Finding the Way Home

Adapted from: Activity 27 "The Great Anadromous Fish Game" Living in Water. The National Aquarium in Baltimore, 1997.

Grade Level: Intermediate

Duration: 1-2 class periods

Setting: Classroom

Summary: Students play a board game to simulate the seasonal migration of fish that live in the ocean and travel to freshwater to spawn.

Objectives: Students will understand the causes and effects of migrations and fluctuations in fish populations.

Vocabulary: migration, spawn, ectotherms, preferred temperature, diadromous, catadromous, anadromous, estuary, brackish, salinity, runoff, thermal pollution.

Related Module Resources:
- Article: *River Herring Return to the Susquehanna*
- Diadromy Fact Sheet
- Back to the Sea Fact Sheet
- Fishways Fact Sheet

Materials (Included in Module):
- Playing Boards & Rules
- Game Cards
- Game Pieces
- Dice
- Calculators (in module)

Additional Materials (NOT Included in Module):
- Graph paper
- Colored pencils

ACADEMIC STANDARDS: ENVIRONMENT & ECOLOGY

7th Grade

4.7B Explain how species of living organisms adapt to their environment
- Explain how living things respond to changes in their environment

4.7C Explain natural or human actions in relation to the loss of species
- Identify natural or human natural or human impacts that cause habitat loss
- Analyze and explain the changes in an animal population over time
- Explain differences among threatened, endangered, and extinct species

10th Grade

4.6A Explain the biotic and abiotic components of an ecosystem and their interaction
- Interpret possible causes of population fluctuations

4.7C Identify and explain why adaptations can lead to specialization
- Explain factors that could lead to a species' increase or decrease
- Explain how management practices may influence the success of specific species

12th Grade

4.7C Analyze the effects of threatened, endangered, or extinct species on human and natural systems
- Identify and explain how a species' increase, decline, or elimination affects the ecosystem and/or human social, cultural, and economic structures
- Explain why natural populations do not remain constant.

BACKGROUND: Migration takes place when animals move from one area to another. Fish migrate because of climate changes, diminishing food resources, and the need to **spawn** (lay their eggs). When the seasons change so does water temperature. Fish are **ectotherms**; the temperature of the surroundings influences their body temperature and functions. Fish are unable to wear wet suits like us; they must migrate to find water that is more suitable to their needs. Each fish species has a specific range of water temperature in which it can live. If the water temperature is not within that range, the fish cannot survive. Within each range of water temperature is a narrower range called the **preferred temperature**, this is the optimal temperature in which the fish can live, grow, and reproduce. It is the ideal temperature for the fish's survival. Fish with similar temperature preferences are separated into three groups: cold water (< 70°F), cool water (>60°F but <80°F) and warm water (>80°F) (PA Fish & Boat Commission, 2000). If the water temperature is not in their preferred temperature range, then the fish must migrate to water that meets their needs. There are two types of **diadromous** fish (fish that migrate between salt water and fresh water). The first type is **catadromous**; they run from fresh water to salt water, an example is the American Eel.

The most abundant population of American Eels in Pennsylvania is located in the Delaware River. Some Eels have been reported in the headwater sections of the Ohio River Watershed (PA Fish & Boat Commission, 2000). The second type is called **anadromous**; these fish run from saltwater to freshwater to spawn. The American Shad, Blueback Herring, Striped Bass, and the Shortnose Sturgeon are examples.

The Blueback Herring is found only in the lower Delaware River and the Delaware **Estuary** (semi-enclosed coastal water body where out-flowing river water meets seawater) in Pennsylvania. While inhabiting the streams they prefer to live in the current above a rocky bottom (PA Fish & Boat Commission, 2000). The blueback herring begin life in the flowing sections of ocean tributaries, not far from the stream's outlet. In their fourth year the bluebacks are mature and spawn. They spawn in **brackish** (somewhat salty) water and in fresh water over a firm, not silted, bottom. Here their sticky eggs sink and stick to the stream bottom. The parents do not care for the young, after spawning they head back to the sea. The tiny one-millimeter-long eggs hatch in two or three days, at a preferred water temperature a little over 70 degrees. When the young bluebacks are about one month old and about two inches long, they head for saltwater. Bluebacks feed on zooplankton, shrimp, small fish, and fish eggs (PA Fish & Boat Commission, 2000).

Migrating fish may encounter several obstacles during their journey. Predation by a wide variety of animals, limited food supplies, changes in **salinity** and water level from unusual rainfall, abnormal temperatures, unusually severe storms, parasites and disease are all natural occurrences that may reduce the fish population (Living in Water, 1997). Flooding is an important natural occurrence that causes many problems for fish. Flooding causes the water in a stream to flow more rapidly. Silt is unable to settle to the bottom of a stream that is moving quickly, this is why the water looks muddy. Fish's gills are damaged by water that has a lot of silt and they have a difficult time breathing. Silt also carries bacteria that can cause an infection. When silt settles to the bottom of a stream it can bury insects that fish eat or smother fish eggs.

