Friends of Tryon Creek
Art-Based Nature Education – Focus on Salmon

2000 Greenspaces Environmental Education grant project

~ Project References ~
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Friends of Tryon Creek
Art-Based Nature Education – Focus on Salmon
Session One: Salmonid life cycle

Session 1

Grade: Adaptable from 3 to 8
Time: 1 hour

Overview: Students will begin their journey through a fish's life with an introduction to salmonid (salmon and steelhead) life cycles.

Objectives: Students will:

- learn the lifecycle of salmon and steelhead
- put together a nature journal to record information and reflections during the unit

Materials

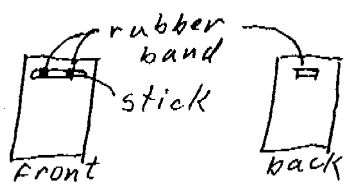
- video *Life Cycle of the Salmon* by Oregon Sea Grant **or** book *Salmon Stream* by Carol Reed-Jones
- covers - cardboard or tag board cut into 9"x 6" rectangles with 2 holes punched
- binding - 8" sticks (about 1/2" in diameter) and rubber bands (#64)
- inserts - paper cut into 81/2 " x 5 ½" rectangles with 2 holes punched to match cover
- crayons for decorating journal covers (be sure to use water proof materials)

Set up: Have journals materials ready at a workstation. Video player if that option is used.

Introduction: Tell the students they are beginning a journey into the life of a fish. Explore what the word journey means to them. Explain that they will be learning about salmon and how they live over the next few weeks. In order to keep a record about everything they are going to learn about the fish – they are going to make a nature journal to record data and gather their observations.

Procedure:

- Read a story about the salmon life cycle or show a video.
- Discuss where salmon live at different times in their lives.
- Show an example of a nature journal.
- Hand out cover sheets – have the students decorate them. Be sure to have them include their names.
- Hand out the inserts, sticks, and rubber bands. Assemble the journals by arranging inserts between covers so that the holes line up. Place a rubber band through one set of holes and secure over one end of the stick. From the back insert the other end of the rubber through the second set of holes and secure over the other end of the stick.
- Draw the salmon life cycle in the journals. Or use life cycle work sheet (attached) as one of the inserts.



Options:
Play Hooks and Ladders to review salmon life cycle.

Life Cycle of a Salmon

STREAM

fry

alevin

egg

smolts

RIVER

ESTUARY

(adapts to salt water) (adapts to fresh water)

Adult

OCEAN

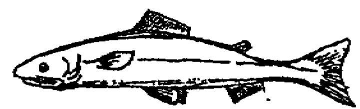
Cut out each stage in the life cycle and paste onto the life cycle chart.

egg

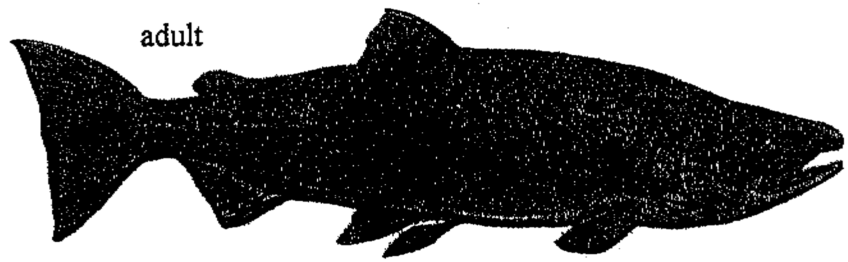
alevin

fry

smolt



adult



Draw arrows showing how the salmon develops.

HOOKS AND LADDERS

OBJECTIVES

Students will be able to: 1) recognize that some fish migrate as part of their life cycle; 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 cycle; and 4) generalize that limiting factors affect all populations of animals.

METHOD

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

BACKGROUND

Many fish live part of their lives in one habitat and then migrate to another habitat. Some make their migratory journeys to mature and reproduce. Both the Atlantic and Pacific salmon are spectacular examples of migrating fish. (See this activity's "Variation" section for adapting "Hooks and Ladders" to Atlantic Salmon.)

Pacific salmon are destined to spawn only once in their lifetime. Within their genetic fiber is an encoded instinct that drives them from the time of hatching along a monumental journey from their freshwater spawning beds downstream into the sea. Once in the sea they spend several years reaching the maturity needed for their single return journey to their original hatching ground. Once there, the salmon spawn and die.

Salmon must face a myriad of hazards that serve as limiting factors in the completion of their life cycle. Limiting factors are factors that reduce the populations of living organisms. Sometimes the limiting factors are natural and sometimes they result from human intervention with natural systems.

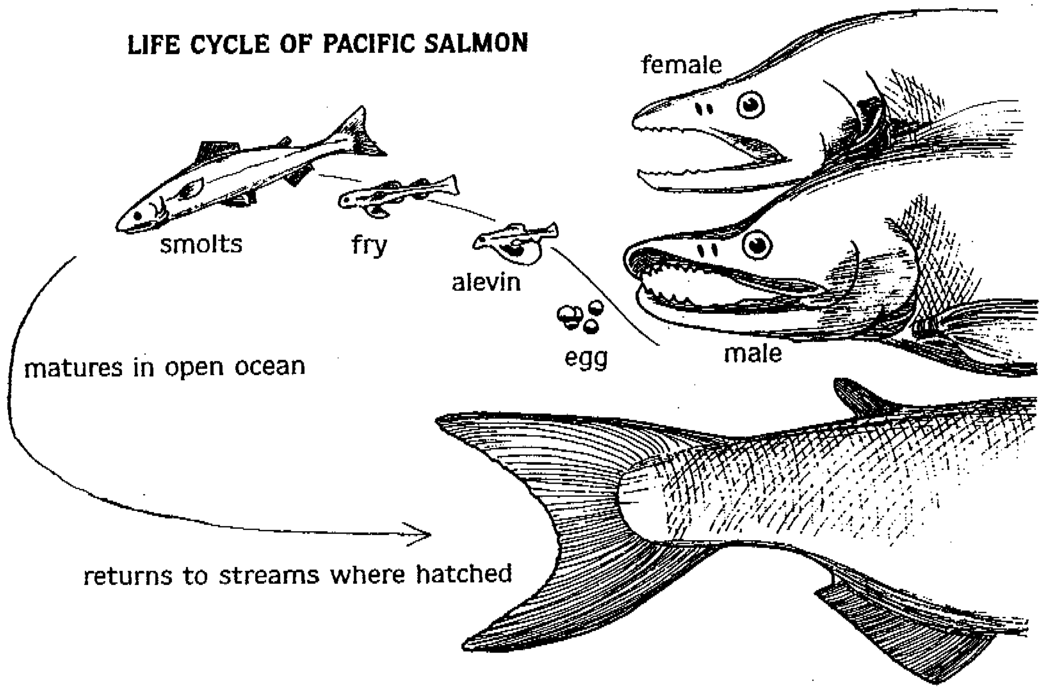
The female Pacific salmon deposits 1,500 to 7,000 eggs in her freshwater spawn. The eggs are deposited in a shallow gravel depression scooped out by the female. Once deposited, the eggs are fertilized by the male and then both fish nudge the gravel back over the eggs to offer as much protection as possible. Within a few days both the male and female salmon have completed their reproduction and soon die.

The eggs, before and after hatching, are susceptible to many limiting factors. Smothering silt can be washed in suddenly from watersheds damaged by a variety of land-use practices and events—including erosion following some road building, logging and fires. Predators can eat some of the eggs and damage hatching populations. Dropping water levels can isolate salmon offspring in streamside depressions to remain isolated and die. After hatching, the small fish—called "alevins"—spend their first two weeks hiding in the gravel. Gradually they absorb their yolk sac and become known as "fry." If they survive the first two weeks, they then begin their journeys. Some head directly to the sea. Depending on the species, young salmon may spend several months to as much as a year or more in the river before migrating to the estuary and then to the open ocean.

The small ocean-bound salmon, now called "smolts," are at once confronted by hazards on their downstream journey. Dams slow salmon migration. Because salmon cannot find the current behind dams they become disoriented in reservoirs. When disoriented, salmon are extremely vulnerable to predators. Low water in streams, predatory birds, mammals, and larger fish pose additional hazards. Up to 90% of the salmon that hatch never reach the sea.

When in the ocean, the salmon grow rapidly by feeding on the ocean's rich food supply. Predators such as sharks, killer whales and other marine mammals take their toll. In addition, humans fish for salmon commercially and for personal reasons, including food and recreation.

LIFE CYCLE OF PACIFIC SALMON



In two to five years, the Pacific salmon start the journey that will guide them back to the rivers and streams leading to their own hatching site. The upstream migration from the ocean is also a series of hazards. For example, dams hinder their journey and would block it completely if fish ladders were not installed. Fish ladders are water-filled staircases that allow the migrating fish to swim upstream around the dam. Humans who fish, eagles, bears, and other predatory mammals also reduce the numbers along the way to the spawning ground. Sometimes landslides and logjams provide unexpected new barriers. So too do the natural waterfalls and rapids that the now weighty salmon must overcome. Once back at the spawning ground the life cycle of the Pacific salmon begins anew. To maintain the Pacific salmon population, some biologists believe that only one pair of fish from each spawn must return to deposit and fertilize eggs.

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

The major purpose of this activity is for students to gain an understanding of some of the complex characteristics of the life cycle of one representative aquatic species, the Pacific salmon.

MATERIALS

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

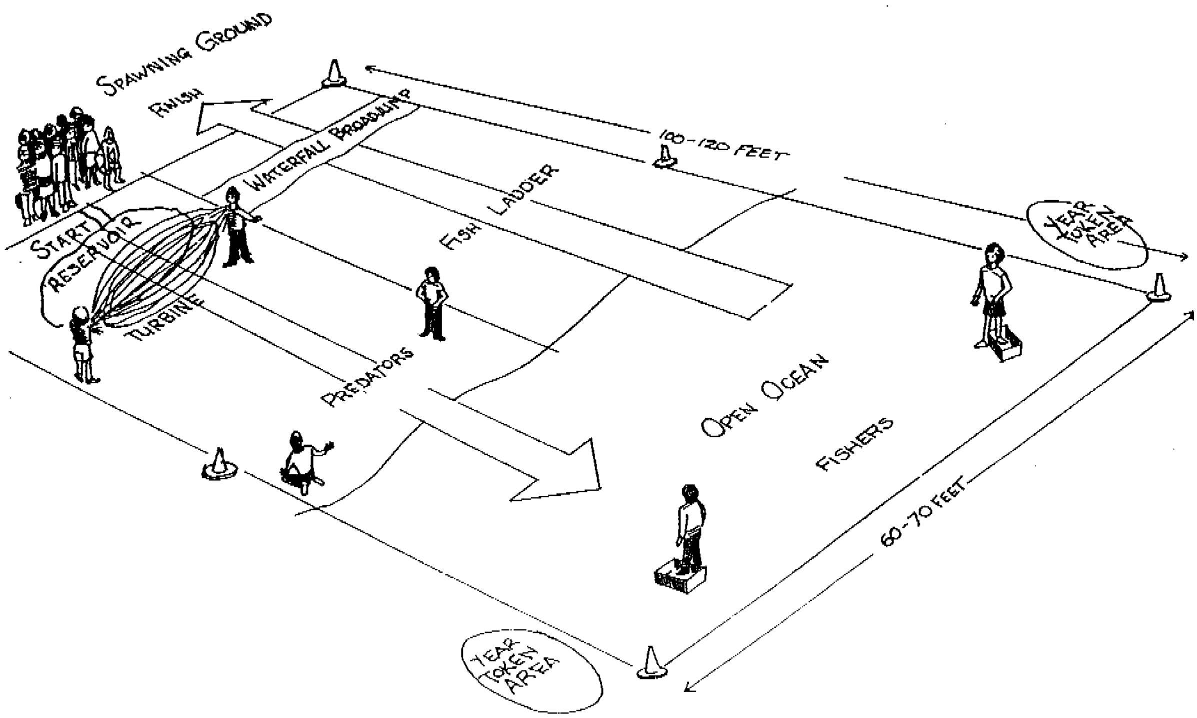
PROCEDURE

1. Begin by asking the students what they know about the life cycle 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.) In this activity, students will learn about some of the characteristics of one species of fish that migrates as a part of its life cycle—the Pacific salmon.

