Hooks and Ladders

Adapted from: "Hooks and Ladders" in Project WILD Aquatic. Council for Environmental Education, 1992.

Grade Level: basic, intermediate

Duration: 30 to 60 minutes

Setting: large open area

Summary: Students simulate lake trout and the hazards they face in a physically involving activity portraying the life cycle of these aquatic creatures.

Objectives: Students will 1) recognize that some fish migrate as part of their life cycle; 2) identify the stages in a steelhead trout life cycle; 3) describe limiting factors affecting lake trout as they complete their life cycle; and 4) generalize that limiting factors affect all populations of animals.

Vocabulary: limiting factor

Related Module Resources:
- Books: on fish
- Posters: Fish Commission Series
- Microscope Slides: fish parts
- Trout Life Cycle Mount

Materials (Included in Module):
- Field Markers
- Poker chips
- Jump rope
- Extra rope
- Bright vests

Additional Materials (NOT Included in Module):
- Two cardboard boxes

ACADEMIC STANDARDS:

7th Grade

4.1.C Explain the effects of water on the life of organisms in a watershed
- describe the life cycle of organisms that depend on water

4.1.E Describe the impact of watersheds and wetlands on people.
- explain the impact of watersheds and wetlands in…wildlife habitats and pollution abatement

4.7.B Explain how species of living organisms adapt to their environment.
- explain how living things respond to changes in their environment
- explain how one species may survive an environmental change while another may not

10th Grade

4.1.C Describe the physical characteristics of a stream and determine the types of organisms found in aquatic environments.
- describe and explain the physical factors that affect a stream and the organisms living there
- explain the habitat needs of specific aquatic organisms

4.7.C 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

4.1.E Evaluate the trade-offs, costs and benefits of conserving watersheds and wetlands.
- evaluate the effects of human activities on watersheds and wetlands

4.6.C Analyze how human action and natural changes affect the balance within an ecosystem.

BACKGROUND: The Steelhead Trout

Many species of fish spend a portion of their life in a habitat that is different from that which they were born in. When these fish reach maturity they often return to their place of birth to spawn. The steelhead trout (*Oncorhynchus mykiss*) is an excellent example of this type of fish in Western Pennsylvania. The steelhead trout is a rainbow trout that migrates from a lake or ocean up a river to spawn.

The steelhead trout requires cool well oxygenated water to survive. Their optimal temperature is about 55 degrees Fahrenheit. They are found in lakes that have relatively low nutrient levels- either from natural sources or pollution. Steelhead trout have a low tolerance for acid and do best in slightly alkaline (basic) waters. During the summer they live in the open lake at depths of up to 200 feet. In the fall and spring they are often found in shallower waters near shore where they feed.

The steelhead trout feeds on a wide variety of organisms. Although they rely heavily on small fish for food, they also feed on plankton, insects, and crustaceans.

When a steelhead is 3-5 years old it is sexually mature and will make its first journey back to its stream of birth to spawn. The female steelhead will lie anywhere from 200 to 12,000 eggs. These eggs are deposited in the gravelly substrate of the stream and are fertilized by one or more male steelhead. The eggs hatch in 4-7 weeks, depending on water temperature. During the first week after hatching the fry will feed off of its' yolk sac, after which, it will start to feed on small aquatic insects. In the fall, when the water begins to cool, the fry will move down stream and into the open lake. The fry will live in the lake for the next 3-5 years until it is mature, then it will return to the river to spawn for the first time. Unlike the Pacific salmon the steelhead does not die after it spawns it will return to the lake and live to spawn 3-5 times.

The steelhead trout face many hazards in their life that serve as limiting factors in the completion of their life cycle. **Limiting factors** are things responsible for reducing the population of an organism. Some limiting factors are natural, while others are the result of human actions and their impacts on nature. Before they hatch, the eggs are susceptible to many limiting factors. Many fish and animals feed on the trout eggs. They can also be smothered by silt. Damaged watersheds are prone to erosion that can results in sediment build up in the stream, which smothers the eggs. This problem is made worse by human actions, such as logging, road building, construction, and unsustainable farming. Lowered water levels from urban withdrawal can also kill eggs by exposing them to air.