Humans have also reduced fish populations by increasing the amount of silt present in a stream. Humans disturb a stream by allowing farm animals to walk along the shore or in it, dig near a stream, or destroy riparian zones; these things allow loose sediment to enter the stream. Destruction of wetlands also disturbs fish populations. Wetlands provide oxygen for fish to breathe, a home for the fish to live, food sources, and clean water. Fish populations also suffer from human pollution; humans release waste products into the water that are either directly toxic or kill fish by lowering the oxygen level of the water. Accidental entry of toxic compounds (pesticides) with **runoff (**precipitation on land that drains off and reaches streams often with dissolved material), runoff sediment from farms or developments, obstructions to migration (dams), over fishing, and **thermal pollution** (the discharge of a heated liquid into natural waters at a temperature harmful to the environment) are all ways in which humans have decreased fish populations.

Even if human influence was not a factor, more fish are spawned than will ever survive to reproduce. A large increase in fish populations may occur if humans were no longer an influence. Overpopulation may result and there would be more competition for food, habitats, and spawning partners.

OVERVIEW: This activity is a board game that will be played in the classroom. The game is designed to simulate the migration of a blueback herring from salt water to fresh water to spawn. The students will encounter many hazards along their journey that will affect their reproductive success and migration.

PROCEDURE:

Teacher Preparation:

1. Copy the two **Fact Sheets** *Back to the Sea*, and *Smart Angler's Notebook:Diadromy*. These **Fact Sheets** are located in the binder. Have the students read these sheets to familiarize themselves with fish migration.
2. Next, copy (one of each per student) "Finding the Way Home" worksheet and the "Data Sheet: Finding the Way Home." The students will need to complete these while playing the game.
3. After distributing and reviewing the materials, assign students to groups. *There are 6 games and there can be 2 to 5 players per game.*
4. Read through the game rules and instructions together. Then, allow the students to play the game independently, remind them to complete their worksheets (Questions #1 through #3) and data tables as they play the game.
5. After the students have completed playing the game; remind them to complete questions #4 through #10 on their worksheets. Question #5 asks the students to graphically display their individual results. Graph paper and colored pencils will be needed to construct the graphs.
6. When the students are finished with their worksheets, hold a discussion session. *Refer to the* **Discussion** *section of these instructions*.

Student Activity:

1. Follow the instructions to play the game. While playing the game, complete the "Data Sheet: Finding the Way Home" and "Finding the Way Home" worksheet (only #1 through #3) that your teacher handed out.
2. After your group has completed the game, complete #4 through #10 on "Finding the Way Home" worksheet. Question #5 asks you to graph your individual results. Graph paper and colored pencils are available from your teacher.

DISCUSSION:

Compare the numbers of fish that successfully completed the annual migration. Have each student plot the number he/she finished with on the blank overhead provided so that everyone can see the variation in outcome.

Discuss the average number of successes and the range of the numbers. Was the herring population increasing or decreasing? At what stages in their lives were the herring the most vulnerable? *The herring face the most challenges when returning to the spawning grounds.*

Why are the healthy herring populations important? Are herrings important to other species? *Yes, the herring are important to dolphins, seagulls, bluefish, striped bass, and tuna for food.* Were they important to humans? *Yes, the herring are important to humans as plant fertilizer, chicken feed, fish bait, pickled herring, salt herring, and smoked herring. They are also used for fish oil in medicines, cosmetics, and paint. Herring are considered a delicacy in Japan.*

Have the students list the possible causes of mortality. *Refer to the **Natural/Human Causes of Mortality** Overhead.*

Ask students to suggest ways they could modify laws or the environment to increase the number of herring. *They may want to restrict fishing or prohibit land development. Answers will vary.*

EVALUATION:

- What does **diadromous** mean? *(fish that migrate between salt water and fresh water)* What are the two types of diadromy? *(Catadromous, anadromous)*
- Why do animals migrate? *(Animals migrate because of climate changes, diminishing food resources, need to spawn)*
- Where do **anadromous** fish migrate? *(from saltwater to freshwater)*
- What are some causes of mortality in anadromous fish populations? *(Refer to the **Natural/Human Causes of Mortality** file)*
- Have students complete and turn in worksheets and graphs.

EXTENSIONS & MODIFICATIONS:

- Have students read the article *River Herring Return to the Susquehanna* and write an article summary.
- What would happen if human-caused fish deaths were reduced? Let the students chose one set of conditions to change, for example, remove all of the fishing cards. Have the students play the game again and compare their numbers to the first round. Would the population of herring always increase? *No, overpopulation would occur and new limits would be reached.*
- Have the students choose another species of animal that migrates. Research its life history and create their own game. Then trade the games with other students and play.