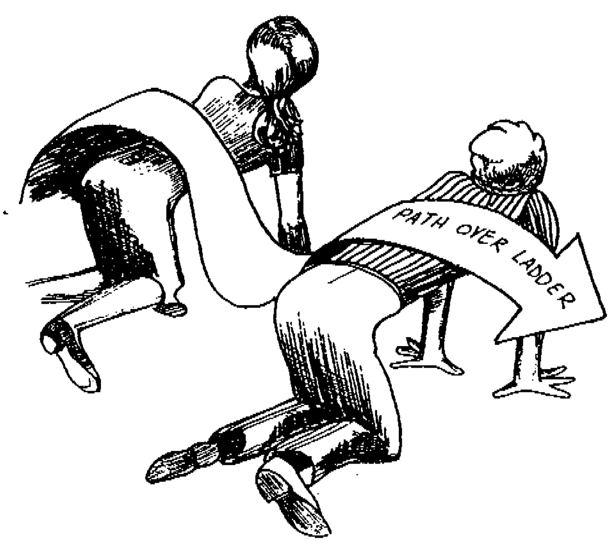
2. This is a physically involving activity! Set up a playing field as shown in the diagram, including spawning grounds, reservoir, downstream, upstream, and ocean. The area must be about 100 feet by 50 feet. Assign roles to each of the students. Some will be salmon, others will be potential hazards to the salmon. Assign the students 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 salmon 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. 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 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 "broadjump" 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. These students in the fishing boats must keep one foot in a cardboard box to reduce their speed and maneuverability.
   - All remaining students are salmon.

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 wild animals 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 simulates the disorientation that salmon face due to 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. A major hazard is the turbines at the dam. At most dams there are escape weirs to 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 it is hit by the turbine (jump rope). The turbine operators may change the speed at which they swing the jump rope. NOTE: 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 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 below, a body-wide space between them.



4. Once past the turbines, the salmon must get past 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 who survive life in the open ocean will 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 open ocean must take dead salmon to the fish ladder site. This gets 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 one year of growth. Once each fish has four tokens (four years' growth), that fish can begin migration upstream. The year tokens can only be picked up one token at a time on each crossing. Remember, the salmon must cross the entire open ocean area to get a token. The "four years" these trips take make the salmon 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 salmon begin the return migration upstream.

6. Once four of the year tokens are gathered, the salmon can begin 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 faces the broad jump waterfall. The waterfall represents one of the natural barriers the salmon must 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 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 salmon. They represent bears—one example of predatory wildlife. Again, remember that the predators must catch the salmon with both hands. If they do catch a salmon, they must then take the students 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-mortality ratio of salmon
- the students' feelings throughout the activity
- 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
- 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 Pacific salmon—are affected by limiting factors. Ask the students to give examples. They might mention availability of suitable food, water, shelter and space; disease; weather; predation; and changes in land use as well as other human activities.

VARIATION: ATLANTIC SALMON

This activity can easily be adapted to feature Atlantic, rather than Pacific, 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.

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 and different to the life cycle of one or more local fish.

4. Investigate similarities and differences in the migration and life cycles of Atlantic and Pacific salmon. Investigate the life cycle of salmon in the Great Lakes ecosystem.

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 and try the activity again:

   In the last 100 years, salmon have experienced many new, human-caused limiting factors. Dams, commercial fishing, timber harvest and road construction have had 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 would spawn and die. Their offspring would hatch and begin their early development in freshwater. The actual migration to the Pacific Ocean could be completed in as few as nine days. Today that trip takes over 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 20th century. Describe some of the possible effects on salmon from increased limiting factors as a result of human activities. 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. Approaching this as a complex dilemma, discuss possible actions, if any, that might be taken to benefit both people and salmon.

10. Substitute striped bass for 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 freshwater and migrate to and mature in saltwater. They also must face the limiting factors outlined in this activity.

11. 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.

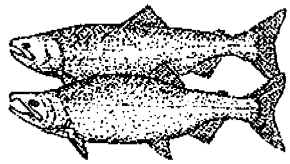
2. Identify and describe some of the factors that affect salmon as they complete their life cycle.

3. Identify and describe some limiting factors that might affect other animal populations.

Age: Grades 3-9
Subjects: Social Studies, Geography
Skills: analysis, description, discussion, generalization, inference, interpretation, kinesthetic concept development, observation, psychomotor development, recognition, synthesis, using time and space
Duration: 30 to 60 minutes
Group Size: 20 to 30 students or more
Setting: outdoors or large indoor area
Conceptual Framework Reference: III.E., III.E.1., III.E.2., III.A., III.A.1., III.A.2., III.A.3., III.B., III.B.1., III.B.2., III.B.3., III.B.4., III.B.5., III.B.6., III.C., III.C.1., III.C.2., III.D., III.D.1., III.D.2., III.D.3., III.D.4., III.D.5., III.F., III.F.1., III.F.2., III.F.3., III.F.4., III.F.5., VI.A., VI.A.2., VI.A.3., VI.A.4., VI.A.5., VI.B., VI.C., VI.D., VII.A., VII.A.1., VII.A.2., VII.A.3., VII.A.4., VII.B., VII.B.1., VII.B.7.
Key Vocabulary: life cycle, limiting factors, population, migration
Appendices: Simulations, Ecosystem

STUDENT HANDOUT 1A

THE JOURNEY OF WILD PACIFIC SALMON



ACTIVITIES:

- As you read, complete the chart in Student Handout 1B: *The Life Cycle Wild Salmon.*
- As you read about each stage of a salmon's life, think about all the possible human and natural challenges, obstacles and problems a salmon might encounter. Use Student Handout 1C: *Challenges to Salmon*, to organize your thoughts and to develop a list of potential problems and challenges to salmon on their journey.
- Use Student Handout 1D: *My Life Cycle*, to compare the similar stages of your life with those of the salmon's.
- Use a dictionary or biology textbook to look up the definitions of words that are unclear. Words that are in **bold** are of particular importance to understanding salmon.

For nearly 10,000 years, salmon have used the rivers and streams of the Pacific Northwest to travel from their birthing streams to the ocean and back. A century ago, between 10 and 16 million salmon returned from the ocean each year to spawn in Northwest rivers. Today less than a million return.

Nothing is more awe-inspiring and remarkable in nature, and nothing defines the character and beauty of the Northwest better than the migratory journey of salmon. It represents life as a cycle, the power of survival and endurance, and the promise of return.

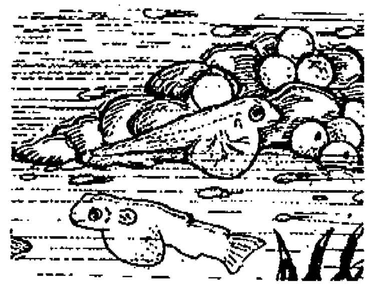
Pacific salmon are extremely important for several reasons. First, they are an important food source. They have been the mainstay for survival for the peoples of the region, and a significant food resource worldwide. Second, salmon are an **indicator species**. Because salmon migrate thousands of miles, moving from streams and rivers through estuaries to the ocean and back, they provide a valuable indication of environmental conditions in those habitats. Third, salmon play a central role in maintaining biologically diverse and productive ecosystems. For example, they are prey for a multitude of species, and their carcasses bring ocean-rich nutrients to relatively nutrient-poor freshwater environments. And finally, Northwest Native American cultures and spiritual beliefs are deeply connected with the great silver fish. In fact, the Chinook salmon takes its name from a Northwest tribe.

The salmon have evolved with incredibly strong instinctive patterns. Born in freshwater streams, **anadromous** or sea-run species like salmon are uniquely compelled to travel to the ocean. The vast ocean food chain supports a growth rate that freshwater members of the same species could never hope to achieve. However, travel to and from the ocean is a very risky venture. Travelling up to a thousand miles, migratory fish are inherently vulnerable to a variety of threats, both human and natural, along the way. Only the strongest, luckiest and most tenacious fish withstand the journey to reproduce. Of the 3,000 to 7,000 eggs in a nest, only one spawning pair will likely make it back to its original spawning habitat.

1. EGG STAGE

Salmon begin their lives in shallow gravel beds within the **substrate** of the freshwater streams and rivers in which their parents were born. The fertile, reddish-orange eggs develop in the safety of the gravel. Cold, clean **sediment** free water must wash the eggs and bring them oxygen. Eggs lie in the gravel through the winter, as the embryos develop. **Incubation** may take 50 days or longer. The colder the water, the longer the incubation period.

2. ALEVIN STAGE

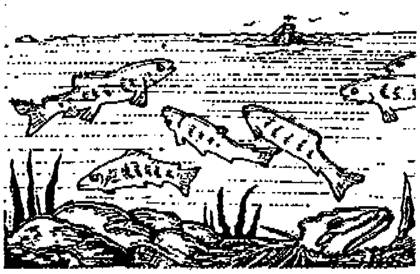


In late winter or spring, young translucent fish with large protruding eyes, called **alevins** (sometimes called yolk-sac fry), hatch and lie protected under the gravel. An orange **yolk sac** attached to the bellies of the tiny fish carry a food supply consisting of a balanced diet of protein, sugars, vitamins and minerals. As the fish grows, the yolk sac gets smaller. They will not leave the protection of the gravel until the yolk is used up, which can be twelve weeks or more. A flow of water is critical to alevin survival.

3. JUVENILE STAGE

In late spring and summer, with yolk sacs buttoned up, or absorbed, and eyes still protruding, small fish called **fry** emerge upward through the gravel and and begin to forage for food. They are about the length of a fir needle and stay in shallow pools near the edge where the current is slow.

When the young fish reach about two inches in length, they are known as **parr** (sometimes called fingerlings) and become intense feeders on plankton, small insects, worms, mussels and snails. The parr growth phase is best recognized by the development of dark bars aligned vertically along each side of the fish. The parr phase is the most vulnerable time in a salmon's life. From sculpins to raccoons, from kingfishers to large trout, parr are the morsel of choice. **Juvenile** (fry and parr) salmon will remain in the river four months to two years before moving downstream to the estuary.



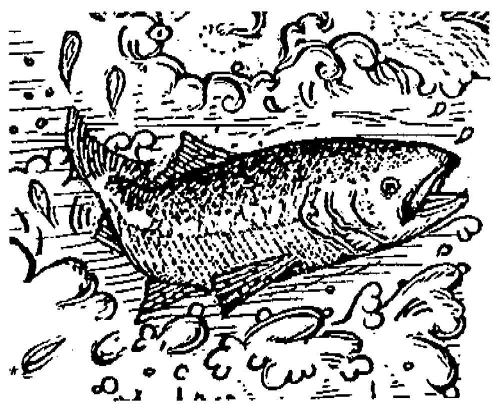
4. SMOLT STAGE

At four to six inches in length, salmon are known as **smolts**. As the parr marks disappear, most young salmon begin a physical change that triggers their downstream migration and adaptation to saltwater environment. Smolts let the current carry them downstream, tail first. Much of their travelling is done at night to avoid predators.

Estuaries occur where coastal rivers enter the ocean, creating a mix of fresh- and saltwater habitats. For salmon, the estuary represents the drastic transition from the river to the sea. Nutrient-rich sediment in estuaries produces nurseries for thousands of tiny organisms, upon which salmon feed. The inner waters of eelgrass beds and salt marshes provide habitat for the fish as they transition from fresh to salt water. This transformation involves amazingly complex body-chemistry changes. In addition, other physical changes occur during smolting: scales become larger, color turns silvery, and tails lengthen and become more deeply forked. Depending upon the species, salmon spend from a few days to a few months in an estuary.

Water flow is again a critical factor during downstream smolt migration. High flows mean higher survival rates. Decreased flows can increase the amount of time it takes smolts to reach the ocean and affect their ability to adjust to saltwater conditions. A delay can also increase their susceptibility to predators and disease.

