



MICROPLASTICS, MAJOR IMPACTS: EXPLORING CHANGE IN SEAGRASS MEADOWS

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Grade Level
High School

Subject Area
Environmental Science

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Focus: This lesson demonstrates the dynamic nature of ecosystems by using a game to model how abiotic factors like microplastic pollution input can have negative impacts on biotic components of seagrass meadow ecosystems. It introduces the concept of a positive feedback loop and how human actions affect natural environments.

Grade Level: Environmental Science

Virginia Standards of Learning:

ENV.1 The student will demonstrate an understanding of scientific and engineering practices by

- interpreting, analyzing, and evaluating data
- developing and using models

ENV.7 The student will investigate and understand that pollutants have physical, chemical, and biological consequences at the local, regional, and global level.

ENV.9 The student will investigate and understand that individual and collective actions influence environmental sustainability and policy at local, national, and global levels.

Learning Objectives:

Students will be able to:

- Identify biotic and abiotic components of an ecosystem
- Record pollution inputs and calculate impacts
- Plot changes in ecosystem health over time
- Discuss how ecosystems respond to pollution and the role of human management
- Recognize the concept of feedback loops

Total length of time required for the lesson: 45 – 60 minutes

Vocabulary:

Abiotic : non-living components of an ecosystem

Biotic : living components of an ecosystem

Ecosystem : the interaction of all the biotic and abiotic parts of an environment

Feedback loop (positive) : a cycle where a change causes effects that make the change even stronger



Habitat : place where an organisms naturally lives that provides food, water, shelter, and space it needs to survive

Microplastic : plastics smaller than 5 mm

Photosynthesis : the process of converting light into sugar and oxygen using carbon dioxide and nutrients

Seagrass : grasses that grow underwater, also called Submerged Aquatic Vegetation

Background Information:

Seagrass meadows are important ecosystems in the Chesapeake Bay and worldwide. Seagrass is a type of Submerged Aquatic Vegetation, meaning it is a “true plant” that photosynthesizes. It is found on the coast of every continent except Antarctica! Seagrass meadows are habitats used by many organisms; they make especially good nursery grounds for fish as prey can hide from predators and there are many resources concentrated in meadows compared to the open ocean. Seagrass meadows have biotic components including plants (seagrass) and animals (fish, skates, whelks, etc.), that are affected by the abiotic components like water, sediment (which has microorganisms living in it), sunlight, nutrients, and temperature.

Microplastics are diverse pollutants smaller than 5mm in size that fall under the abiotic category. They come from many sources, have many pathways to the environment, and their impacts are not well understood (check out the “Trawling through the Five Gyres: A Microplastic Research Study” VA SEA Lesson Plan). However, microplastics have been found everywhere scientists have looked for them, including the deepest parts of the ocean, on remote islands, and even in the human body. Most microplastics found in the environment came from the breakdown of larger plastics like water bottles, plastic bags, or fishing gear (referred to as secondary microplastics). As plastics spend time in the environment, they interact with fish, plants, and even the water itself. This may be problematic because plastics are made with lots of chemicals, some of which are harmful to aquatic and marine life.

Research on microplastic pollution in seagrass meadows is currently being carried out by researchers all over the world, including here in VA! Scientists think coastal zones like the Chesapeake Bay and Eastern Shore may be important areas for microplastic concentration, as microplastics can enter coastal areas from both land runoff and ocean tides. My research at the Virginia Institute of Marine Science investigates how much microplastic gets trapped in seagrass meadows, how long it stays there, and whether the seagrass blades themselves or the sediment below holds more. The answers to these questions will help us understand what risks there are to the health of seagrass itself and all the organisms living in the meadow from the threat of microplastic pollution. In this lesson, students will simulate this ongoing research by investigating microplastic inputs and calculating their impact on seagrass ecosystem health. *If you are interested in learning more about this research, check out <https://www.plasticpollutionlab.com/>

This lesson can be adjusted to apply to other pollutants or nutrients/eutrophication

Materials & Supplies:

- Gameboards – 1 per group (OR make an interactive meadow with 1 container of playdoh and 5-10 pipe cleaners per group)
- Dice – 1 per group
- Coin or token – 1 per group
- Player Role Nameplates – 1 per group
- Events cards – print in color or black/white on colored paper
- Management Decision cards - print in color or black/white on colored paper
- Management Decision board – 1 per group
- Microplastic tokens or dry erase marker – beans/beads/bingo chips
- Ziplock bags – 1 per group
- Optional : calculators

Teacher Preparation:

Print Player Role Nameplates (1 set of 4 per group), Gameboards (1 per group), Events cards (1 set of 4 for the teacher), Management Decision cards (1 set of 4 per group), and Management Decision board (1 per group). Cut out nameplates and cards. Laminate the boards and cards for reuse. Sort ≥ 20 microplastic tokens, Management Decision cards (1 of each = 4 total), 1 coin, and 1 die into a ziplock bag for each group. *This only needs to be done once.* Print out instructions handout (1 per group) and worksheets.

* Advanced option to print out events cards for the groups instead of the teacher. *

* Option to have student groups build a 3D meadow rather than using the given Gameboard. Note this will extend the lesson time. *

Procedure:

Introduction – 10 minutes

1. The instructor will introduce the lesson and activity with the included PowerPoint. Go over background information on seagrass meadows in the Chesapeake Bay as a focal ecosystem, seagrass, and microplastics. Refer to the slide notes for extra information and/or talking points!
 - a. Slides 1-4 introduce the lesson, author, and hook
 - b. Slides 5-9 introduce seagrass ecosystems
 - c. Slides 10-14 introduce microplastic pollution and the research driving this lesson
 - d. Slide 15 introduces the game. Slide 16 has a diagram version of the instructions. Slides 17-23 walk through all phases of the first round of the game. Cycle through these slides each round to keep students on track, or leave slide 16 projected on the board while students are playing for reference.