As juveniles and adults in the open lakes the steelhead face more challenges. They are highly sought after by fishermen for sport and food. They are preyed upon by larger fish and are stressed by water pollution. Warm water that is consequently low in dissolved oxygen is a major problem for these fish. This warming is largely a result of human actions such as riparian zone removal, parking lot runoff and industrial wastewater discharge. On their journey to their spawning grounds the steelhead populations are reduced. In the shallow confining waters of rivers and streams the trout are easy prey for bears, humans, and birds. The rivers that they migrate up are often blocked off by flood

control gates and hydroelectric dams as well as by natural landslides and logjams. These obstacles are often impossible to pass over or through by these now large trout. In an attempt to correct the problems created by man-made dams fish ladders are installed at the dams. Fish ladders are water filled staircases that allow the fish to pass over dams and continue up stream. They do this by jumping from one water filled step to the next, slowly moving up a few feet with each jump.

The American Shad like many other fish is **anadromous**. This means they migrate up rivers from the ocean to spawn. The American Shad (*Alosa sapidissima*) is the largest member of the Herring family. A typical adult fish weighs between 4-8 pounds. The largest shad ever caught in Pennsylvania weighed 9 pounds 9 ounces.

Unlike the Pacific Salmon, American Shad do not all die after they spawn. Many shad spawn and then return to the ocean, living to spawn another year. The female shad produces as many as 600,000 eggs, but the average is closer to 250,000. Males fertilize the eggs during spawning, which takes place at dusk in water that is 60 to 65 degrees Fahrenheit. The fertilized eggs fall to the river bottom and settle into the gravel substrate. The eggs hatch in 5-6 days.

The young grow rapidly feeding on freshwater plankton and aquatic insects. By fall the fry are 4-6 inches long and travel and feed in schools, large groups of fish that travel and feed together. As the water temperature drops in mid fall the fry begin their journey to the ocean. Once in the ocean the shad will follow the coastline in a north and south migration until they are mature. In the summer they migrate as far north a Newfoundland; then in the winter they migrate south as far as Florida.

At 3 to 4 years of age the males reach sexual maturity and break away from the north bound schools in the spring returning to their natal rivers to spawn. The females will mature and do the same at 4-5 years of age. Most American Shad make this trip several times in their life.

In Pennsylvania shad are found in the Susquehanna River and Delaware River drainage systems. In the last 30 years the shad population has become threatened by many factors. Hydroelectric dams made it impossible for migrating shad to reach their natal rivers and spawn. Over fishing by commercial fisheries and sport fishermen caused drastic declines in the American Shad populations as well. Pollution and sedimentation of rivers has also become a serious threat to the American Shad. In the 1970's the American Shad populations had dwindled to almost nothing.

Thanks to the joint efforts of the PA Fish Commission, the Department of Environmental Protection, the Maryland Department of Natural Resources, and the Upper Chesapeake Watershed Association the American Shad is making a comeback in PA. Programs were instituted to build fish ladders allowing shad to migrate past dams. New regulations concerning the harvest of shad were created and artificial breeding and stocking programs were implemented.

OVERVIEW: Students play and active game to simulate steelhead trout and the hazards they face.

PROCEDURE:

1. Begin by asking the students what they know about the life cycle of other fish that live in their area. Do any local fish migrate to spawn? If yes, which ones? (Mullet, shad, striped bass, suckers, carp, and salmon are examples of fish that migrate to spawn.) In this activity, students will learn about some of the characteristics of the steelhead trout, one species of fish that migrates as a part of its life cycle.

