Edition 3 (2016)

AGsploration
The Science of Maryland Agriculture

UNIVERSITY OF MARYLAND EXTENSION

Something Fishy

Seafood and Aquaculture in Maryland

GOAL STATEMENT:

Students will understand the importance of aquaculture's role in providing a sustainable seafood supply for an increasing human population in the Chesapeake Bay watershed.

OBJECTIVES:

- Relate Chesapeake Bay seafood to Maryland agriculture and identify watershed species that serve as food for people.
- Understand that harvest rates that are higher than reproductive rates can lead to a population's decline.
- Compare the effects of human activity on publicly and privately owned seafood resources.
- Explain how aquaculture can help provide a sustainable seafood supply for humans.

REQUIRED MATERIALS:

This activity in this lesson must be completed in groups of 4 students.

- Large plates (1 per group)
- Small plates (1 per student)
- Spoons (1 per student)
- Paper or plastic cup (1 per group)
- Copies of activity instructions (1 per student)
- Copies of simulation data sheets (1 per student)
- Copies of analysis and conclusion questions worksheet (1 per student)
- Goldfish crackers, crab crackers, or gummy fish (may be substituted for colored beads)
- Calculator (optional)

AMOUNT OF TIME TO ALLOW:

60 minutes. Extension activities will take additional time.

Background Information

About 17 million people live in the Chesapeake Bay watershed. This large population can have adverse affects on wildlife species living in the Chesapeake Bay, including species such as blue crabs and oysters that we harvest for food. Decreased water quality due to pollution, loss of habitat, and over harvesting due to increased demand puts stress on aquatic species and can lead to population decline.

Much of the seafood eaten in the Chesapeake Bay region is harvested from the wild, but many of the species we eat can be grown in captivity. **Aquaculture** is the practice of growing aquatic species in captivity to produce food and other resources for humans. Aquaculture is sometimes known as "fish farming" and is being used to raise a variety of species including catfish and rockfish (striped bass). New technologies are being developed in Maryland that are enabling producers to raise valuable seafood species such as soft crabs, oysters, and hard shell blue crabs.

Aquaculture can be used to raise fresh water or salt water species. Salt water aquaculture is sometimes called **mariculture** because it is used to raise marine (ocean) organisms. In addition to aquatic animals, aquaculture can also support the growth of aquatic plants. In Maryland there is a major aquatic plant industry that raises varieties for water gardens, shoreline stabilization, and storm water pond management. Maryland also has companies that raise marine ornamental species like corals for aquarium use.

The Northeastern Regional Aquaculture Center (NRAC), headquartered at University of Maryland, College Park, is one of five Regional Aquaculture Centers funded by the U.S. Department of Agriculture. The center serves 12 northeastern states and the District of Columbia and sponsors cooperative regional research and extension projects in support of the aquaculture industry. Current projects include research into the effects of temperature on infection rates in clams, techniques for raising green sea urchins, and construction of low-cost raceway systems for raising fish.

Aquaculture can be accomplished in a variety of ways including raising organisms in tanks with high-quality aeration and filtration systems, large ponds with aeration systems, and cages that are placed within natural aquatic habitats. For tank and pond farming, aeration systems are needed to increase dissolved oxygen available to aquatic animals. Filtration systems are necessary in tank systems to remove contaminants from water. Today's modern aquaculture tank systems incorporate technologies that help convert nearly all of the toxic substances into non-toxic ones.

Natural aquatic habitats and aquaculture facilities have a **carrying capacity** – a maximum number of organisms that can be supported. Exceeding the carrying capacity in a natural or human-made habitat will usually result in death of organisms due to resource shortages and/or reduced water quality. Aquaculture facilities must carefully regulate the density or number of organisms raised in each tank, pond, or unit of space.

Engagement
10 minutes

Ask students what they think of when they hear the word agriculture and what products are produced through agriculture. Discuss the ideas generated by the class. Students will probably not associate seafood with agriculture because people typically think of agriculture as farming carried out on land. Tell the class that Maryland's seafood industry is actually considered to be part of Maryland agriculture because it helps provide food for the state's residents.

Ask students what they think of when they hear the word seafood. Discuss ideas and have the class generate a list of types of seafood items that people eat. Can the students identify kinds of seafood that come from the Chesapeake Bay or the Bay watershed? Compile a list of ideas. Examples may include blue crabs, oysters, clams, and a variety of fish species. Transition to the concept of aquaculture by asking if students have heard the word aquaculture. How is aquaculture similar to agriculture? Compare and contrast the terms agriculture and aquaculture.

Ask the following series of questions and have students stand on one side of the room for "True" or the other side of the room for "False." Review each question and answer before moving on to the next question.

