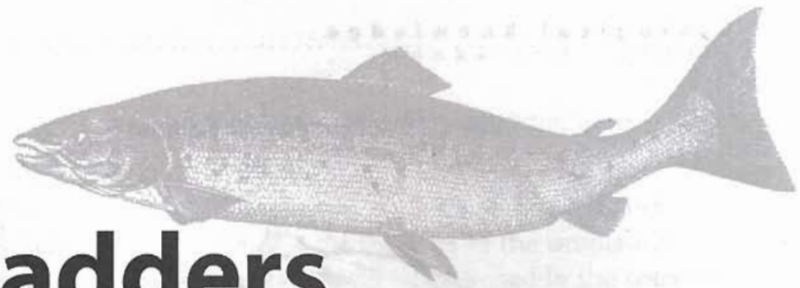

Hooks and Ladders

Objectives

Students will (1) describe how some fish migrate as part of their life cycles, (2) identify the stages of the life cycle of one kind of fish, (3) describe limiting factors affecting Pacific salmon as they complete their life cycles, and (4) generalize that limiting factors affect all populations of animals.

Method

Students simulate the Pacific salmon and the hazards faced by salmon in an activity portraying the life cycle of these aquatic creatures.

Materials

Large playing area (100 feet × 50 feet), about 500 feet of rope or string or six traffic cones for marking boundaries (masking tape may be used if area is indoors), two cardboard boxes, 100 tokens (3″ × 5″ cards, poker chips, macaroni, etc.), jump rope

Grade Level: 5–8

Subject Areas: Social Studies, Science, Environmental Education, Expressive Arts

Duration: one 30- to 60-minute session

Group Size: 20 to 30 students or more

Setting: outdoors or large indoor area

Conceptual Framework Topic Reference: IDIIB

Key Terms: life cycle, limiting factors, population, migration

Appendices: Simulations, Ecosystems

Background

Many fish migrate from one habitat to another during their lives. Both the Atlantic and Pacific salmon are examples of fish that endure a spectacular migration.

The life cycle for Pacific salmon begins when the female deposits 1,000 to 5,000 eggs in her freshwater spawn. The eggs are deposited in a shallow gravel depression that she digs by flapping her tail from side to side. Once the eggs are deposited, the male fertilizes them; then both fish nudge the gravel back over the eggs to offer as much protection as possible. The eggs are susceptible to factors such as predation or oxygen deprivation. Within a few days, both the male and female salmon have completed their reproduction cycle and soon die.

Newly hatched salmon, called "alevins," live in the gravel and survive by absorbing proteins from their yolk sacs. After a few weeks, the yolk sacs are gone and the small fish, known as "fry," move into deeper water to find food on their own. Salmon remain in freshwater streams feeding and growing for many months or even years before migrating downstream to the ocean. These small ocean-bound salmon are now called "smolts." These salmon will feed in estuaries where fresh and salt water mix. After a few weeks of adjusting to the brackish water, the young salmon swim into the ocean.

In the ocean, the salmon grow rapidly by feeding on a rich food supply that includes other fish, shrimp, and crustaceans. Young salmon may encounter many limiting factors, including sharks, killer whales, other marine mammals, and humans who are fishing for salmon for commercial and personal uses.

