Floatees
- Magazine Design Workshop I
- Plastics Aplenty
- The Life Cycle of Plastics

## Vocabulary

| Term | Part of Speech | Definition |
|---|---|---|

| Term | Part of Speech | Definition |
|---|---|---|
| **apex predator** | *noun* | species at the top of the food chain, with no predators of its own. Also called an alpha predator or top predator. |
| **decomposer** | *noun* | organism that breaks down dead organic material; also sometimes referred to as detritivores |
| **entanglement** | *noun* | the state of being trapped or caught in something |
| **ingestion** | *noun* | the act of eating or consuming. |
| **primary consumer** | *noun* | organism that eats producers; herbivores. |
| **primary producer** | *noun* | organisms, such as plants and phytoplankton, that can produce their own food through photosynthesis or chemosynthesis; also called autotrophs. |

# ACTIVITY 2: BIOMAGNIFICATION AND BIOACCUMULATION | 1 HR 40 MINS

## DIRECTIONS

***Plastics: From Pollution to Solutions* unit driving question**: *How can humans solve our plastic problem in the ocean?*

***Plastic in the Plankton, Plastic on your Plate* lesson driving question**: *How do plastics affect ocean organisms and ecosystems?*

**1. Guide students to see themselves as being part of the marine food web.**

- Ask: *Who likes to eat seafood? What is your favorite kind of seafood?*
  - After hearing several responses, it may be useful to remind students that seafood includes not only fish and fish products such as tuna salad, fish sticks, or sushi, but also shellfish like lobster, crab, shrimp, clams, oysters, and mussels.
- Inform students that if they eat any type of seafood, they are part of the ocean food web.
- Define *food web* and add it to your class unit word wall. Instruct publishing teams to add this entry to their magazine glossary list, including the definition and an example sentence.
- Ask: *What trophic level would you consider yourselves to be?* (apex predator)

- Remind students that although eating seafood provides essential nutrients such as protein and omega-3 fatty acids, doing so can also come with some negative consequences.
- Ask: *What could be some negative consequences from eating seafood?*
  - Possible response: If the fish have eaten microplastics, we could also be eating those microplastics.
- Tell students that in this activity, they will make an argument, based on evidence, about whether microplastics have any effect on humans. Explain that this is a question that scientists are currently researching.
- Introduce students to the issue and how scientists are approaching the question with the video *Are Microplastics in Our Water Becoming a Macroproblem?* (2:51)

**2. Read an article summarizing the state of research on plastics in the food web.**

- Project the article *We Know Plastic Is Harming Marine Life. What About Us?*
  - Preview the article's structure to generate interest and predictions about its content; then read it aloud to the class.
  - Because there is a significant amount of high-level vocabulary in this article, it is best facilitated through a whole-class read-aloud with opportunities to pause for questions and clarification.
  - It begins by summarizing information students already know about plastic impacts, but continues to add information and lingering questions about toxic chemicals working their way up the food chain.
- To conclude the article, ask students to discuss one or two of the following questions with a partner, then invite several groups to share their responses with the class:
  - *In your opinion, what is the most serious health impact of plastics on animals addressed in this article? Why?*
  - *In your opinion, what is the most serious health impact of plastics on people brought up in this article? Why?*
  - *Which of the solutions proposed in the article seem most effective? Why?*

**3. Guide students to confront both the evidence and the uncertainties about the impacts of ocean microplastics on humans.**

- Label four large sections of your whiteboard with these titles:
  - Plastics in the food chain are harming humans now.

  - Plastics in the food chain are not harming humans now, but may in the future.
  - Plastics in the food chain do not harm humans, now or in the future.
  - I still need more information to make a decision about this.

- Explain that each of these statements is a claim. Tell students that in science, a claim is like an opinion, but one that must be supported by facts and evidence.
- Organize students into their publishing teams and distribute several sticky notes to each student.

  - Ask students to consider all of the evidence they have learned so far and decide which of these four claims they most agree with.
  - Prompt students to write two to three pieces of evidence on their sticky notes that support their claim.
  - Call students up by publishing team to place their sticky notes on the section of the board with the claim that most closely matches their current understanding. Students should be called up with their publishing teams, but should place their sticky notes individually.