1. Agriculture is the growing of plants to feed people. (*False — it is the growing of plants and animals to feed people and animals and for making non-food products.*)
2. If a waterman harvests oysters from the Chesapeake Bay, his work is considered to be part of Maryland agriculture. (*True*)
3. The population of blue crabs in the Chesapeake Bay is increasing rapidly. *(False — it is declining due to pollution, overharvesting, and other factors.)*
4. The population of oysters in the Chesapeake Bay is increasing rapidly. *(False — it is also declining due to pollution, overharvesting, diseases, and other factors.)*
5. A commercial fisherman is considered to be an agriculture career. *(True)*
6. Aquaculture is the practice of growing aquatic species in captivity to produce food and other resources for people. *(True)*
7. Aquaculture decreases the amount of seafood available to Maryland residents. *(False — it increases available seafood by supplementing the organisms harvested from the wild.)*

Exploration
35 minutes

Tell students that they will be participating in two simulations. During simulation A, students will harvest and eat seafood (snack items) from a public aquatic habitat such as the Chesapeake Bay. During simulation B, students will harvest from a public aquatic habitat AND a privately-owned pond or aquaculture facility.

The simulations work best with minimal class discussion beforehand. It is best to have students complete the activities without thinking about them too much in advance. Pre-discussion sometimes prompts students to use population management strategies instead of acting by instinct.

Simulation A: Harvesting from Public Waters

1. Divide students into groups of 4. Have each group place 16 snack items on a large plate in the center of the table. Explain that the plate represents an aquatic habitat (i.e. Chesapeake Bay, pond, etc.) from which food can be harvested. Snack items represent a seafood species (i.e. crabs, oysters, fish, etc.) that students harvest and eat for nourishment and to keep themselves and their families alive.
2. Start round 1. Have each student in each group take a turn harvesting and eating seafood. Each student must eat at least 2 organisms to get enough nutrition to stay alive, but students may take more than 2 organisms if they are hungry. (If there is a group of 3 people, have one person in the group "eat" for two people.)
3. At the end of round 1, have students complete the round 1 row in their data chart.
4. Have students add seafood to the habitat by following these reproduction rules.
   - The organisms that remain at the end of the round reproduce (double), BUT:
   - There is an upper limit (carrying capacity) on how many organisms the habitat can support. The plate can never hold more than 16 organisms at a time because the carrying capacity of the habitat is 16.
5. Have students repeat steps 2 – 4 for four rounds.
6. At the end of round 4, have students calculate the total number of organisms harvested during the simulation.

Simulation B: Harvesting from Public Waters AND a Private Aquaculture Facility

During this simulation, students will repeat the previous simulation with one major change. This time, each person will also have his or her own private aquaculture facility.

1. Provide each student with a small plate (to represent their private aquaculture facility) populated with 3 organisms. The public aquatic habitat will remain in place just as in simulation A. Have students populate the public habitat with 16 organisms.
2. Start round 1. Have each student in the group take a turn harvesting and eating seafood. As before, each student must eat at least 2 organisms to stay alive but may take more than 2 if they are hungry. Students can take food from the shared habitat, their private aquaculture facility, or both.
3. At the end of round 1, have students complete the round 1 row in their data chart.
4. Have students add seafood to the public habitat and their private aquaculture facilities by following these reproduction rules:
   - The organisms that remain at the end of the round reproduce (double), BUT:
   - The public habitat still holds a maximum of 16 organisms.
   - Each student's private aquaculture facility can hold a maximum of 3 organisms.
5. Have students repeat steps 2 – 4 for rounds 2, 3, and 4.

After the simulations are complete, have students complete the analysis and conclusion questions on their worksheets.

Explanation

15 minutes

Lead the class through a comparison of results from simulation A and simulation B. For simulation A, most groups tend to drive the public habitat population they are harvesting to extinction, which means that all individuals of the species in a given habitat have died or been removed. Someone gets greedy (you can increase the greed factor by using very tasty snack items) and takes more than what he or she needs to survive. The overharvesting causes the population to decline and eventually be depleted, and one or more people starve due to lack of food. Sometimes certain groups plan ahead and manage the population from the beginning by taking no more than two organisms per student each round. Groups that manage the population carefully end up harvesting a total of 32 organisms without depleting the population. They have implemented a population management practice that is sustainable.

For simulation B, groups sometimes successfully manage the public habitat by taking only two organisms per student each round, but most groups once again drive the public habitat extinct. In contrast, nearly all students manage their private aquaculture facilities carefully by taking only one organism each round. If everyone in a group took exactly two organisms from the public habitat each round and one organism from his or her private aquaculture facility each round, a total of 48 organisms would be harvested without depleting the public or private populations.