5. OCEAN-FARING ADULT STAGE



Some theories suggest that salmon follow a life cycle of going to the ocean in order to overcome the limits of food and space in freshwater habitats. Upon entering the ocean, salmon will turn toward their **hereditary** feeding grounds. For some it is north to Alaska. Others will feed in the deeper waters off of the California coast. To avoid predators like seals they will remain in large schools. Their two-tone coloring helps conceal them from enemies. Seen from above, they blend with the dark ocean waters; from below, they blend with lighter sky. They feed heavily on such prey as crab larvae, barnacles, herrings, sand lance, rockfish, anchovies and squid. Time spent at sea varies according to species ranging from one to five years.

6. UPSTREAM MIGRATION STAGE

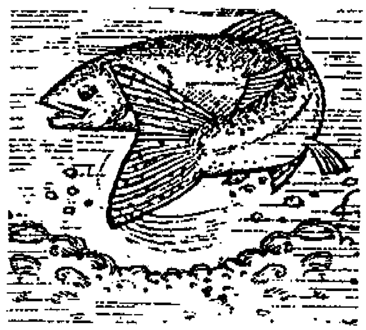
The salmon's return to the estuary is remarkable. For a fish to travel thousands of miles in the open ocean, up to thirty miles a day, and then locate and return to the estuary of its origin seems to defy all odds. This is called **homing**. Although still a mystery, scientists hypothesize that salmon navigate at sea with the aid of an inner magnetic map and a strong sense of day length, thus a salmon knows approximately where it is in relation to its home stream. As changing day length signals the advance of the season, the fish moves more or less directly toward the river mouth. As the salmon gets closer to the river the salmon's keen sense of smell comes into play, drawing it toward water smells encountered during the juvenile phases of life. Salmon can pick up the scent of their home river with noses so sensitive that they can detect dissolved substances in parts per 3,000,000,000,000,000,000! Arrival occurs during all seasons depending on the species.

A unique feature of the life cycle is that salmon migrate and spawn in mass groups called stocks or runs. The fish within each stock or run has a unique "map" with special genetic codes that instruct and direct the fish's behavior specifically to when and where to migrate and spawn. For example, the Sandy River Fall Chinook is a stock or run of salmon that migrate up the Sandy River in the fall to spawn.

The struggling, leaping salmon against the torrent of the stream is one of nature's most incredible feats. Upon re-entering fresh water to spawn, salmon lose their desire to eat and live off their accumulated fat reserves. In proceeding toward their spawning grounds, the fish move quickly upstream in groups. They make their way by stages upstream, pausing for days at a time to rest in **pools**, often waiting for improved water flows. They tend to move as long strands, hugging the deeper channels and shaded areas of the stream. At shallow **riffles**, where the river steps down a gravel ramp, running fish raise rooster tails of water as they speed over the rocks.

7. COURTSHIP STAGE

Once they come to their home gravel, females search for suitable egg-laying territories to build nests, called **redds**. As the sac around the eggs loosen, the urge to **spawn** quickens. Aggressive displays between the fish occur at this time. Males chase, bite and attack to ward off competitors. Females butt other females that appear to threaten their redd.

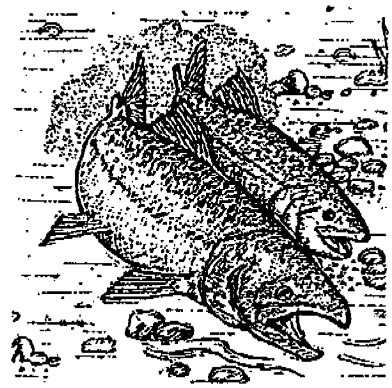


At this stage, the final days of the salmon are near, with many changes in color and body apparent. The males of some species get humped backs, hooked jaws, and sharp canine teeth. With muscles softening, skin thickening and body chemistry changing, white fungus may grow over sores or the eyes of the fish. The fins and tail fray from pounding against rocks and wounds from the journey may mark the body.

8. SPAWNING STAGE

Spawning is the process of reproduction for salmon. When a female salmon arrives at her home stream, she chooses a nesting site with just the right combination of clean gravel, adequate depth, and good flow to provide oxygen for her eggs. Once the female has selected the general location for laying eggs, she turns on her side and uses sweeping or **undulating** movements of her tail to dig the nest in the gravel. Every so often she checks the depth of the nest by "**crouching**" or lowering herself into the nest. In time, she eventually produces a cone-shaped nest up to 16 inches deep. Within that site, she may dig several nests and deposit eggs in them over a period of several days.

The digging of redds attracts males. As a male manages to ward off competitors, he joins the female in the nest in a series of courting movements. Eventually, he will move alongside the female and move his body against hers slightly. Frequently he will open his mouth in a "**gape**." When the female is ready to deposit her eggs, she too will open her mouth to resist the current and help her deeper into the nest. Finally, as both rapidly vibrate their tails, the eggs and sperm, or **milt**, are released. A female may lay up to 7,000 in a series of redds.



9. KELT STAGE

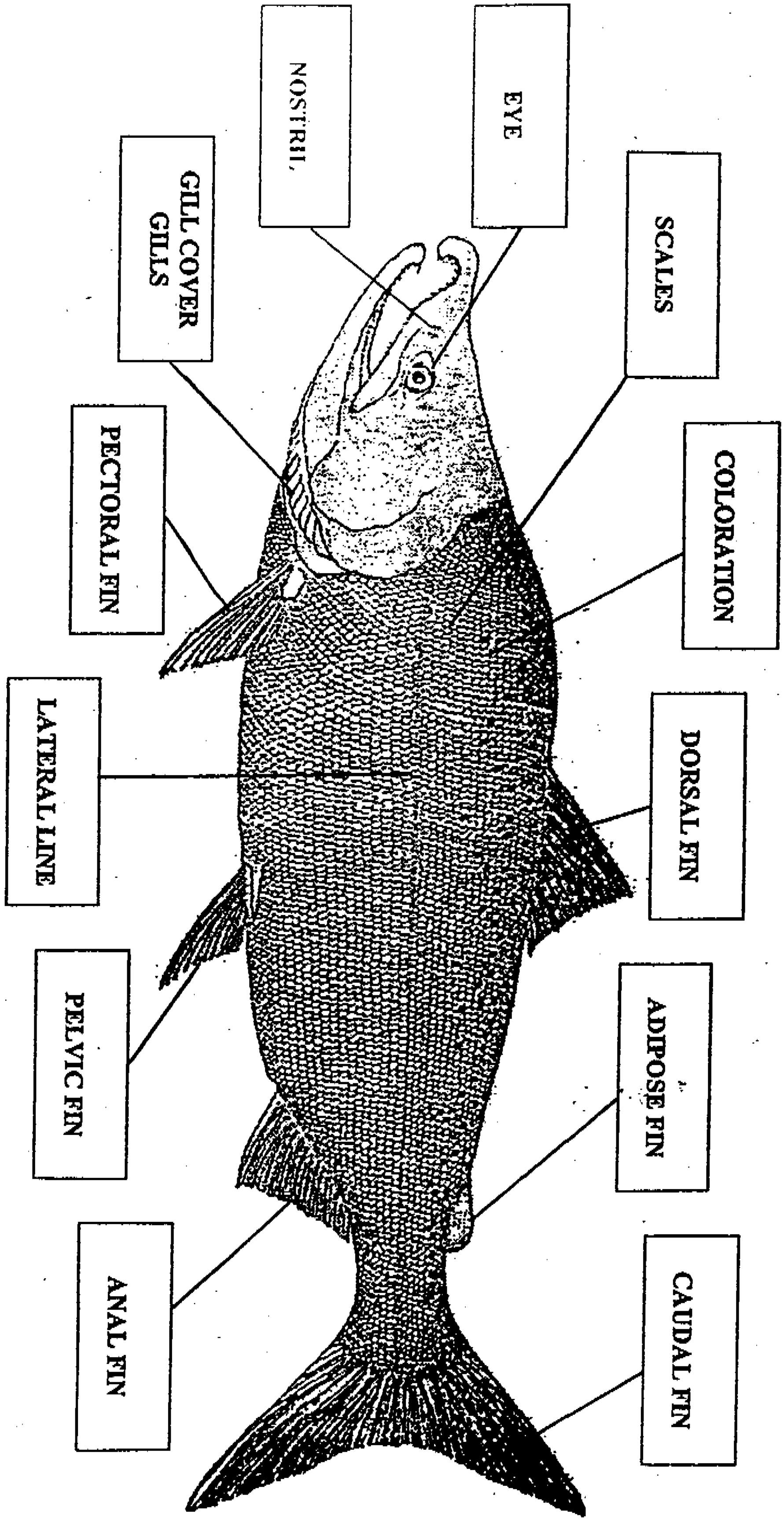
As the female has released her eggs, she instinctively covers them by moving upstream slightly and repeating her digging motions. This lifts gravel just above the nest, so that the current carries it into the depression. Females will defend their redds until they die, which may be a few hours or a week. Males can spawn more than once and often will leave the female, in search of another that is preparing a nest. Salmon that have spawned are called **kelts**.

10. CARCASS STAGE

Most salmon spawn only once during their lifetime (**semelparous**), although steelhead have the ability to spawn more than once (**iteroparous**). Both the male and female salmon die within a week after spawning. Their **carcasses** float downstream, get caught in roots and limbs, line beaches and sink to the bottom of the river. Opportunists like bears, gulls, crows, and eagles dine on the dead salmon.

The death of the salmon serves the next generation. As decaying salmon add nutrients to the rivers, they feed aquatic life that will in turn feed young salmon already growing in the gravel in the streambed. In Cascade streams, as much as 40 percent of the nitrogen and carbon in young fish and 20 percent of the nitrogen in streamside plants come from dead salmon.

TEACHER HANDOUT 1E



FUNCTION OF EXTERNAL CHARACTERISTICS OF SALMONIDS

FINS help a fish swim. Salmonid fins are supported by branched, flexible rays rather than stiff sharp spines. Thus, they are placed in the "soft rayed" family of fish.

DORSAL & ANAL FINS help keep the fish balanced so its body won't tip from side to side. One function of the anal fin may be to sense the size and texture of the gravel that is best suited for spawning.

PECTORAL & PELVIC FINS are found on each side of the body, like arms and legs in animals. These fins are used for turning, backing up and stopping, in addition to balancing.

CAUDAL OR TAIL FINS sweep from side to side and push the fish forward.

ADIPOSE FIN is small and fleshy and has no apparent use.

BODY SHAPE: The shape of a salmonid fish is highly efficient and streamlined for movement and stability in swift water. Salmon can move at an estimated speed of 14 mph and have been observed to jump to a height of 10 feet.

MUCOUS COVERING: A mucous coating covers the skin of the fish and protects it from fungal and bacterial attack. The slippery texture of the mucous also allows the fish to swim more easily through the water. To prevent damage to its mucous protection, it is important to wet your hands before handling live fish.

EYES: A fish has eyes which can see in all directions. Each eye works by itself, so the fish can see to the front and back at the same time. Eyelids and tear glands are not needed. Water keeps the eyes wet and clean. It is important to note that most fish are nearsighted, using other senses to detect food at a distance then moving closer to visually identify it. Their eyes are large and pupils do not contract in response to light. Consequently, they are more likely to remain in shaded areas.

NOSTRILS: A fish uses its nostrils for smelling, but not for breathing. Salmon have an extremely sensitive sense of smell. They return to the spawning area by following the faint scent of the stream in which they were reared.

HEARING: Although the salmonid lacks external ear opening, the inner ear and swim bladder sense can detect sounds in the water.

GILLS: Just like people, fish must breathe oxygen in order to live. While we get oxygen from breathing the air around us, fish get the oxygen they need from the water which flows through their mouths and passes by their gills. Gills are found under a flap just behind the head. They have many folds and pieces of thin skin which take oxygen from the water.

COLORATION: The dorsal or top surface of salmonids is dark colored and the ventral or bottom surface is a silvery white. A predator viewing the fish above sees a dark back which blends in with the color of deep water or stream bottom. If viewed from below, the white belly blends with the lighter color of the water surface.

LATERAL LINE: Most fish have a line running along each side of their body. The lateral line has a series of pores that detect low frequency vibrations and pressure changes near the fish's body.