- Observe and discuss any patterns in the distribution of sticky notes.

  - Beginning with the first claim, ask a student who chose this statement to defend their claim, citing evidence to support their position.
  - Ask for other students who agree with this student to add further supporting evidence.
  - Then, ask for a volunteer who disagrees with this first claim. Ask which claim they chose and on what evidence their claim is based.
  - Continue in this fashion until all four claims have been addressed. For the last claim, ask students what additional information they would need to make a decision, and what questions they have.
  - Finally, ask if this discussion has caused any students to change their opinion about which claim is best supported by the evidence. Give students an opportunity to move their sticky note and explain why they changed it.

- Remind students that scientists also disagree about this topic, and it is an active area of research where new information is being learned all the time.
- Tell students that there are two more concepts they should understand to grapple with this issue: *bioaccumulation* and *biomagnification*. These concepts will also help them complete the *Food Web Infographic* element of their final project.

**4. Introduce the concepts of bioaccumulation and biomagnification.**

- Ask students to review the *Biomagnification and Bioaccumulation* infographic with the goal of defining both words.
- After reviewing the inforgraphic, invite students to help define *bioaccumulation* and *biomagnification* and add the words to your class unit word wall.
- Prompt publishing teams to add these entries to their magazine glossary list.
    - Introduce and encourage alternate forms of these words, such as *bioaccumulate* and *biomagnify*.
- To reinforce the difference between these two similar-sounding concepts, display the simplified *bioaccumulation and biomagnification infographic* so that all students can see it clearly. Ask: *Based on this infographic, what is the difference between bioaccumulation and biomagnification?*
    - Bioaccumulation takes place in a single organism over the span of its life, resulting in a higher concentration in older individuals.
    - Biomagnification takes place as chemicals transfer from lower trophic levels to higher trophic levels within a food web, resulting in a higher concentration in apex predators.
- Elaborate by telling students that some of the toxic chemicals found in microplastics form chemical bonds with certain body parts, such as fatty tissues and organs. Therefore, when the body excretes wastes, these chemicals often stay behind and continue accumulating instead of being flushed out with other wastes.
- Add that ingestion is not the only way microplastics can enter our bodies. In fact, some microplastic fibers from synthetic clothing, carpets, and furniture are small enough to float in the air, where we can breathe them in.

**5. Develop the concept of a marine ecosystem as a particular habitat within the ocean.**

- Refer to the *Final Project Checklist and Rubric* to remind students that their final project will contain a *Food Web Infographic* explaining the process of biomagnification. Remind students that, just like their *Ocean Plastics Movement Model*, the *Food Web Infographic* will require drafting and revision.
- Explain that, just like plastic is not a single material but a whole family of materials, the ocean is not a single habitat, but consists of a variety of different ecosystems.
    - Define *ecosystem* and add it to your class unit word wall.
    - Tell students to add this entry to their magazine glossary list, including the definition and an example sentence.

- Emphasize that an ecosystem consists of both living and nonliving things. The class has spent a lot of time discussing living things, or organisms, in the ocean.
- Ask: *What are examples of nonliving parts of ocean ecosystems?*
  - Possible responses:
    - water
    - salt
    - rocks
    - sand
    - light and sound energy
    - macroplastics and microplastics
    - other types of pollutants and litter

**6. Guide teams through the development of an ecosystem-specific food web to model biomagnification.**

- Assign each publishing team one of the following specific marine ecosystems (more than one team likely will be assigned to each ecosystem):
  - arctic
  - kelp forest
  - mangrove
  - sandy shore
- Distribute one *Food Web Organizer* and one copy of each group's assigned *Food Web Infographic* to each team.
  - *Food Web Infographic: Arctic*
  - *Food Web Infographic: Kelp Forest*
  - *Food Web Infographic: Mangrove*
  - *Food Web Infographic: Sandy Shore*
- Guide teams through the following process (also see Tips):
  - Ask students to look at the ecosystem presented on their *Food Web Infographic* and use the *Food Web Organizer* to classify each organism in their ecosystem according to their perceived trophic level.
    - Each ecosystem should have only one apex predator.

- Some organisms may fit in more than one trophic level. For example, sea urchins and oysters can be considered both primary consumers and decomposers.
- Circulate around the room while students are working and correct any major misconceptions using the answer keys provided.