Emphasize to the class that public aquatic resources such as those in the Chesapeake Bay are difficult to manage. It is challenging to manage a resource that is being harvested by a large number of people over a vast area such as the Bay watershed. People often don't feel responsible for shared resources, and so they tend to overexploit them. (Note that these simulations do not account for any organisms lost through death by any means other than consumption. Factors such as disease, predation, and toxicity decrease population numbers even further.)

Privately-owned resources such as aquaculture facilities are almost always managed carefully. (You might want to go online and print some photos of aquaculture facilities in your area to help students visualize what you are describing.) Owners of private facilities are in business to make a profit, and as a result the owners ensure the populations of seafood organisms are not overharvested. The simulations demonstrate that aquaculture in Maryland has the potential to supplement harvests from the Chesapeake Bay and provide seafood for a growing human population without depleting the Bay's species.

Aquaculture, combined with species management overseen by the Department of Natural Resources (DNR), can help maintain stable aquatic populations within the food chains and food webs of the Bay while simultaneously feeding the state's residents. In Maryland, DNR sets and manages limits on the daily number of species that can be harvested from all Maryland waterways including the Chesapeake Bay and its tributaries. There is often controversy over whether harvesting limits have been set too high or too low, and the decisions sometimes involve political debate. DNR is also responsible for licensing both commercial and private fishermen. If DNR did not set harvesting limits, a variety of species, such as the Atlantic Sturgeon, would be near or at extinction. Atlantic Sturgeon was overfished in the Atlantic region from colonial times to the early 1900's and drastically declined. In 1998, the Atlantic Marine Fisheries Commission closed the entire Atlantic coast to Atlantic Sturgeon fishing for the next four decades in hopes that healthy populations will rebound. Other examples include the shad fishery which has been closed for many years, the rockfish moratorium of the 1980s, and blue crab restrictions during the early 2000s.

Extension

Conduct an in-depth investigation of aquaculture. Here are some ideas to explore.

- Use the internet to show students photos of a variety of aquaculture setups and facilities.
- Have the class generate a list of potential pros and cons of aquaculture.
- Discuss some of the problems with modern aquaculture and how they might be remedied.

Scientists and producers haven't yet perfected all aquaculture techniques. There can be problems such as increased spread of diseases among organisms kept in high population density. Sometimes the feed given to farmed aquatic organisms is significantly different from the diet of wild populations, and the nutritional content of farm-raised seafood can vary if an improper diet is implemented.

Have students to research food and/or non-food aquatic species that are farmed in Maryland. What are they? How are they raised? Where are they raised? How important are they in the state's agricultural economy? What are the current issues and challenges related to Maryland aquaculture?

Career Connections

- **Seafood Harvester (Waterman)** – This career includes fishermen as well as ship operators and crew. The job duties are varied, but seafood harvesters work together to catch fish, dredge oysters, or otherwise harvest wild aquatic species for use by humans.
- **Seafood Marketer** – This is a business person that specializes in promoting, advertising, and selling seafood and seafood products.
- **Seafood Restaurant Owner** – This person owns one or more restaurants that purchase fresh or frozen seafood, cook it, and serve it to customers.
- **Seafood Processor** – This person or facility works to prepare aquatic organisms for consumption by people or use in a wide variety of seafood products.
- **Fisheries Worker** – This is a worker who routinely gathers biological information about fish to help monitor the health of populations.
- **Fisheries Manager** – This is a person who uses biological data about fish to develop plans that help prevent overharvesting of fish populations. This person may help manage wild fish populations and/or breed fish and other aquatic species for release into the wild to replenish wild populations.
- **Watershed Restoration Specialist** – This person works to protect valuable aquatic habitats and is often involved in activities such as Bay grass planting that help to improve watershed habitats and water quality.
- **Aquaculture Facility Owner** – This is a person – also called an aquaculturist, fish farmer, or shellfish farmer – who owns a business that contains ponds, tanks, and/or cages used to farm aquatic species and sell them for profit.
- **Water Quality Specialist** – This person monitors water quality and the health of fish and

other species by analyzing water samples and maintaining filtering equipment. Some water quality specialists take jobs as aquarists, meaning that they monitor the water quality to keep species healthy in aquarium settings.

- **Marine Scentist** – This career involves researching, studying, and working to solve problems related to oceans and marine-life as well as its related industries.
- **Environmental Research Biologist** – This is a person who studies ways to protect the health of animals and plants in a particular environment.