SCALES: The bodies of most fish are usually covered with thin overlapping scales. Just like the cross section of a tree trunk, the oval scales of the salmon show annual growth rings. And just like a tree, annual rings can be used to learn the age. During the summer or other times when growing conditions are good, the fish grows quickly and the rings are far apart. In the winter when living conditions are not as good, the fish grows slowly so the rings are closer together.

STEELHEAD

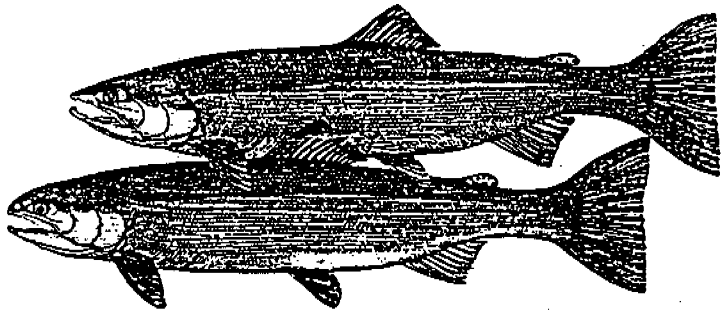


Illustration Courtesy of NOAA

DID YOU KNOW? Unlike salmon which die after spawning, steelhead may spawn several times.

SCIENTIFIC NAME: Oncorhynchus mykiss, previously known as Salmo gairdneri.

COMMON NAMES: Kamchatka salmon trout, coastal rainbow trout, silvertrout, salmon trout, steelie, hardhead and ironhead.

DESCRIPTION: In the sea, bluish from above and silvery from below -- tends to be more greenish in freshwater. Small black spots on back and most fins. Up to 45 inches in length and 40 pounds in weight; although usually weighs less than 10 pounds.

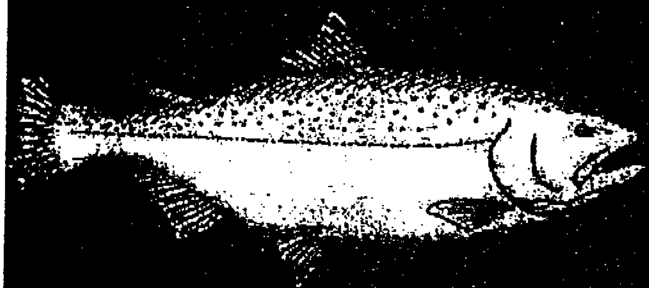
LIFECYCLE: Spawning in streams and rivers, steelhead rear in freshwater for 1 to 4 years before migrating downstream through estuaries to the open ocean. Unlike salmon, steelhead migrate individually rather than in schools. Steelhead spend 1 to 5 years at sea before returning to natal streams or rivers. At least two specific stocks of steelhead have developed; those that enter fresh water during fall, winter and early spring -- the winter run -- and those that enter in spring, summer and early fall -- the summer run. Steelhead do not always die after spawning, but will again migrate through estuaries to the ocean.

HABITAT AND ECOLOGY: Steelhead rely on streams, rivers, estuaries and marine habitat during their lifecycle. In freshwater and estuarine habitats, steelhead feed on small crustaceans, insects and small fishes. Eggs are laid in small and medium gravel and need good water flow (to supply oxygen) to survive. After emerging from the redd (nest) they remain in streams and rivers for 1 to 4 years before migrating through the estuaries to the ocean.

Because young steelhead spend a significant portion of their lives in rivers and streams, they are particularly susceptible to human induced changes to water quality and habitat threats. Poor timber and agricultural management practices can lead to siltation in streams, which may ruin spawning beds or smother the eggs. Additionally, in the Columbia River, migrating steelhead face the physical obstacles and high water temperatures resulting from dams, inadequate water flows in rivers and streams due to water diversions for irrigation, and the impoundment of water for power generation.

- OVER -

SALMONID HABITAT REQUIREMENTS



FOR NORTHERN OREGON COASTAL STREAMS

TILLAMOOK BAY
VATIONAL ESTUARY PROJECT

Habitat

Salmonid populations in the Pacific Northwest have been in decline for many decades. As a result some populations are listed as threatened or endangered species. One of the reasons for their decline is a lack of suitable habitat.

Studies show that salmon require a range of conditions in which to migrate upstream, spawn, and grow. This chart outlines some of those conditions ar represents best professional judgement compiled fron scientific reports and studies. It is designed to be a reference chart.

Dissolved Oxygen - The oxygen carried in the wat is called dissolved oxygen and is required by fish. The amount of dissolved oxygen in the water varies with water temperature. Salmonids, in general, tend to require high levels of dissolved oxygen.

Temperature - In general, colder temperatures are preferred by salmon. Colder water carries more dissolved oxygen and also slows fish metabolism, which allows f t gain weight more easily and grow to larger sizes.

Velocity - Water velocity needs to be great enough provide continuous oxygen supply, but slow enough not to wash away eggs and juvenile salmon.

Percent Fines - "Fines" refer to the very small sediments carried by the water. Too much sediment in streams can stop migrations and kill fish by clogging gills a suffocating eggs. Fines prevent fish from getting essential dissolved oxygen.

Depth and Substrate - Salmonids seek good place to make their redds, or nests. Appropriate conditions depend on the size of the gravel in the nest and the depth water.

For more information about salmon, water qualit or other related topics, contact the National Estuary Project at (503) 322-2222 or visit our web site at: http://osu.orst.edu/dept/tbaynep/nephome.html

California. They will remain in large schools and feed heavily on baitfish, like anchovies and herring.

Time spent at sea is variable according to species, ranging from one or two years for coho to four or five for chinook. When the time comes, a little-understood combination of genetic memory and sense of smell brings them back to their **natal** streams.

Arrival occurs during both spring and fall. Salmon returning in the spring, primarily chinook, tend to enter the freshwater rivers and streams immediately upon their arrival offshore. After proceeding upstream toward the spawning grounds, they will enter deep pools to rest until fall. Then they come out of their lethargy to spawn.

Fall fish, both chinook and coho, will typically concentrate in ocean waters outside their native streams during the summer. There they will feed and mature while waiting to begin their inland journey in the autumn months.

Upon re-entering fresh water to spawn, both spring and fall salmon lose their desire to eat and live off their accumulated fat reserves. They make their way by stages upstream, pausing for days at a time to rest and wait for improved water flows.

On reaching the spawning grounds, males stand guard while the females clear a series of nests or **redds** with vertical sweeps of their tails. The females then lay their eggs and the males deposit clouds of sperm or **milt** over them. They repeat the process in separate redds until all eggs have been laid. Salmon die within days of spawning.

STEELHEAD

Steelhead, or sea-run rainbow trout, parallel salmon in much of their life-cycle but differ in several significant ways. First, unlike the salmon, steelhead do not migrate in schools, but seek their own way at sea. Although the migratory picture is not clear, tagging studies have shown that steelhead travel far and wide. Oregon steelhead have been caught in the waters off Japan, a 2,000 mile journey from their home streams.

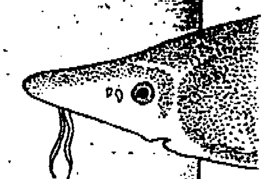
Steelhead also stop eating upon entering fresh water; although they maintain an aggressive bite response which is a never-ending source of joy to sport anglers. Unlike salmon, not all steelhead die following their spawning cycle. Although survival percentage is low, some steelhead survive to spawn twice or even more. Another trait that endears steelhead to anglers is their spawning schedule: Unlike salmon, which return primarily in spring or fall, steelhead have both winter and summer runs, with considerable overlap. Some rivers enjoy both. The end result is that steelhead can be found somewhere in Oregon waters 12 months a year.

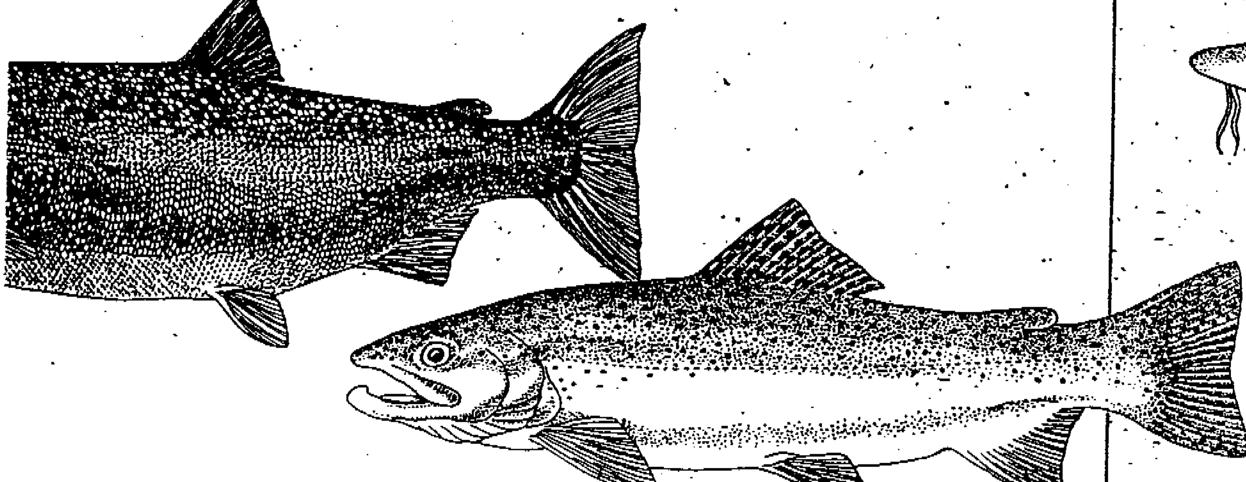
The Lateral Line

In addition to their senses of sight and smell, most fish have developed a highly sensitive sense of touch through their lateral lines. Lateral lines are a series of microscopically small skin openings to sensory organs arranged in lines from head to tail on either side of the fish.

Lateral lines enable fish to feel and accurately estimate the size, distance and direction of disturbances in the water around them through small changes in water pressure. This well-developed sense of touch allows fish to respond quickly to potential predators or prey, even without adequate visual contact.

Although the processes are not completely understood, lateral lines may also improve the sense of smell and help fish to avoid unseen, motionless obstacles.





Steelhead Trout

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RANGE: Steelhead were originally found from northwestern Mexico to the Kuskokwim River in Alaska; however, now it is unusual to find steelhead south of Ventura River, California. Significant steelhead rivers in Oregon include the Rogue, Umpqua and Clackamas Rivers.

ECONOMIC VALUE: Steelhead is one of the top five sport fish in North America, and is caught primarily in streams and rivers. At the present time only Native Americans are allowed to fish for steelhead commercially in Washington or Oregon.

Revised 10/13/97

Fact Sheet

West Coast Steelhead

March 1999

Background: The National Marine Fisheries Service (NMFS) has completed its comprehensive scientific review of steelhead on the West Coast, and has continually updated steelhead status as new information has emerged. Coast-wide there are 15 distinct groups, or evolutionarily significant units (ESUs), of steelhead, from southern California to the Canadian border and east to the Rocky Mountains. In March 1998, NMFS proposed protection under the Endangered Species Act (ESA) for upper Willamette River and Middle Columbia River steelhead. The Fisheries Service has now made final listing determinations for these steelhead ESUs.

Special Features: Steelhead are most prized by anglers. They depend more on the freshwater environment than most salmon species, relying heavily on rivers and streams as nursery areas. Steelhead penetrate farther into headwater areas, and do not usually die after spawning.

Scientific Findings:

Middle Columbia River ESU, *Threatened* : Long-term decline in steelhead abundance throughout the ESU. Recent average adult abundance for the Yakima, Walla Walla, Umatilla, John Day and Deschutes river basins combined has been estimated at 13,400 adults (compared to a historical run size estimate of 100,000 fish in the Yakima River alone). Natural steelhead escapement in the Yakima and Umatilla rivers has dropped to as low as 500 fish in some years, and steelhead are now extinct in the Crooked and Metolius rivers. Increasing proportions of hatchery fish in the Deschutes, John Day and Umatilla rivers pose genetic and ecological problems to remaining natural fish. Habitat blockages, reductions in streamflow and water quality, and mortality passing hydroelectic dams pose significant impacts to these fish.