2. Set up a playing field as shown in the diagram at the end of the activity, including spawning grounds, reservoir, downstream, upstream, and ocean. The area must be about 100 feet by 60 feet. Assign roles to each of the students. Some will be trout; others will be potential hazards to the salmon. Assign the roles as follows:
   - Choose two students to be the turbine team. These are the ones who operate the jump rope, which represents the turbines in hydroelectric dams. Later in the simulation, when all the trout have passed the turbine going downstream, these students move to the upstream side to become the waterfall-broad jump monitors (See diagram).
   - Choose two students to be predatory wildlife, such as eagles or bears. At the start of the simulation, the predators will be stationed in the reservoir above the turbines to catch the trout fry as they try to find their way out of the reservoir and downstream. Later in the activity when all the trout are downstream, these same two predators will patrol the area above the "broad jump" waterfalls. There they will feed on trout just before they enter the spawning ground. (See diagram.)
   - Choose two students to be humans in fishing boats catching trout in the open ocean. These students in the fishing boats must keep one foot in a cardboard box to reduce their speed and maneuverability.
   - All remaining students are the lake trout.

   Note: These figures are based on a class size of 25-30. If the group is larger or smaller, adjust the number of people who are fishing and predatory wild animals accordingly. (For larger groups, there should be more humans and predators, for smaller, groups, there should be less.)

3. Begin the activity with all the trout in the spawning ground. The trout first move into their reservoir above the dam. They must stay in the reservoir while they count to 30. This simulates the disorientation that trout face due to a lack of current in the lake to direct them on their journey. During this time, the predators may catch the trout and escort them one at a time to become part of the fish ladder. The trout then start their journey downstream. A major hazard is the turbines at the dam. At most dams there are escape wires to guide migrating trout past the turbines. The student trout 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 trout dies if the turbine (jump rope) hits it. The turbine operators may change the speed at which they swing the rope.

*Note: any trout 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 ladders now used by migrating trout to get past barriers such as dams. The students who are the fish ladder kneel on the ground as shown under the diagram, a body-wide space between them.

4. Once past the turbines the trout must get past some predatory wildlife. The predators, who have moved from the reservoir area to the area below the turbine, must catch the trout with both hands—tagging isn't enough. Dead trout are escorted by the predator to become part of the fish ladder. Later, the trout who survive life in the lake use the structure of the fish ladder—by passing through it—to return to the spawning ground.
   *Note: Both the predatory wildlife in the last downstream area and the people fishing in the lake must return the trout to the ladder site. This gets the predator and fishing boats off the field regularly, helping to provide a more realistic survival ratio.

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

6. Once four of the tokens are gathered, the trout can begin upstream. The trout 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 trout.

7. Once through the ladder, the trout faces the broad jump waterfall. The waterfall represents one of the natural barriers the trout must face going upstream. Be sure the jumping distance is challenging but realistic. The two former turbine students will monitor the jump. The trout must jump the entire breadth of the waterfall to be able to continue. If the trout 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 for safety on hard floors.

8. Above the falls, the two predators who started the simulation as the predators below the turbines are now the last set of limiting factors faced by the lake trout. They represent the bears—one example of predatory wildlife. Again, remember that the predators must catch the trout with both hands. If they do catch a trout, they must then take the students caught to become part of the structure for the fish ladder.

9. The activity ends when all the trout are gone before the spawning ground is reached—or when all surviving trout reach the spawning grounds.

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

Explore topics such as

- The apparent survival-mortality ratio of trout
- The students' feelings throughout the activity
- The role of the barriers
- The role of the predatory wildlife and people fishing
- Where the losses were greatest
- Where the losses were least
- What the consequences would be if all the eggs deposited became trout that made the successful journey
- What seemed realistic about this simulation and what did not

EVALUATION:

- Describe the life cycle of a steelhead trout
- List limiting factors that affect steelhead trout and describe their effects

EXTENSIONS AND MODIFICATIONS:

- Write a report on the life history of one species of trout (brook trout, rainbow trout, etc.). Create a mural showing the life cycle of this trout.
- Research and illustrate the life cycle of any local fish. If possible, look for one that migrates.
- Visit fish hatcheries that work with migratory species and investigate how they function.
- Explore ways that dams can be modified to let fish safely pass downstream and upstream. Design the "perfect" fish ladder.
- Find out about laws protecting migratory species, including fish.