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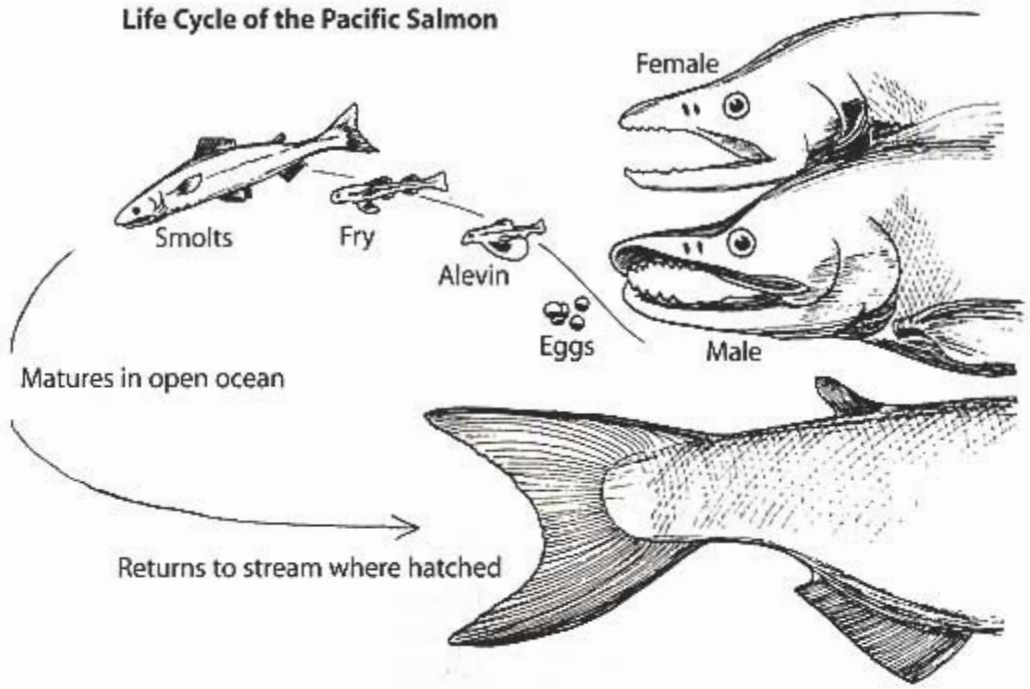


After 2 to 5 years in the ocean, the Pacific salmon begin the journey that guides them to their own hatching sites. Pacific salmon spawn only once in their lives. Salmon have an inherent ability to return to their original streams. Juvenile salmon imprint or memorize the unique odors of their home streams. As returning adults, they use their senses of smell to detect those odors and guide them upstream to where they were hatched. Once there, the salmon spawn and then die.

Salmon face a variety of limiting factors in the completion of their life cycle. A limiting factor is a reason or cause that reduces the population of an organism. Some limiting factors are natural, and some result from human intervention into natural systems.

Natural limiting factors include drought, floods, predators, and inadequate food supply. Throughout their lives, salmon depend on a habitat that provides plants to shade streams and deep pools of water for spawning and resting. Incorrect logging practices, grazing, mining, road building, and development often destroy streamside vegetation, erode land, and fill streams with silt that covers gravel beds.

Dams are another limiting factor that block or slow migration to and from the ocean. Salmon become disoriented by the reservoirs formed by dams and become exposed to unhealthy conditions like high water temperatures and predators. Fish ladders can be installed to help salmon through the dams. Fish ladders can be water-filled staircases that allow migrating fish to swim around the dam.

Another threat to salmon is overfishing. Overfishing, combined with habitat destruction, is viewed by biologists as a cause for the decline of salmon populations.

NOTE: All possible conditions are not covered by the design of this activity. However, the activity does serve to illustrate three important concepts: life cycle, migration, and limiting factors.

Procedure

1. Ask the students what they know about the life cycles of fish that live in their area. Do any local fish migrate to spawn? If yes, which ones? (Mullet, shad, lake trout, striped bass, suckers, carp, and salmon are examples of fish that migrate to spawn.)
2. Set up a playing field as shown in Diagram A, including spawning grounds, reservoir, downstream, upstream, and ocean. The area must be at least 100 feet by 50 feet. Assign roles to each of the students. Some will be salmon; others will be potential limiting factors to the salmon. Assign the students roles as follows:
   - Choose two students to be the turbine team. They will operate the jump rope, which represents the turbines in hydroelectric dams. Later in the simulation, when all the salmon have passed the turbine going downstream, those students move to the upstream side to become the waterfall-broad jump monitors. (See diagram.)
   - Choose two students to be predatory wildlife. At the start of the simulation, the predators will be stationed in the reservoir above the turbines to catch the salmon fry as they try to find their way out of the reservoir and move downstream. Then they will move to below the turbines where they catch salmon headed downstream. Later in the activity, when all the salmon are in the sea, these same two predators will patrol the area above the "broad jump" waterfalls. There they will feed on salmon just before they enter the spawning ground. (See diagram.)
   - Choose two students to be humans in fishing boats catching salmon in the open ocean. The students in the fishing boats must keep one foot in a cardboard box to reduce their speed and maneuverability.
   - All remaining students are salmon.