  - *Food Web Infographic: Arctic Answer Key*
  - *Food Web Infographic: Kelp Forest Answer Key*
  - *Food Web Infographic: Mangrove Answer Key*
  - *Food Web Infographic: Sandy Shore Answer Key*

- As teams work, you can inform them that they will have more time to work on their *Food Web Infographics* in the next activity, *Magazine Design Workshop II*, so they do not necessarily need to finish the infographics by the end of this activity.

- Have each group select a color to represent photosynthesis, the flow of energy from the sun to primary producers. Tell them to include this color in their *Food Web Infographic* legend, and then to draw arrows using that color from the sun to the producers.

  - Use *this image of producers in a coral reef* as an example of correct arrow placement and direction.

- Next, have students select a color to represent herbivory, the flow of energy from primary producers to primary consumers. Tell them to include this color in their *Food Web Infographic* legend, and then to draw arrows using that color from primary producers to primary consumers.

  - Use *this image of primary consumers in a coral reef* as an example of correct arrow placement.
  - Emphasize to students that the head of the arrow shows the direction that matter and energy travel through an ecosystem, which is also the direction that plastic particles accumulate through a food web. Many students initially draw the arrows pointing from predator to prey, based on the misunderstanding that arrows represent hunting behavior.

- Repeat the same process for the flow of energy from primary consumers to secondary and tertiary consumers. For the purposes of this infographic, secondary and tertiary consumers will be considered part of the intermediate consumers trophic level (between primary consumers and apex predators).

    - Use *this image of secondary and tertiary consumers in a coral reef* as an example to show correct arrow placement.
    - Note that there are multiple “correct” ways to draw these arrows, since many marine organisms are opportunistic feeders that will attempt to prey on whatever vulnerable organisms they encounter. Tell students that the aim is to show the overall flow of matter and energy, not to draw every possible arrow, which would create a cluttered image.

- Repeat the same process for the apex predator.

    - Use *this image of an apex predator in a coral reef* as an example of correct arrow placement.

- Finally, repeat the same process for decomposers.

    - Use *this image of decomposers in a coral reef* as an example of correct arrow placement.
    - Remind students that, for the purposes of this activity, any small, bottom-dwelling invertebrates can be considered decomposers, and that some organisms in the ocean are both decomposers and consumers.
    - Since every living thing ultimately dies, every organism should have an arrow leading to a decomposer.

- Finally, have students choose a color to represent microplastics. Tell them to include this color in the legend, and then draw dots inside each organism representing ingested microplastic particles. This allows them to demonstrate their understanding of biomagnification.
- Ask: *How many dots should you draw inside each organism?*

    - Student's responses should demonstrate the following concepts:

        - Producers do not consume plastics, so they should have none.
        - Primary consumers should have a few dots.
        - Secondary and tertiary consumers should have more dots.
        - Apex predators should have the most dots.
        - Decomposers will have some dots as well, but since they do not consume prey whole, their concentration should be lower than the apex predator’s.

- In conclusion, have students summarize biomagnification and its effects on their *Food Web Organizer*.

# Tip

- **Step 3:** Working with students on supporting a claim using evidence connected through reasoning is an important skill emphasized in the Next Generation Science Standards (NGSS). Read more about the relationship between using evidence to support claims in *this article* from Ambitious Science Teaching. For even more information about how to implement and reinforce the Claim-Evidence-Reasoning framework in your science classroom, read this *blog post by Model Teaching*.

- **Step 6:** The point of the *Food Web Organizer* is not to be absolutely correct about every organism's trophic level, but rather to divide up the organisms in the ecosystem in a reasonable way. For example, the smaller an organism is, the lower its trophic level should be, and vice versa. Organisms on the sea floor can reasonably be classified as decomposers unless there is a compelling reason to believe otherwise. Encourage students to work efficiently and make justifiable decisions as a team.

# Informal Assessment

*Food Web Infographics* completed by students provide insights into their current understanding of the cycling of matter through ecosystems, which they should demonstrate in both words and pictures; these documents should be stored in their project folders. Students' participation in the discussion about the impact of microplastics on human health demonstrates their current ability to make claims and support them with evidence.