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

HOOKS AND LADDER DATA SHEET

ROUND	# Predators (include humans)	List hazards	# Fish Start	# Fish Survive
1				
2				
3				
4				
5				

NOTES:

DIAGRAM FOR HOOKS AND LADDERS

Adapted from an illustration from:
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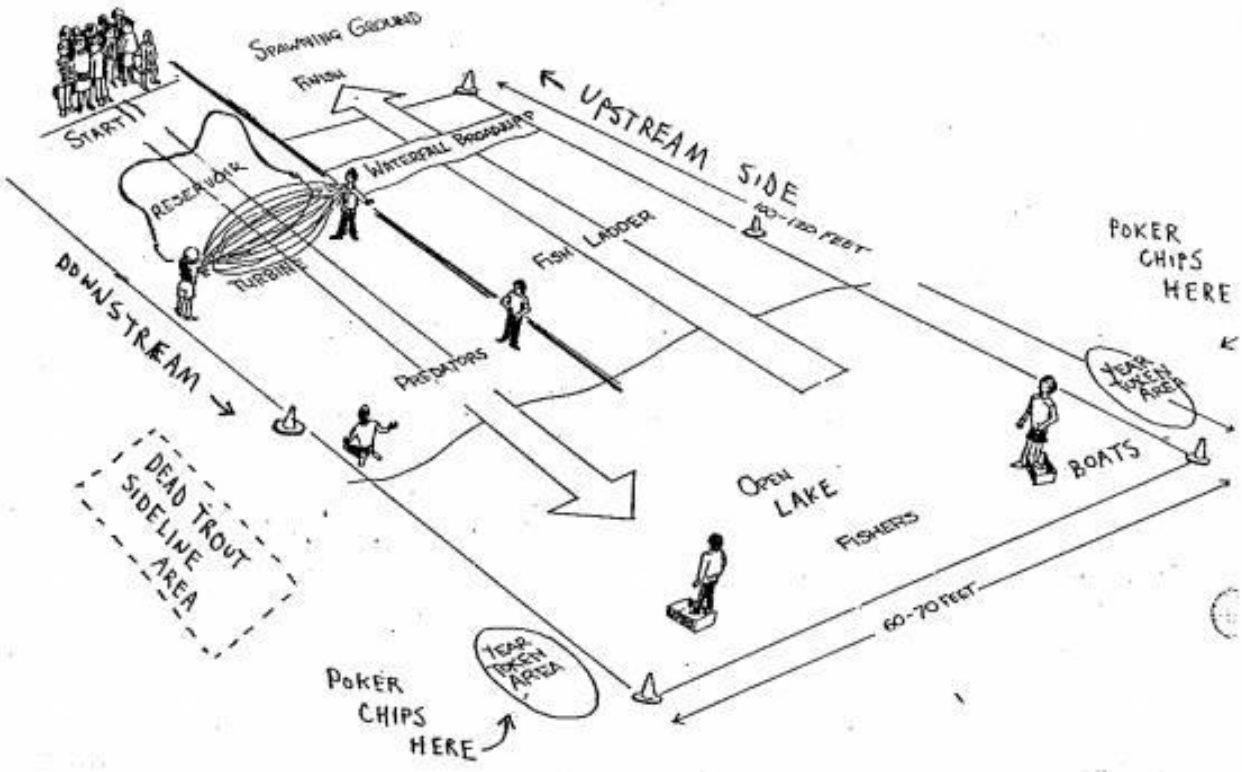

MAKE A FISH LADDER OUT OF PIECES OF ROPE TO LAY ON GROUND