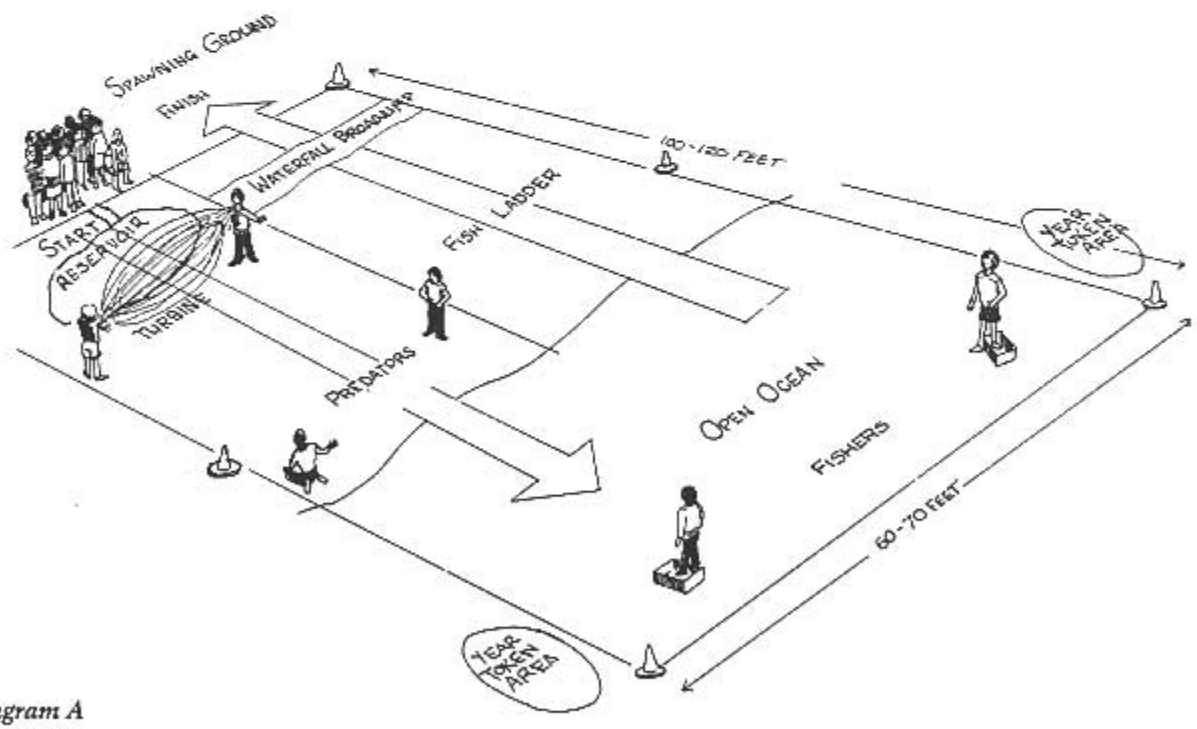


Diagram A

continued

NOTE: These figures are based on a class size of 25 to 30. If the group is larger or smaller, adjust the number of people who are fishing and predatory wildlife accordingly.

3. Begin the activity with all the salmon in the spawning ground. The salmon first move into the reservoir above the dam. They must stay in the reservoir while they count to 30. This pause simulates the disorientation that salmon face because of a lack of current in the lake to direct them on their journey. During this time the predators may catch the salmon and escort them one at a time, to become part of the fish ladder. The salmon then start their journey downstream. The first major limiting factor that the salmon encounter is the turbines at the dam. At most dams, escape weirs guide migrating salmon past the turbines. The student salmon cannot go around the jump-rope swingers, but they can slip under the swingers' arms if they do not get touched while doing so. A salmon dies if the turbine (jump rope) hits it. The turbine operators may change the speed at which they swing the jump rope. Any salmon that "dies" at any time in this activity must immediately become part of the fish ladder. The student is no longer a fish, but becomes part of the physical structure of the human-made fish ladders now used by migrating salmon to get past barriers such as dams. The students who are the fish ladder kneel on the ground as shown on page 47, with one body space between them.