Evaluation

Student understanding can be evaluated through class discussion or assessment of completed activity data sheets. The following questions may also be used to evaluate student learning.

1. Define aquaculture.
2. How can aquaculture help preserve natural populations of aquaric organisms?
3. Why is it difficult to manage public aquatic resources like the Chespeake Bay?

References

Maryland Department of Agriculture, <www.mda.maryland.gov>.

Maryland Seafood and Aquaculture, <www.marylandseafood.org>.

Maryland Sea Grant Program, <www.mdsg.umd.edu>.

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Name: ______________________

Date: ____________ Period: ________

Seafood Harvesting Simulation Instructions

Simulation A: Harvesting from Public Waters

1. Get into your group. Place 16 snack items on a large plate in the center of your table. The plate will represent an aquatic habitat (i.e. Chesapeake Bay, pond, etc.) from which food can be harvested. Snack items will represent a seafood species (i.e. crabs, oysters, fish, etc.) that you will harvest and eat for nourishment and to keep yourself and your family alive.
2. Start round 1. Take turns harvesting and eating seafood. You must eat at least 2 organisms to get enough nutrition to stay alive, but you may take more than 2 organisms if you are hungry. (If there are only 3 people in your group, have one person “eat” for two people.)
3. At the end of round 1, complete the round 1 row in your data chart.
4. Add seafood to the habitat by following these reproduction rules.
    - The organisms that remain at the end of the round reproduce (double), BUT:
    - There is an upper limit (carrying capacity) to how many organisms the habitat can support. The habitat can never hold more than 16 organisms.
5. Repeat steps 2 – 4 for four rounds.
6. At the end of round 4, calculate the total number of organisms harvested during the simulation.

Simulation B: Harvesting from Public Waters AND a Private Aquaculture Facility

During this simulation, you will repeat the previous simulation with one major change. This time, each person will also have his or her own private aquaculture facility.

1. Set up your private aquaculture facility by putting 3 organisms on a small plate. The public aquatic habitat will remain in place just as in simulation A; start with 16 organisms in the public habitat.
2. Start round 1. Take turns harvesting and eating seafood. As before, you must eat at least 2 organisms to stay alive but may take more than 2 if you are hungry. You can take food from the shared habitat, your private aquaculture facility, or both.
3. At the end of round 1, complete the round 1 row in your data chart.
4. Add seafood to the public habitat and your private aquaculture facility by following these reproduction rules:
    - The organisms that remain at the end of the round reproduce (double), BUT:
    - The public habitat still holds a maximum of 16 organisms.
    - Your private aquaculture facility can hold a maximum of 3 organisms.
5. Repeat steps 2 – 4 for found rounds.
6. At the end of round 4, calculate the total number of organisms harvested during the simulation.

After the simulations are finished, complete the analysis and conclusion questions on your worksheet.

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Name: ______________________

Date: ______________ Period: ________

Simulation A Data Sheet: Harvesting Seafood from Public Waters

Round Number	Number of Organisms Harvested			
	Person A	*Person B*	*Person C*	*Person D*
1				
	Number of organisms remaining in public habitat:			
2				
	Number of organisms remaining in public habitat:			
3				
	Number of organisms remaining in public habitat:			
4				
	Number of organisms remaining in public habitat:			
Total Public Organisms Harvested Per Person				

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Date: ____________ Period: ________

Simulation B Data Sheet: Harvesting Seafood from Public Waters AND an Aquaculture Facility

Round Number	**Number of Organisms Harvested** (# harvested from public habitat PLUS # harvested from aquaculture facility)			
	Person A	*Person B*	*Person C*	*Person D*
1				
	Number of organisms remaining in public habitat:			
2				
	Number of organisms remaining in public habitat:			
3				
	Number of organisms remaining in public habitat:			
4				
	Number of organisms remaining in public habitat:			
Total Organisms Harvested Per Person				

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Date: _______________ Period: ________

Analysis and Conclusion Questions

During simulation A:

1. What happened to the population in the public waters? Why?

2. If everyone in your group ate 2 organisms during each round, your group could have harvested a total of 32 organisms. How many organisms did your group harvest? ___________ If less than 32, why?

During simulation B:

3. What happened to the population in the public waters compared to the population in the private aquaculture facilities? Explain any differences.

4. If everyone in your group ate 2 organisms from the shared habitat and 1 organism from their private facility each round, your group could have harvested a total of 48 organisms. How many organisms did your group harvest? ___________ If less than 48, why?

Conclusions:

5. Compare your data with other groups. Did any groups experience different results? If so, what strategies did they use to manage their populations?

6. Why are shared seafood resources more likely to go extinct than privately owned seafood resources?