- e. Slide 24 prompts discussion of the results, including which team won. Slide 25 gives a real-world example of a positive feedback loop from eutrophication.



Ecosystem Simulation – 15 minutes

1. Separate class into teams of 4 and distribute materials.
 - a. Each team should receive one bag of prepared game pieces with nameplates, one gameboard, one Management Decision board, one Instructions Handout, one Data Collection Worksheet, and two Graphing Worksheets.
 - b. Students will self-assign roles, switching each round. Roles and responsibilities are labeled on the nameplate and include “Human Activities” to roll the die, “Marine Scientist” to place tokens, “Data Analyst” to record data throughout the round, and the “Policy Advisor” to make management decisions.
2. Before starting the game, remind students that each round represents a year (or one growing season) in the seagrass meadow. All teams should start with 6 “Policy Points”, 1 microplastic token in the sediment, and “Seagrass Health” at 14. The team with the healthiest meadow at the end of the game wins!
 - a. Healthy: ≥ 12 , unhealthy: 7-12, collapsed: ≤ 7
3. The teacher will lead the groups through each phase of the game using the PowerPoint to keep everyone on track. Each round consists of 5 phases. It is recommended the teacher demonstrates a round before the students join in.
 - a. Phase 1 - Random Event: The teacher draws an event card that will apply to every group. Groups record impacts in the Data Collection Worksheet. Return event card to pile and shuffle.
 - b. Phase 2 - Management Decision Phase: *Skip this phase in Round 1. Include in all other Rounds. * Each team may spend policy points on management decisions once per round. Once spent they cannot be renewed unless an events card is drawn which gives new policy points. Management decisions are optional. If spending Policy Points, do so now. Record any impacts in Data Collection Worksheet.
 - c. Phase 3 - Inputs Phase: Roll die for number of microplastic tokens to take. Flip a coin for the fate of all microplastic tokens: heads = sediment, tails = blade. Record in Data Collection Worksheet and place microplastic tokens in appropriate space on gameboard.
 - d. Phase 4 - Impacts Phase: Calculate Ecosystem Impacts in Data Collection Worksheet. First calculate the Light Blocking Penalty (# of microplastic tokens on blades) and Nutrient Blocking Penalty (# of microplastic tokens in sediment (starting + new)). Then calculate Total Growth (3 (baseline photosynthesis) - light penalty - nutrient penalty) for the round. Use the Total Growth to calculate Adjusted Seagrass Health and move the Seagrass Health Indicator. Refer to the Data Collection Answer Key for an example.
 - e. Phase 5 - Feedback Loop Check: If Seagrass Health ≤ 7 , enter a feedback loop. Lose -1 health at the end of each turn even if total growth is positive. If Seagrass Health returns to 14 you may exit the feedback loop.

- f. End of Round: Reset blade microplastic tokens. Remove HALF of sediment microplastic tokens. Rotate team member roles and start next round at Phase 1 Random Event.
4. At least 5 rounds are recommended, but this activity can be lengthened or shortened as necessary. Starting points and penalties may need to be adjusted.
 - a. Students should continue playing if the seagrass health reaches zero or negative values. When they do the graphing activity, however, the minimum value should be 0 (i.e. any negative values should be treated as zeros).

Graphing Data – 10-20 minutes

1. After playing 5 rounds, students will use the Graphing Worksheet provided to graph the data collected during play.
2. Students should work in pairs to make a double bar graph of Seagrass Health (y-axis) over Time (x-axis); each round will have a bar for starting and final seagrass health.
*Easier option for students to make a single bar chart using either starting or final health. Advanced option for students to work individually or to remove axis labels from given chart. *
 - a. Data will look different for each team. The “Graphing Worksheet Answer Key” provides examples of what graphs may look like for healthy, unhealthy, and collapsed meadows.

Assessment – 10 minutes

1. Teams present the outcome of their simulation to the rest of the class (using PowerPoint slide 23), comparing how graphs differ between them. Discuss team strategies for management decisions and how effective they were.
2. Students will answer a few reflection questions on the Graphing Worksheet to tie their simulated game results back to the Chesapeake Bay and feedback loops.

Assessment:

Students will complete interpretation and reflection questions as part of the graphing worksheet. The instructor can decide whether these should be completed independently or in groups. A full class discussion of answers is recommended to ensure the take home messages of the activity are clear to students.

References:

- Li, C., Zhu, L., Li, W. T., & Li, D. (2023). Microplastics in the seagrass ecosystems: A critical review. *Science of the Total Environment*, 902, 166152.
- Tang, K. H. D. (2024). Microplastics in seagrass ecosystems: a review of fate and impacts. *Research in Ecology*, 6, 41-53.

Handouts/Worksheets:

1. Instructions Handout
2. Data Collection Worksheet
3. Graphing Worksheet

Answer Keys:

- 2A. Data Collection Worksheet Example
- 3A. Graphing Worksheet Answer Key

Appendices:

1. Gameboard
2. Management Decisions Board
3. Events Cards
4. Management Decisions Cards
5. Player Role Nameplates