Upper Willamette River ESU, *Threatened* : Winter steelhead are in steep decline after exhibiting wildly fluctuating abundance. Recent average adult abundance has been estimated at 3,000 fish. Natural fish adult returns in 1995 were the lowest in 30 years. Declines have been recorded in almost all natural populations. Natural steelhead integrity is at risk from introduced summer steelhead.

What's Next: The listings will become effective in 60 days. At that time, federal rules will go into effect, but they will affect only activities on federal lands or projects that require a federal permit. On non-federal lands, other so-called "4(d) rules" (protective regulations) will be proposed later. They will be tailored to mesh with whatever efforts have already been made by state, tribal and local conservation initiatives.

Get more information on these listings by visiting the National Marine Fisheries Service's Website at www.nwr.noaa.gov; **by contacting Garth Griffin, NMFS Protected Resources Division, 525 NE Oregon St., Suite 500, Portland, OR, 97232; or by calling 503-230-5400.**

Exploring Fish Habitat
Create a Healthy Stream

Salmon, steelhead and trout need a cool clean stream in which to live. But fish need more that just water in the stream. Students will create a healthy habitat for fish using materials they collect from around the schoolyard.

Materials

Blue cellophane (one 3-4 foot sheet per group)
1-quart plastic zip lock bags (one per student)
Fish and macroinvertebrate sheet (one per group)
Scissors
Crayons or markers (optional)

Session 2

Outside Activity (15-30 minutes)

Divide students into groups of 5. Give each student a plastic bag and have each group member label the bag with one of the items listed below.

1. Sand or soil
2. Gravel
3. Rocks
4. Logs and sticks (woody debris)
5. Leaves (organic matter)

Take a walk outside and have each student gather items to put into his/her plastic bag. Be sure that enough material is gathered to fill a quart size bag.

Inside Activity (45 minutes)

Explain that all of the items gathered are part of a healthy fish habitat. Brainstorm how these items would get into a stream. (Carried by water, blown by the wind, and dropped from trees growing near the stream.)

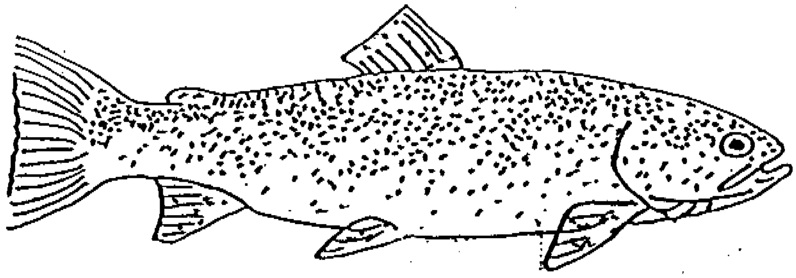
Brainstorm what each item contributes to the healthy fish habitat.

Sand – Homes for some insect larvae and worms. (Fish food)
Pool bottom where fish can rest.
Gravel – Nesting areas (salmonids lay their eggs in nests (redds) dug into gravel beds
Riffles - shallow water passing over gravel produces riffles, which helps put more oxygen into the water
Rocks – Homes for insect larvae (macroinvertebrates)
Riffles
Hiding places for fish and fry (baby fish)
Barriers – help to slow down water
Logs and sticks – Hiding places
Barriers
Leaves – Food for insect larvae. Insect larvae are the main food for the fish.

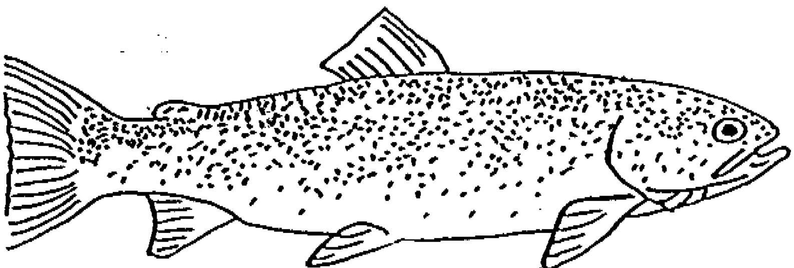
Give each group of students a sheet of cellophane and fish macroinvertebrate work sheet.

Tell the students that the cellophane is the water in the stream. Have them take the materials they collected and create a fish habitat in the cellophane stream. Then have them cut out the fish and insect larvae pictures and place them in the stream. Be sure to include pools, hiding places, and riffles.

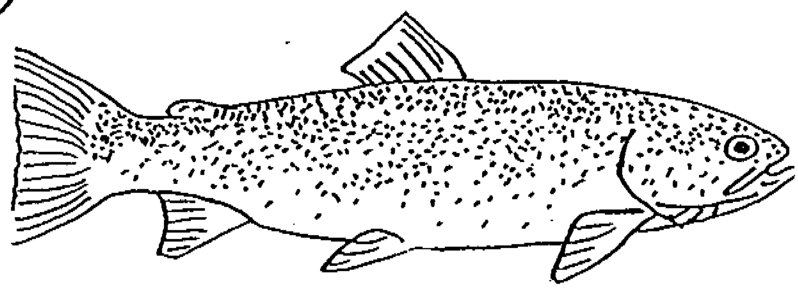
Review why each item in the stream is important. The fish will not have a healthy habitat unless all of these parts are present.

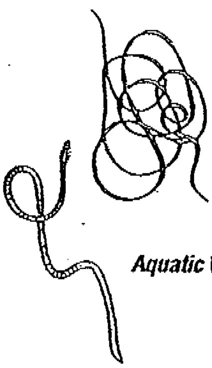


Steelhead

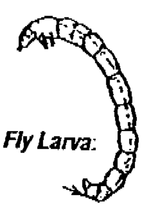


Cutthroat Trout



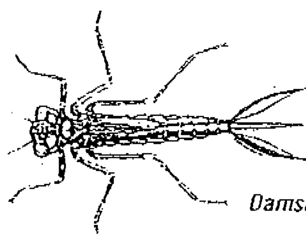


Aquatic Worm.



Midge Fly Larva:

Crane Fly:



Damselfly:

Pouch Snail and Pond Snails:

Leech:

TEMPERATURE

Introduction

Temperature (average kinetic energy of molecules) is measured in degrees. The two most commonly used thermometer scales are Celsius and Fahrenheit. Eight major factors can effect the temperature of the water in a stream:

1. The color of the water: if the water or stream bottom is dark, the water will readily absorb light and the temperature will rise. Erosion and other pollutants can have an effect on the water color as well.

2. The depth of the water: deeper water will take longer to heat up.

3. The amount of shade covering the water.

4. The latitude of the waterway: streams in colder climates are naturally colder than those in warm climates.

5. The time of year.

6. The temperature of the water entering the stream.

7. The volume of water.

8. The temperature of any effluents dumped into the water.

Unusually high water temperatures can have a devastating impact on aquatic life and can alter an entire ecosystem. Warm water, for instance, holds less oxygen making it more difficult for aquatic plants and animals to survive. Unnaturally warm water can decrease oxygen levels in several other ways as well, one of which is by increasing the metabolic rate of aquatic plants and microorganisms thereby increasing their oxygen demand.

The life cycles of aquatic insects also tend to speed up in warm water. Animals that feed on these insects can be negatively affected, particularly birds that depend on insects emerging at key times during their migratory flights. Fish migration is also linked to water temperature. In early spring, rising water temperatures may cue fish to migrate to a new location or begin their spawning runs. In the autumn, the drop in temperature spurs baby marine fish and shrimp to move from nursery grounds of the estuaries (where the river enters the ocean) to open water.

Aquatic organisms are adapted to a specific water temperature range. If the temperature of the water increases, cool water species will be replaced by warm water species thus altering the entire ecosystem.

Human activity can have a dramatic affect on water temperature. One problem is thermal pollution caused by dumping relatively warm effluent into lakes and rivers. For instance, nuclear power plants release hot water used to cool machinery. Cutting down trees and shrubs that shade a body of water also causes the temperature to rise because the water is exposed to more sunlight, this can also contribute to soil erosion which raises water temperatures by darkening the water, allowing it to absorb more sunlight. Other problematic occurrences that effect water temperature include over-grazing and urban runoff.

Temperature ranges

32 degrees Fahrenheit or below - Cold blooded animals can not survive

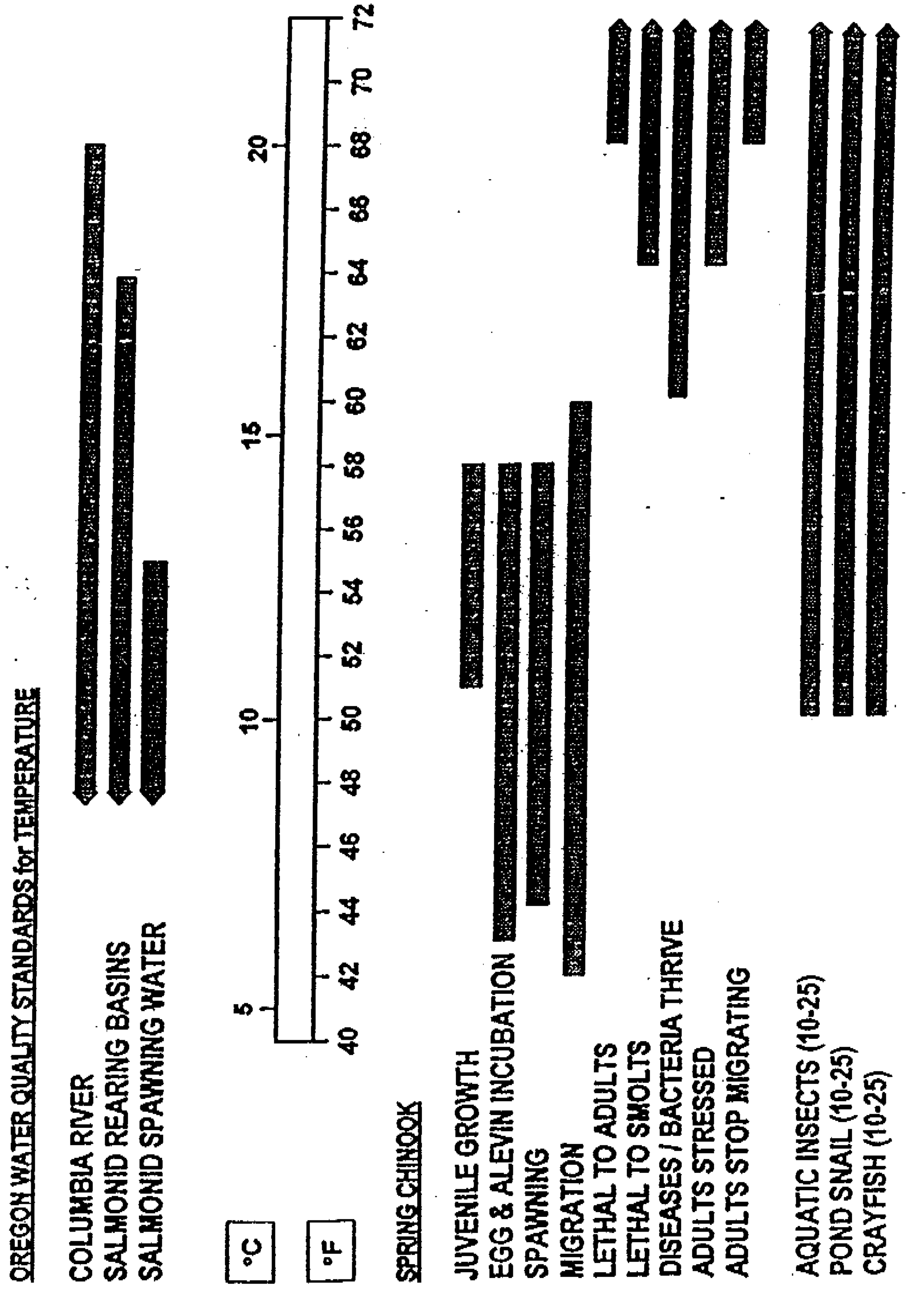
97 degrees Fahrenheit or warmer - Only rough fish like carp and bluegill can survive

72-95 degrees Fahrenheit - between these temperatures most fish reach a temperature in which they can no longer survive

37-77 degrees Fahrenheit - between these temperatures most fish reach a temperature in which they can no longer spawn

Plants also have specific temperatures in which they can grow successfully. The physical stress of rising water temperatures, and the resulting decrease in dissolved oxygen affects aquatic life's sensitivity to toxic wastes, parasites, and disease. Warm water makes substances such as cyanides, phenol, xylene and zinc more toxic for aquatic animals by increasing the chemicals ability to react. If this is combined with low oxygen levels, then the affect is increased.