# Extending the Learning

Biomagnification and Bioaccumulation Game: This interactive, kinesthetic activity helps students review organisms in each trophic level of the food web and experience firsthand how biomagnification and bioaccumulation function to cycle plastics in an ecosystem.

## OBJECTIVES

# Subjects & Disciplines

- **Biology**
  - Ecology
  - Health
- Chemistry
- Conservation

# Learning Objectives

Students will:

- Create an argument about whether they think this plastic pollution is capable of causing harm to humans, and justify their argument with evidence.
- Identify producers, consumers, and decomposers in a variety of different marine ecosystems.
- Illustrate the process of biomagnification within a food web, showing the cycling of plastics and toxic chemicals between organisms.

# Teaching Approach

- Project-based learning

# Teaching Methods

- Discussions
- Multimedia instruction
- Simulations and games

# Skills Summary

This activity targets the following skills:

- Science and Engineering Practices
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Developing and using models
  - Engaging in argument from evidence

- Obtaining, evaluating, and communicating information

# National Standards, Principles, and Practices

### NATIONAL GEOGRAPHY STANDARDS

• **Standard 8:**
The characteristics and spatial distribution of ecosystems and biomes on Earth's surface 

### NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction
• **LS2.B Cycles of Matter and Energy Transfer in Ecosystems:**
Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
• **MS-LS2-3:**
Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
• **Science and Engineering Practice 7:**
Engaging in argument from evidence

**Preparation**

## BACKGROUND & VOCABULARY

# Background Information

Do microplastics in the ocean food web affect humans? The short answer is, it’s too soon to tell. We know we are consuming some amount of microplastics (and even tinier nanoplastics), but we don’t know how they are affecting us, or indeed if they are affecting us at all.

However, studies show that microplastics are part of the marine food web, and that the amount of microplastics in the oceans is increasing. Possibly the most concerning aspect of this problem comes not from the plastics themselves, but from their ability to ferry additives and other contaminants into our bodies: chemicals including polychlorinated biphenyls (PCBs), endocrine disruptors, flame retardants, and more. The precautionary principle suggests that we should pursue this line of inquiry until we arrive at satisfactory answers.

In spite of these uncertainties, the principles of bioaccumulation and biomagnification are well-established in toxicology. Perhaps the best-known example of this is with the pesticide DDT. Developed in the 1940s, DDT was sprayed widely throughout the mid-20th century to control harmful insects such as mosquitoes and elm bark beetles. Soon, scientists such as Rachel Carson noticed that birds that preyed upon these insects were also suffering as a result. Most dramatically, the eggshells of bald eagle eggs became thinner as a result of DDT's interaction with calcium, ultimately leading the EPA to ban the pesticide in 1972.

While the health effects of PCBs and DDT are well-established, the effects of other chemicals such as phthalates and endocrine disruptors are the subject of contentious debate. As with microplastics and nanoplastics, more research is required.

# Prior Knowledge

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# Recommended Prior Activities

- Autopsy of an Albatross
- Follow the Friendly Floatees
- Magazine Design Workshop I
- Plastics Aplenty
- The Life Cycle of Plastics

# Vocabulary

| Term | Part of Speech | Definition |
| --- | --- | --- |

| Term | Part of Speech | Definition |
|---|---|---|
| **bioaccumulation** | *noun* | process by which chemicals are absorbed by an organism, either from exposure to a substance with the chemical or by consumption of food containing the chemical. |
| **biomagnification** | *noun* | process in which the concentration of a substance increases as it passes up the food chain. |
| **ecosystem** | *noun* | community and interactions of living and nonliving things in an area. |
| **food web** | *noun* | all related food chains in an ecosystem. Also called a food cycle. |
| **ingest** | *verb* | to take material, such as food or medicine, into a body. |
| **pollutant** | *noun* | chemical or other substance that harms a natural resource. |

# ACTIVITY 3: MAGAZINE DESIGN WORKSHOP II | 50 MINS

## DIRECTIONS

***Plastics: From Pollution to Solutions*** **unit driving question**: *How can humans solve our plastic problem in the ocean?*

***Plastic in the Plankton, Plastic on your Plate*** **lesson driving question**: *How do plastics affect ocean organisms and ecosystems?*