NOTES: (TEACHERS, PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR OTHER TEACHERS USING THIS ACTIVITY IN THE FUTURE):

DATA SHEET: FINDING THE WAY HOME

Name_____Date_____

1. You are a female herring at the spawning ground carrying 100,000 eggs. You release your eggs and they are fertilized in the water. Pick a **Reproduction** card to find out how many of the fertilized eggs survived. Record them here: _____ offspring. This is the size of your school at the beginning of the game.
2. Play the game and record the numbers of your school and the causes of their death (mortality) on the Data Sheet: Finding the Way Home.
3. After you finish the game enter the numbers that remained at the end of each section of the migration for each player in your group.

Player Name	100,000 eggs in female	# eggs that survive	# young at end of stream	# young at estuary	# adults at end of ocean	# adults at end of estuary	# adults at spawning ground
1							
2							
3							
4							
5							
6							
Total							
Average							

4. Each of you played the same game. Explain why you got different numbers of fish at the end.

5. Graphically display what happens to herring at different stages by showing the average school size at each stage of the herring life cycle shown in question #3. Use a piece of graph paper. Work together in your group to develop ideas about a good graph to display your group's game data from question #3. Then each of you should make your own graph of your group's results. Compare and refine your work. Attach it to this paper.

6. Describe the changes in numbers of herrings as they grow from fertilized eggs to adults.

7. What percent of your group's eggs grew into fish that returned to spawn?

8. If you were a fisheries manager, list three specific changes you would do to increase the number of herring.
   1)

   2)

   3)

9. Assume that half the returning fish are female. How many of your school have to return to replace their mother?

10. Based on the returning fish from your group, could your group's population of fish increase in the next generation? Explain your answer.

FINDING THE WAY HOME RULES

GOAL

You are an adult female fish at the spawning ground. Your objective is to produce as many offspring that return to the spawning ground as possible. You will play the game to see how many of the baby herring get to the ocean to grow up and then return to spawn. You only need two fish to survive to replace your female in the population. But beware, there are many hazards lurking along the way!

HOW TO PLAY

1. There are two pieces to the board, a top and a bottom. Put them together and shuffle each set of hazard cards. Place the cards in the marked locations, the colors of the cards correspond to the colors of the board game spaces.

2. Select your game piece and place it in the Spawning Grounds. This is your starting point as an adult female herring. Record 100,000 as the number of eggs you carry. Pick a Reproduction Card to find out how many of your fertilized eggs survive. Record this number on your data sheet. Your offspring will now swim through the Streams and Creeks and then into Rivers and Estuary and out to the Ocean where they will feed and grow over several years. Survivors swim back into the Estuary, upriver and then upstream to spawn in the Creek where they were born.

3. Roll the die. The highest number starts first. The person to the left goes next. Play proceeds clockwise from that player.

4. Roll the die to find out how far you move your game piece. If you land on a space that says to draw a card, do so and read it out loud. If you picked a hazard card, you must record the number of fish in your school on your worksheet and the cause of mortality or death. For example, if you have 50,000 herring left and it says half of them were caught in nets, then you must reduce your herring to 25,000 fish and make note under human causes “fishing.”

5. If you picked a hazard card that wiped out your entire school going TO the Ocean, record and start completely over again back at the beginning. If you are wiped out coming back to the Stream Spawning Grounds then you are finished.

6. Going to the Ocean only draws cards that say To Ocean. Once you arrive at the ocean, your fish will live there for several years before returning to spawn.

7. When mature, your fish will return in early spring to the Estuary from which they came and swim back up to the exact place where they were born, to produce a new generation.

8. The player who gets the most fish back to the Spawning Ground WINS, not the player who gets there first!

DATA SHEET: FINDING THE WAY HOME

Name_____Date_____

Direction	Game Board Section	# Before hazard	Fraction or % that die	Kind of Natural Hazard	Kind of Human Hazard	Number after hazard
					# Of fertilized eggs you started with	
To Ocean	Stream & Creek					
	Stream & Creek					
	Stream & Creek					
	Stream & Creek					
					# Of offspring at the end of Stream	
	Estuary & River					
	Estuary & River					
	Estuary & River					
	Estuary & River					
					# Of fish at the end of Estuary	
Ocean	Ocean					
	Ocean					
	Ocean					
	Ocean					
	Ocean					
	Ocean					
					# Of adult fish at the end of Ocean	
Return to Spawn	Estuary & River					
	Estuary & River					
	Estuary & River					
	Estuary & River					
					# Of adult fish at the end of River & Estuary	
Return to Spawn	Stream & Creek					
	Stream & Creek					
	Stream & Creek					
	Stream & Creek					
					# Of adult fish that reached Spawning Grounds	