4. Once past the turbines, the salmon must pass some predatory wildlife. The predators, who have moved from the reservoir area to the area below the turbine, must catch the salmon with both hands—tagging isn't enough. Dead salmon are escorted by the predator to become part of the fish ladder. Later, the salmon that survive life in the open ocean will pass through the fish ladder to return to the spawning ground. NOTE: Both the predatory wildlife in the downstream area and the people fishing in the open ocean must take dead salmon to the fish ladder site. This action moves the predators and fishing boats off the field regularly, helping to provide a more realistic survival ratio.

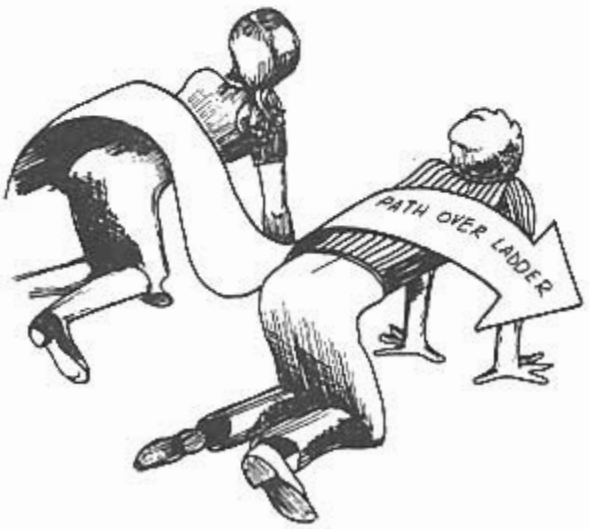
5. Once in the open ocean, the salmon can be caught by fishing boats. The salmon must move back and forth across the ocean area in order to gather four tokens. Each token represents 1 year of growth. Once each fish has four tokens (4 years' growth), that fish can begin migration upstream. The year tokens can be picked up only one at a time on each crossing. Remember, the salmon must cross the entire open ocean area to get a token. The "4 years" that these trips take make the salmon more vulnerable; thus they are more readily caught by the fishing boats. For this simulation, the impact of this limiting factor creates a more realistic survival ratio on the population before the salmon begin the return migration upstream.

6. When four of the year tokens have been gathered, the salmon can start upstream. The salmon must walk through the entire pattern of the fish ladder. This enforced trip through the fish ladder gives the students a hint of how restricting and tedious the upstream journey can be. In the fish ladder, predators may not harm the salmon.

7. Once through the ladder, the salmon face the broad-jump waterfall. The waterfall represents one of the natural barriers salmon face going upstream. Be sure the jumping distance is challenging but realistic. The two former turbine students will monitor the jump. The salmon must jump the entire breadth of the waterfall to be able to continue. If the salmon fails to make the jump, then it must return to the bottom of the fish ladder and come through again.

NOTE: When playing indoors, the broad-jump waterfall may be changed into a stepping-stone jump defined by masking tape squares on hard floors.

8. Above the falls, the two predators who started the simulation as the predators below the turbines have now become the last set of limiting factors faced by the salmon. They represent bears—one example of predatory wildlife. Again, remember that the predators must catch the salmon with both hands. If they catch a salmon, they must then take the student they caught to become part of the structure of the fish ladder.
9. The activity ends when all the salmon are gone before the spawning ground is reached—or when all surviving salmon reach the spawning ground.
10. Next engage the students in a discussion. Explore topics such as
    - the apparent survival or mortality ratio of salmon,
    - the role of the barriers,
    - the role of the predatory wildlife and the people fishing,
    - where the losses were greatest,
    - where the losses were least,
    - what the consequences would be if all the eggs deposited made the journey successfully, and
    - what seemed realistic about this simulation and what did not.