**1. Prepare students for focused group project work.**

- Use personal reflection to remind students that their project is meaningful, and to ensure that limited group work time will be well spent.
  - Ask: *What is your favorite marine organism and why?*
  - Ask: *How can plastics impact that organism?* Possible responses:
    - They can ingest microplastics, which can block their ability to digest food.
    - Ingested microplastics can also deliver toxics, such as PCBs and BPA.
    - Organisms can also become entangled in plastics, which can lead to wounds, infection, deformed limbs, and decreased mobility.
- Ensure that all groups have their *Final Project Checklist and Rubric* with three key items highlighted:

- *Featured Marine Organism Profile*, showing how plastics impact that organism specifically
- *Food Web Infographic,* explaining the process of biomagnification in an ocean ecosystem (This is the same document publishing teams started working on in the *Biomagnification and Bioaccumulation* activity.)
- Glossary of related vocabulary used in the magazine

- Provide models of each of these elements for students to analyze.
  - For the *Featured Marine Organism Profile*, show students the *Orangutan* profile from National Geographic's Photo Ark.
    - Point out how it includes colorful pictures and basic information, including size, habitat, diet, and behavior.
    - Highlight the final section about threats to survival. Emphasize to students that this will be an important piece of their *Featured Marine Organism Profile*.
- Distribute the *Featured Marine Organism Profile* handout.
- For teams that did not finish the *Food Web Infographic* in the previous activity, it may be helpful to provide copies of one or two *Food Web Infographic Answer Keys* provided in the *Biomagnification and Bioaccumulation* activity as examples of a completed food web. Make sure the answer keys you provide don't match the ecosystem the team has been assigned, so each team still has the experience of creating a food web for their ecosystem.
- For the glossary, there are 13 new vocabulary words that have been introduced in the two previous activities, *Under the Sea* and *Biomagnification and Bioaccumulation*.
  - Teams should include all of these words in their glossaries with student-friendly definitions and meaningful sentences.
- Instruct groups to spend a few minutes discussing ideas and compiling notes as a group, and then quickly moving on to divide appropriate tasks between group members.
  - Monitor and support groups by checking in with each group and individual group members about their progress. Answer any clarifying questions that arise about the rubric or project expectations.
  - Highlight positive examples of teamwork as you witness them.

**2. Wrap up with a gallery walk to demonstrate group progress.**

- Prompt students to clean up their project work areas, clearing away all materials and notes except for the products of their teamwork.

- Acknowledge that the magazines are still works in progress, but that every team is getting closer to their goal.
- Explain to students that they will spend a few minutes walking around the room quietly to view their peers' work, then return to their seats.
- Ask students for examples of teams whose work they admired. Tell students to refer to the *Final Project Checklist and Rubric* so they can provide meaningful feedback, both positive and constructive.
- Finally, have students update the class *Know and Need to Know* chart, using their *Final Project Checklist and Rubric* as a reference, to indicate what else they still need to know in order to finish the rest of their final project. Possible responses may include:

  - We still need to write survey questions about community members' attitudes and behaviors regarding plastics, administer the survey, and analyze results.
  - We still need to write a profile of the winner of the 2019 Ocean Plastic Innovation Challenge and a *Call to Action* for readers.

# Tip

- **Step 1:** To read more about structuring time and expectations for teamwork, read *5 Strategies for Making Project Work Time More Productive* from the PBL Works blog. To read more about assigning roles to team members, read *Roles in PBL: 3 Approaches For Organizing Group Tasks* from the PBL Works blog.
- **Step 1:** For teams that benefit from extra time management scaffolding, read *The Ultimate Teamwork Management Tool: Kanban Boards* from the PBL Works blog.
- **Step 1:** A well-documented phenomenon in extended project-based learning is the mid-project slump. Read about *The Surprising Science of Project Fatigue (And How Teachers Can Help Prevent It)* from PBL Works. The article *29.5 Tips for Successfully Managing a Project* also contains useful ways to troubleshoot problems that arise from team dynamics.