SALMON HANDOUT 4.8



OPTIMUM TEMPERATURE LIMITS FOR AQUATIC ORGANISMS

Compiled from Stream Scene, Streamkeepers Field Guide, DEQ Administrative Rules, Aquatic Project Wild, Investigating our Ecosystem

DISSOLVED OXYGEN

Introduction:

The amount of dissolved oxygen present in water (DO) is an important factor in determining the health of a stream. DO is measured in milligrams per liter, mg/L, which means that there are "X" milligrams (mg) of oxygen present in every one liter of water. This is equivalent to parts per million, ppm, which means that there are "X" oxygen molecules present for every million water molecules. In addition DO can be measured as the percentage of saturation, for example 100% oxygen is equal to 100% of the oxygen in the air, which is 21% of all the elements in the air.

The oxygen in water comes from two main sources: 1) the air around the water by means of waterfalls, waves on lakes, and fast moving water in rivers and streams. 2) when the sun is out, algae and other rooted aquatic plants release oxygen in the water by photosynthesis. Photosynthesis is a process where carbon dioxide and water are used by the plant with the sun's energy to produce oxygen and sugar.

Aquatic plants and animals need oxygen to survive. Fish breathe the oxygen in the water through their gills. When there is no light available plants take oxygen out of the water in a process called respiration and produce carbon dioxide. Water with DO levels that are regularly high are usually healthy and can support a wide variety of plants and animals. Low DO levels may indicate a water quality problem. The Oregon water quality standard is 7 mg/L (same as 7 ppm) for water used by anadromous (fish that return to their stream of birth to lay eggs) and resident fish. The average dissolved oxygen level for good fishing is 9 mg/L. Studies show a DO of 4 - 5 mg/L is the minimum amount that will support a large, diverse fish population. Levels less than 5 mg/L lead to mortality in anadromous fish species.

Organic waste is a type of pollution that can have a major effect on DO levels. Organic waste is material that was part of a plant or animal including leaves, twigs, food, sewage, and fertilizers. Organic waste enters the surface water in many ways. It may be carried to streams by runoff from industries such as dairy farms and meat packaging. It can also be deposited in the water by sewer overflows and agricultural runoff. Agricultural runoff, mainly fertilizer contains nitrates and phosphates which contribute to a problem called eutrophication. Eutrophication occurs when water contains an excess of organic nutrients. The extra nutrients can cause too many plants to grow, when these plants die bacteria decompose the organic matter and use up valuable oxygen in the process.

When the DO levels of a water body are consistently low, it can have a dramatic affect on the plants and animals living in or near the water body. Often, the result is a drop in the number and diversity of fish and plants in the body of water.

The temperature of the water also has an effect on DO levels. As the temperature rises the solubility, the amount of oxygen that can be dissolved, of the oxygen decreases. Shade, overgrazing, thermal pollution, and other factors can cause dramatic temperature changes.

pH

Introduction

Water (H_2O) naturally dissociates (separates into chemical components) to form H+ (hydrogen ions) and OH- (hydroxyl ions). pH tests measure the concentration of H+. In pure de-ionized water the H+ and OH- concentrations are equal. If the concentration of H+ exceeds the concentration of OH- then the solution is said to be acidic. If the OH- concentration exceeds the H+ concentration the solution is said to be basic. pH is measured on a scale of 0 to 14; pH 7 is neutral, pH values below 7 are acidic and values above 7 are basic.

Animal and human waste and industrial and chemical discharges can have an impact on the pH of water. Another serious problem that affects pH are nitrogen oxides and sulfur dioxides which are released into the atmosphere by automobiles and power plants. While in the atmosphere, they are converted to nitric acid and sulfuric acid, which enter rivers and streams either as acid rain or by acid snow.

The geology of an area can also affect the pH of the water in a watershed. If limestone is present (basic), it helps neutralize acids that might be present in lakes and streams. Acidic water causes metals to be more water soluble (such as bridges or debris in a stream). This can be devastating to fish because dissolved metal particles in the water can accumulate on their gills and can also cause deformities in younger fish, lowering their chance for survival.

Most organisms are adapted to a particular pH range. If the pH of an environment is altered slightly, it could have a dramatic effect on the survival of resident organisms.

pH ranges

5.0 to 9.0. - Most fish can tolerate pH values in this range.

6.5 to 8.2. - The best water for aquatic life.

3.8 - minimum pH for fish eggs to hatch, but the young are often deformed.

10.0 - maximum pH for fish eggs to hatch, but the young are often deformed.

Taken from: of Cabbages and Chemistry

Great Explorations in Math and Science
Lawrence Hall of Science
University of California at Berkeley

What is pH?

Like the concepts of acid and base, a complete understanding of pH is too difficult for typical 4th–8th graders. If you have mature students and would like to present a simplified version of pH, following is a suggested approach. In *Session 3: Concentrating on Amounts*, in this guide, you present students with the concept of the acid/base continuum. At this time, explain that scientists have come up with a numbering system to quantify how acidic or basic a substance is. The scale runs from 0 to 14. The number in the middle, 7, describes neutrals. Numbers less than 7 are used to quantify acids. The lower the number the "more acidic" the acid. Numbers greater than 7 are used to quantify bases. The higher the number the "more basic" the base.

If possible, follow this explanation with an opportunity to measure the pH of various substances using universal indicator or pH paper.

Here are some pH values of common substances:

human gastric juice	1.3-3.0
lemon juice	2.1
orange juice	3.0
black coffee	5.0
milk	6.9
egg white	7.6-9.5
baking soda in water	8.4
household ammonia	11.9

The pH scale is a logarithmic scale, like the Richter scale used to measure the extent of ground movement in earthquakes. This means that a substance of pH 6.0 is ten times more acidic than a substance of pH 7.0, a substance of pH 5.0 is one hundred times more acidic than a substance of pH 7.0, and so on.

The abbreviation pH stands for "the power of hydrogen," and it is a measure of the number of hydrogen ions in a given volume of a substance.

Technically, pH is calculated by dete the negative logarithm of the hydrog concentration expressed in moles per given substance. The number of hy in pure water is 10^{-7} moles per lite calculating the negative logarith arrives at a pH of 7.0 for water. reasons for this calculation is to make miniscule quantities such as 10^{-7} int easily usable numbers, like 7.

Please note that because one solution n 100 times "more acidic" than another, not necessarily mean that its effects w be one hundred times greater. In additi describing a solution that is "more acid being "stronger" can also be misleading question of "concentration" is very imp in evaluating the effects and the "streng an acid or base. For more discussion of sometimes confusing terminology used differentiate "strong" and "weak" acids sidebar on page 35 of this guide and the GEMS Acid Rain guide.

There are two factors that determine t exact shade of pink cabbage juice beco with a particular acid: 1) the acid's concentration; and 2) the acid's "stren While an acid's concentration can be changed by adding another substance, as water, its "strength" is determined its molecular structure. Acids that eas "dissociate" in water (break into piece known as ions) are considered to be "strong acids." Those acids that disso less readily in water are classified as " acids." This is true of most bases as u These two factors are easily confounde you can have a "strong acid" (such as sulfuric or battery acid) made to be extremely dilute, but it would still be referred to as a "strong acid." Similar "weak acids" in a concentrated form c very irritating, but they're still consid to be "weak." Due to the difficulty of explaining these concepts to students t have not reached a formal level of reasoning, we have chosen to presen the concept of concentration. If y that your students are ready to lea s of these high school level concepts, go ahead and present this information du the session.

Aquatic Life in Tryon Creek

Fish
cutthroat trout
steelhead salmon - anadramous (ocean migrating)
sculpin (bottom feeders)
Pacific lamprey

Macroinvertebrates
crayfish
mayflies
caddisflies
craneflies
blackflies
aquatic worms
scuds
riffle beetles
water striders?

It is rare to find macroinvertebrates in Tryon Creek. Why?

* need for cold water. Human impacts on the creek - run off from homes and activities near the creek. For example, during breeding season for macroinvertebrates, in the summer, a summer rain will wash over the hot paved surfaces, and run into Tryon Creek, throwing dynamics of the creek off. .
* unnatural discharge from cars and fertilizer
* tree removal, again effecting the temperature of the creek.
* kids - turning over the same rocks at the access points. Critters up and leave, or are killed.
* dogs - creating disturbances to the stream and increasing the siltation problem.
* the natural gradient of the creek. Flow doesn't naturally give many opportunities to increase the level of dissolved oxygen necessary for these critters.

Trout requirements

Temperature: The best temperature for trout is less than 12 degrees Celsius, (about 55 degrees Fahrenheit), although they have been known to survive within a range between 42 and 77 degrees F (5.6 and 25 degrees C). At 5 degrees C (41 F), trout use about 50 - 60 mg. oxygen per hour; at 25 C (77 F), they may need five or six times that amount. As fish are cold blooded, they use more oxygen at higher temperatures when their metabolic rate increases.

Dissolved Oxygen: Healthy trout habitat requires between 7 - 12 parts per million. Several studies suggest that 4-5 parts per million (mg/L) of DO is the minimum amount that will support a large, diverse fish population. The DO level in good fishing waters generally averages about 9.0 ppm. When DO levels drop below about 3.0 ppm, even the tough fish die. For percent saturation, 125% or more is too high - it may be dangerous to fish. 80 - 124% is excellent, 60 - 79% is okay, but not great, and below 60% is poor, for the water is too warm or bacteria are using up precious oxygen.

pH: Most fish can tolerate pH values in the 5.0 to 9.0 range, but 6.5 to 8.2 is the best water for aquatic life. A pH of 3.8 is the minimum pH for fish eggs to hatch, but the young are often deformed. 10.0 is the maximum pH for fish eggs to hatch, but again the young are often deformed.

Habitat requirements: Ideally, a healthy trout stream contains 40 - 60 % pools, a 1 - 20 foot gradient, lots of woody material to trap gravel and slow the stream velocity, boulders to help create pools, and undercut banks. Pools provide resting spots and protection for fish and undercut banks provide protection and cover as well as shade, although if too many pools exist there is less reoxygenation of the water and little area ideal for spawning. The creek requires shade to prevent a mid-day temperature increase. Riffles help increase the DO of the stream, for the water runs quickly over gravel and cobbles. Fish spawn in shallow riffles where well oxygenated water can provide oxygen and remove wastes. However, higher stream velocity can tire a fish, especially a young fish that is not large enough to fight the current. Too much silt deposited over spawning gravel can deprive developing eggs of oxygen rich water that normally percolates in the spaces between the pebbles.

Friends of Tryon Creek

Art-Based Nature Education – Focus on Salmon

Session Two: Salmonid habitat

Grade: Adaptable from 3 to 8
Time: at least 2 hours

Overview: Students will explore a stream and discover necessary habitat requirements for salmonid reproduction. Ideally the class will be able to visit a stream on a field trip. Friends of Tryon Creek has a 2-hour program to introduce students to Tryon Creek. A walk to a neighboring stream would also allow students to observe the features of a salmon stream. If it is not possible to visit a stream - videos and modeling can be used to introduce the habitat components necessary for successful salmonid reproduction.

Objectives: Students will:

- learn the habitat requirements of salmon
  - water quality (dissolved oxygen, pH, and temperature) requirements
  - stream components (riffles, runs, and pools)
  - food requirements
- build a model of a salmon spawning stream

Materials:

- **Volunteer Field Guides (parents or wildlife stewards)**
- Nature Journals
- pencils
- 4 buckets (on a rope if stream banks are steep)
- 4 dissolved oxygen (DO) measurement kits
- 4 pH strip containers
- 4 thermometers
- Create a Healthy Stream curriculum (attached)

Set up:

- Make field kits comprised one bucket, one DO kit, one pH strip container, and one thermometer. Tie ropes to the handles if water access is difficult.
- Add a data collection page to Nature Journals

Introduction:
Today we are going to explore a stream. Brainstorm: What do you think fish need to live? This is what makes up their habitat. Where do you think we need to go to find those things? Today we are going to walk to the creek and explore fish habitat.