11. Ask the students to summarize what they have learned about the life cycle of salmon, the salmon's migration, and limiting factors that affect salmon. Make sure the students have a clear working definition of limiting factors. Encourage the students to make the generalization that all animals—not just the Pacific salmon—are affected by limiting factors. Ask the students to give examples of limiting factors. They might mention the availability of suitable food, water, shelter, and space; disease; weather; predation; and changes in land use and other human activities.

Variation: Atlantic Salmon

This activity can easily be adapted to feature Atlantic salmon. The most significant difference between Pacific and Atlantic salmon is that the Atlantic salmon can spawn more than once. Many Atlantic salmon make their complete migratory journey and spawn two or more times. All Pacific salmon die after spawning only once. To adapt this activity for Atlantic salmon, students are to make as many complete migratory trips as possible. After the activity is finished, ask students to report how many times they successfully completed the migratory cycle. Graph the data. Have the students explain how age influences mortality rates and susceptibility to limiting factors.

Variation: Striped Bass

This activity can also be adapted to feature striped bass rather than salmon. The striped bass is more widely distributed along the United States' coastlines than either the Atlantic or Pacific salmon. Like the salmon, striped bass reproduce in fresh water and migrate to and mature in salt water. They also must face the same limiting factors described in this activity.

continued

Extensions

1. Write a report on the life history of one of the species of salmon (e.g., chinook or king, chum or dog, pink or humpback, coho or silver, sockeye or red, Atlantic). Create a mural showing the life cycle of this salmon.
2. Research and illustrate the life cycle of any local fish. If possible, look for one that migrates.
3. Compare how the life cycle of a Pacific salmon is similar to and different from the life cycle of one or more local fish.
4. Investigate similarities and differences in the migration and life cycles of an Atlantic and a Pacific salmon. Investigate the life cycle of salmon in the Great Lakes region of the United States.
5. Visit fish hatcheries that work with migratory species and investigate how they function.
6. Explore ways that dams can be modified to let fish safely pass downstream and upstream. Design the "perfect" fish ladder.
7. Investigate and discuss commercial fishing for salmon. Investigate and discuss personal, including recreational, fishing for salmon.
8. Find out about laws protecting migratory species, including fish.
9. Consider this approach, and try the activity again:

   In the past 100 years, salmon have experienced many new, human-caused limiting factors. Dams, commercial fishing, timber harvest, and road construction have had a tremendous impact on salmon populations. In 1991, the Snake River sockeye salmon was placed on the federal endangered species list. In the past, tens of thousands of sockeyes would make the 900-mile return trip from the sea to Idaho's mountain streams and lakes. There they spawned and died. Their offspring hatched and began their early development in fresh water. The actual migration to the Pacific Ocean could be completed in as few as 9 days. Today that trip takes more than 60 days. In 1991, only four Snake River sockeye salmon returned to their spawning grounds.

   To simulate these increases in salmon limiting factors, play several rounds of "Hooks and Ladders." Allow each round to represent the passage of 25 years. Start in 1850. In that year, do not include dams or commercial fishing operations in the scenario. As time passes, add the human commercial fishing operations. Build dams (jump ropes) as the scenario progresses into the 21st century.

   Describe some of the possible effects on salmon from increased limiting factors as a result of human activities and interventions. Discuss possible positive and negative effects on both people and salmon from these increases in limiting factors affecting salmon. When the activity reaches "the present," predict what might happen to salmon in the future. Recognizing the complexity of the dilemma, discuss possible actions, if any, that might be taken to benefit both people and salmon.
10. Find out if salmon exist in your state. If so, are they native or were they introduced?

Evaluation

1. List, describe, and illustrate the major stages in a Pacific salmon's life cycle.
2. Identify and describe some of the limiting factors that affect salmon as they complete their life cycles.
3. Identify and describe some limiting factors that might affect other animal populations.