# Informal Assessment

Students' abilities to model matter and energy flows in ecosystems are demonstrated by their *Food Web Infographics*. Their *Featured Marine Organism Profiles* demonstrate their ability to use accurate, relevant data and credible sources to support claims. As with all other documents that will be part of the final project, these should be stored in the publishing team's project folder. Students' abilities to revise models and use oral arguments are demonstrated by their reflections of their own progress and their feedback to other teams.

# OBJECTIVES

## Subjects & Disciplines

- Arts and Music

  **Biology**
  - Ecology
  - Health
- Conservation
- English Language Arts

  **Storytelling**

## Learning Objectives

Students will:

- Articulate a personal connection to their unit project.
- Synthesize information from notes and resources to make progress toward unit project goals.
- Reflect on what information they still need to embark on the next steps of their project.

## Teaching Approach

- Project-based learning

## Teaching Methods

- Cooperative learning
- Reflection
- Writing

## Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Creativity and Innovation
    - Critical Thinking and Problem Solving
  - Life and Career Skills
    - Initiative and Self-Direction
    - Leadership and Responsibility
    - Productivity and Accountability
- Critical Thinking Skills
  - Creating
- Science and Engineering Practices
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Obtaining, evaluating, and communicating information

# National Standards, Principles, and Practices

## NATIONAL GEOGRAPHY STANDARDS

• **Standard 8:**
The characteristics and spatial distribution of ecosystems and biomes on Earth's surface 

## COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **CCSS.ELA-Literacy.WHST.6-8.1:**
Write arguments focused on discipline-specific content.
• **CCSS.ELA-LITERACY.WHST.6-8.1.B:**
Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. 

## NEXT GENERATION SCIENCE STANDARDS

• **MS-LS2-3:**
Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

• **Science and Engineering Practice 2**:
Developing and using models
• **Science and Engineering Practice 7**:
Engaging in argument from evidence

**Preparation**

## BACKGROUND & VOCABULARY

# Background Information

The creation of food webs and focal marine organism profiles are authentic parts of the work of ecologists. Students are taking on the roles of researchers, writers, and graphic designers in this activity, which are all roles that can be found outside the classroom. Students will find the work of creating and presenting their *Food Web Infographics* and *Focal Marine Organism Profiles* relevant if their connections to marine organisms and ecosystems are genuine, and they will find the role of audience member relevant if they are able to provide meaningful feedback to their peers.

# Prior Knowledge

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# Recommended Prior Activities

- Autopsy of an Albatross
- Follow the Friendly Floatees
- Magazine Design Workshop I
- Plastics Aplenty
- The Life Cycle of Plastics

# Vocabulary

| Term | Part of Speech | Definition |
|---|---|---|
| **adhere** | *verb* | to stick to or support. |
| **apex predator** | *noun* | species at the top of the food chain, with no predators of its own. Also called an alpha predator or top predator. |

| Term | Part of Speech | Definition |
|---|---|---|
| **bioaccumulation** | *noun* | process by which chemicals are absorbed by an organism, either from exposure to a substance with the chemical or by consumption of food containing the chemical. |
| **biomagnification** | *noun* | process in which the concentration of a substance increases as it passes up the food chain. |
| **decomposer** | *noun* | organism that breaks down dead organic material; also sometimes referred to as detritivores |
| **ecosystem** | *noun* | community and interactions of living and nonliving things in an area. |
| **ecotoxicology** | *noun* | study of substances that are harmful to the environment. |
| **food web** | *noun* | all related food chains in an ecosystem. Also called a food cycle. |
| **ingestion** | *noun* | the act of eating or consuming. |
| **pollutant** | *noun* | chemical or other substance that harms a natural resource. |
| **primary consumer** | *noun* | organism that eats producers; herbivores. |
| **primary producer** | *noun* | organisms, such as plants and phytoplankton, that can produce their own food through photosynthesis or chemosynthesis; also called autotrophs. |
| **producer** | *noun* | organism on the food chain that can produce its own energy and nutrients. Also called an autotroph. |
| **secondary consumer** | *noun* | organism that eats meat. |
| **tertiary consumer** | *noun* | carnivore that mostly eats other carnivores. |
| **toxin** | *noun* | poisonous substance, usually one produced by a living organism. |
| **trophic level** | *noun* | one of three positions on the food chain: autotrophs (first), herbivores (second), and carnivores and omnivores (third). |