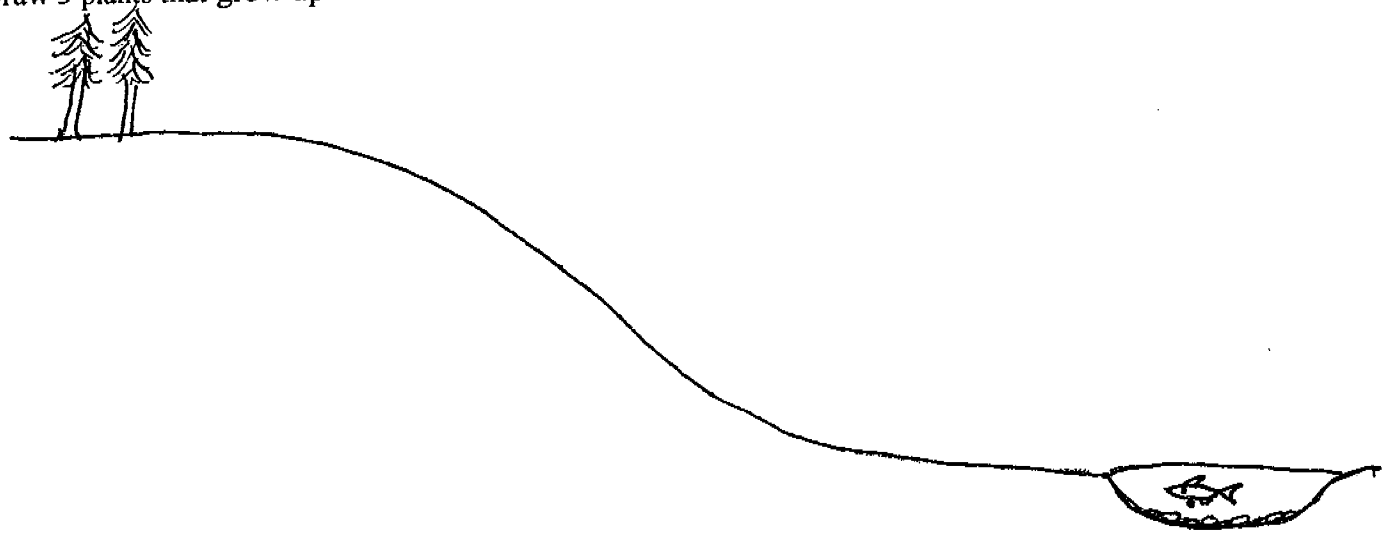
Procedure:
Divide class into three or four groups. Hike to the creek together or as individual groups depending on the site.

On the way to the creek investigate the upland forest by having students draw three plants on their work sheet. (Attached). The upland forest is the area uphill from the stream. It is composed of a different flora than the riparian forest next to the stream. The upland plants require less water year round, but they are very important in soil preservation and water retention. When soils are functional, water is retained through absorption and can slowly make its way into the creek. When soils are not functional water runs off the surface, causing erosion and high creek velocity, and creeks can dry up, when rainfall is low, since water has not been retained in the system.
As you get near the stream stop and look at the riparian zone. Do the plants look the same of different? Draw picture of three plants in the riparian zone.
When you reach the creek have groups spread out along the bank. Be sure to talk about making as small an impact as possible on the creek bank. Fill the bucket with creek water to do the water quality testing.
1. Take the **temperature** of the air and then the water. Be sure to leave the thermometer in the water at least one minute for equilibration. Have the students record data in their nature journals. Salmonids need cold water to live. If the water temp is higher than 68 degrees the fish can die.
2. Ask the children about how they get **oxygen.** How do fish get oxygen? It is dissolved in the water and fish absorb it through their gills. We can use special chemicals to see how much oxygen is in the water. Use the Chemetrix DO kits to measure the amount of dissolved oxygen. Break ampoule tip off in the water sample. Allow two minutes for the color to develop. Compare color to the chart. Have students record their findings in their journals. Dark blue means more oxygen – a DO of 8 to 12 mg/L is necessary for salmonids to live.
3. Give each student a **pH** strip. Have them dip the colored end in the water and compare the color to the color chart. Record their findings in the nature journal. Fish can life in water with a pH of 5.5 to 8. If you want
4. Discuss if this is a healthy stream for salmonids. What have they learned from the tests they have taken? We need to be careful about how we take care of our streams so they can be healthy places for fish to live.
5. Take a look at the stream as a whole. Are there places (pools, rocks, overhanging vegetation) for fish to hide? Riffles to help oxygenate the water? Gravel areas for spawning? Trees along the banks to keep the water cool in summer? If time allows have the students draw a sketch of the stream in their journals.

Optional: Create a Healthy Stream – this allows students to build a model of the stream they have seen and incorporate some of the features necessary for health fish habitat.

Are plants important to fish?

UPLAND FOREST
Draw 3 plants that grow up here.

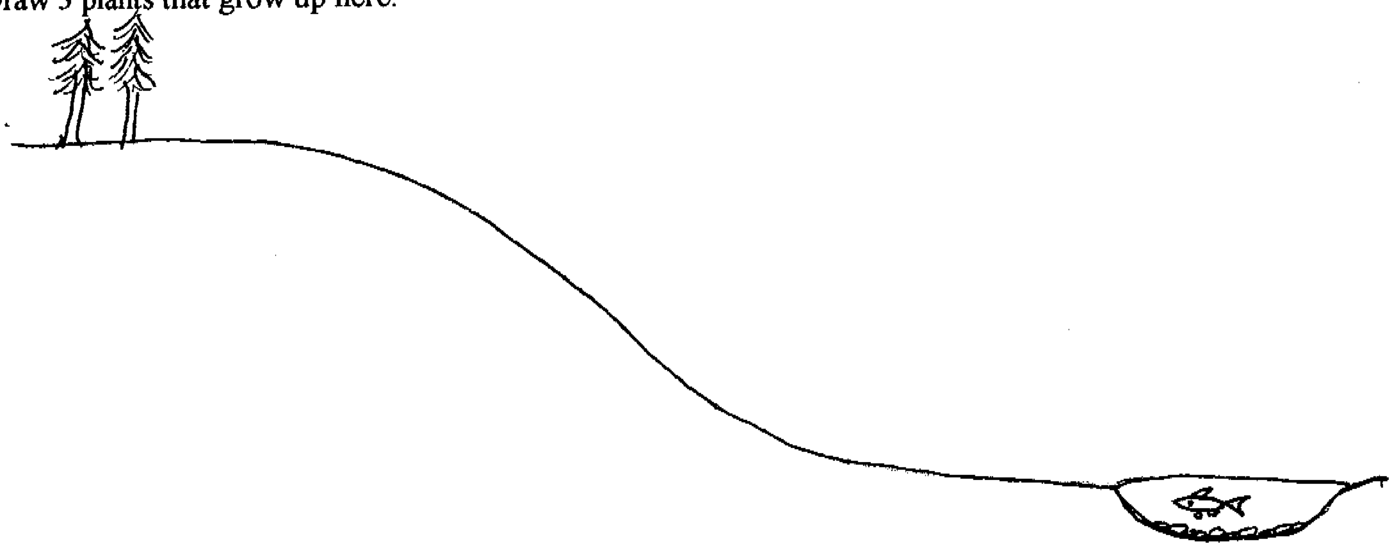


What percentage is the tree canopy?________________

RIPARIAN ZONE
Draw 3 plants that grow down here.

Are plants important to fish?

UPLAND FOREST
Draw 3 plants that grow up here.



What percentage is the tree canopy?________________

RIPARIAN ZONE
Draw 3 plants that grow down here.

Stream Data

Date______________ Weather_____________________

Location____

Air Temperature ___________________________________

Water Temperature_________________________________

Is this a good temperature for fish?_____________________

Dissolved Oxygen__________________________________

Is that enough oxygen for salmon to live?________________

Water pH____

Is this a good pH for fish? ___________________________

What does the stream look like?

Stream Data

Date______________ Weather_____________________

Location____

Air Temperature ___________________________________

Water Temperature_________________________________

Is this a good temperature for fish?_____________________

Dissolved Oxygen__________________________________

Is that enough oxygen for salmon to live?________________

Water pH____

Is this a good pH for fish?___________________________

What does the stream look like?

Friends of Tryon Creek
Art-Based Nature Education – Focus on Salmon
Session Three: Introduction to Salmon, Muscles and Bones

Session 3

Grade: Adaptable from 3 through 8
Time: 1 to 1 1/2 hours

Overview: Students will begin their exploration of a fish as an organism by exploring the skeletal and muscle systems of salmon, and beginning to build.

Objectives: students will:

- Be introduced to salmon and take a close look at a fish
- Find out how important bones and muscle are to a fish, and how they work together by:
  - Creating a model of the basic body structure of a fish
  - Adding materials to the basic structure to provide models of bones and muscles

Materials:

- Live fish for observation (any fish will do – but try to bring in fish with a salmon shaped (fusiform) body
- Fish bones (and/or handout of fish skeletal structure)
- One wire coat hanger for every student
- Rubber bands
- Straight sticks for vertebral column
- Pine needles or tooth picks
- Masking tape
- Tag board – cut into fish body shapes (pattern attached)
- Glue

Set up: Place a life fish for each work group to observe. Each student will be given a wire hanger and tag board insert. Set up a materials table with masking tape, pine needles (or tooth picks) and sticks. Hove each student take out a pencil and glue.

Introduction: Tell students that they have had a chance to explore where salmon live and where they go as they grow up. Do a quick review of the salmon life cycle. Today they will have the opportunity to start exploring what happens inside a fish. They will start by looking at how salmon move.

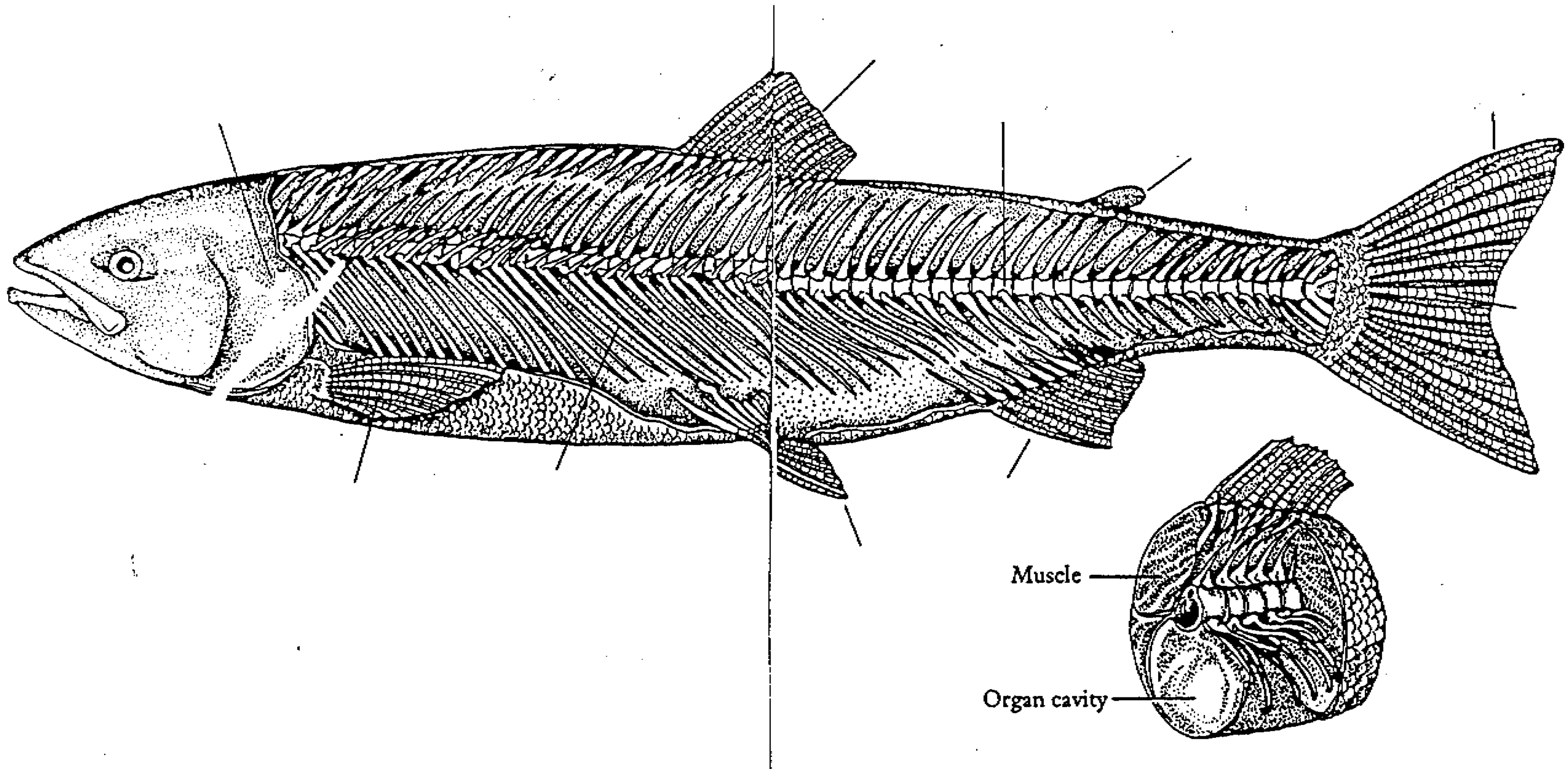
Procedure:

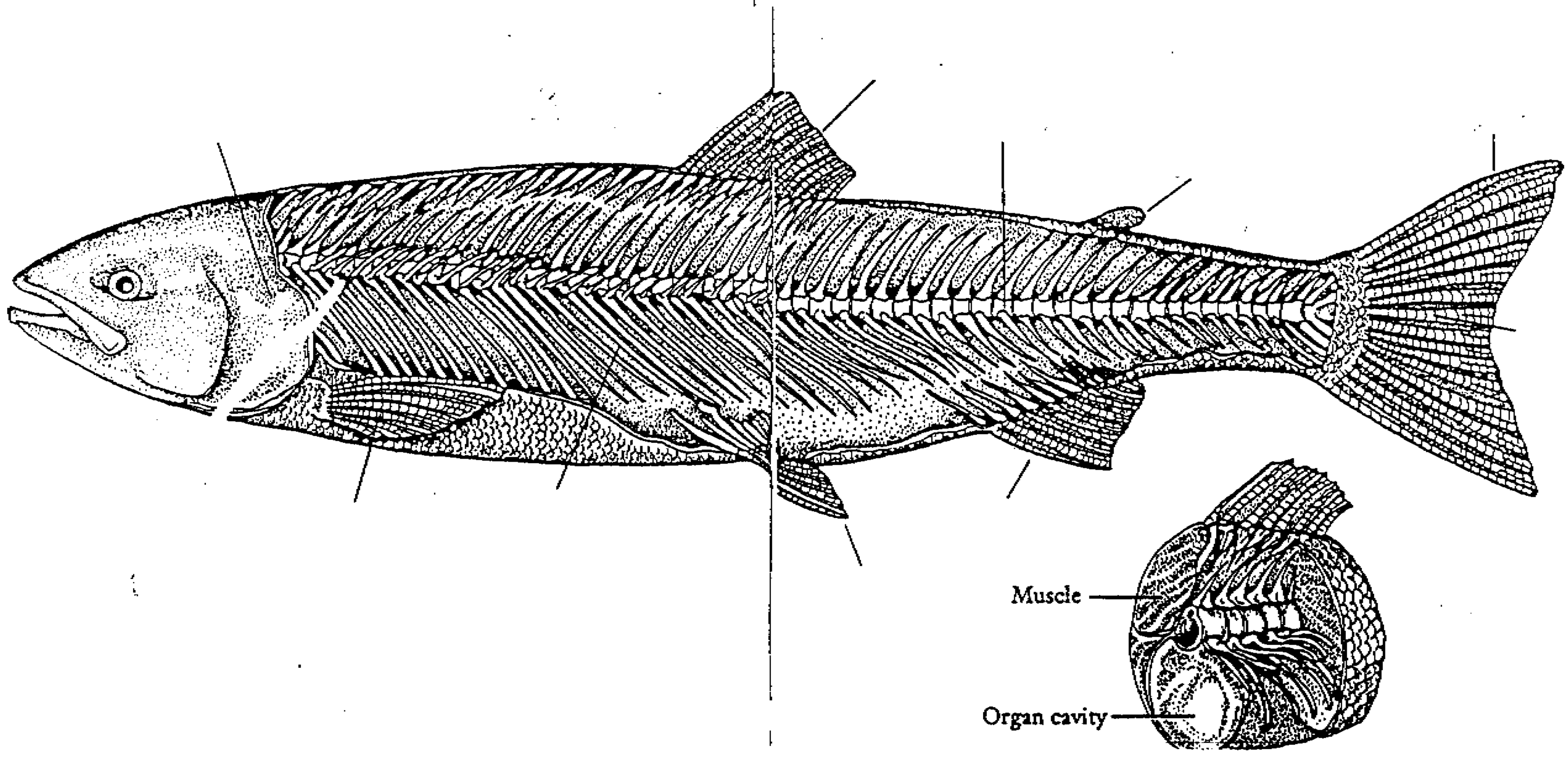
- **Observe the live fish.** Look at how a fish moves. What parts of its body does it use? How does it move around its container?
- **Vertebrate/Invertebrate review** – students feel their own back bone, brainstorm a list of animals and categorize them according to vertebrate/invertebrate. End discussion talking about fish.
- Show fish bones – Ask question "What are bones and muscles for?" Lead students in using the hanger and rubber bands to explore how bones and muscles work together and function in a body system.
- Fish Body - Lead students in stretching hanger into a fish shape. Bend in the tail; draw shape on tag board to use for skeletal structure. Make sure they include their name. You now have the body (without the head).

- Skeletal Structure – Lead students in gluing the skeleton onto tag board. Start by gluing on the backbone. Have them look at the fish skeleton or diagram. As they create the skeleton, teach about how bones are connected, the direction that they face, and difference in length. Have students figure out why the fish's skeleton is built that way. Work on creating the model by gluing pine needles or toothpicks onto the tag board as rib bones. When the "bones" are on and dry enough, have them tape the coat hanger to the tag board. They now have a fish body and skeleton and they are ready for the next class.

Wrap-up: Find the muscle! This can be done outside or standing at their desks.
1. Stretch out your arm – can you find the muscle that makes your arm bend? Put your hand on that muscle. Which bone moved?
2. Put your hands on your hips and bend to the side – what happens to the muscles on the side that is bent? On the side that is stretched?
3. Jump up and down – what muscles did you have to use to make yourself go up in the air? Are these muscles attached to bones?
4. Move like a fish swimming! Which muscles and bones would you need to use?

Evaluation:
Have the students write three ways they use their bones in muscles in their journals. (i.e. walking, lifting their arm, etc.) Then have them write three ways a fish uses its muscles.


Muscle
Organ cavity


Muscle
Organ cavity

BONES AND MUSCLES

Write three ways you use your muscles:

1. ____

____

2. ____

____

3. ____

____

Write three ways a fish uses its muscles:

1. ____

____

2. ____

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3. ____

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BONES AND MUSCLES

Write three ways you use your muscles:

1. ____

____

2. ____

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3. ____

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Write three ways a fish uses its muscles:

1. ____

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2. ____

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3. ____

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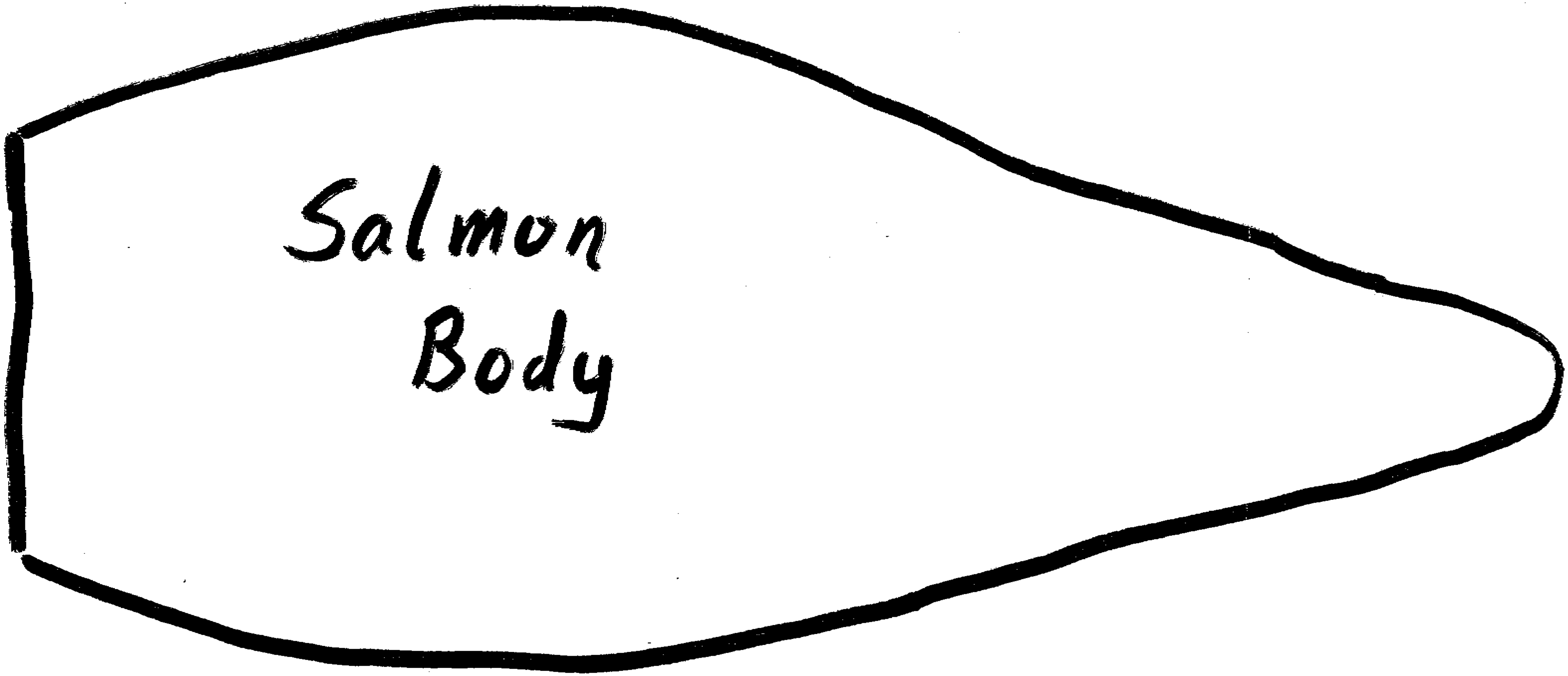

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Friends of Tryon Creek
Art-Based Nature Education – Focus on Salmon
Session Four: The Senses

Grade: Adaptable from 3 through 8
Time: 1 ½ to 2 hours

Overview: Students will continue their journey through a fish's life by exploring the senses that fish have to help them to gain information they need to survive.

Objectives(What Taught): students will:

- explore a few of their own senses and how they obtain information by using them.
- understand how the "lateral line" gives the fish information by:
  - adding a lateral line and "message" stimuli to their fish model
  - retelling the story of each of the "message stimuli that they added, and explaining why the fish needed those messages – in other words, how those messages help the fish – in their journals

Materials:
1 pieces of candy (Jolly Ranchers) for every student
Colored Beads
Push Pins
Small pieces of craft wire
Bead color key

Session 4

Set up: Place project materials (except candy) at a workstation.

Introduction: Tell students that they will be continuing their fish journey and adding new parts to their fish. Today's session will be focusing on senses.

- Ask the students:
  - o why they need senses
  - o what their senses are, what they do, how they work
  - o what their strongest sense is (what they use the most)
  - o what about other animals and their senses

- Hand out a piece of candy to each student (be sure to set clear expectations). Have the children unwrap the candy and smell it. See if they can imagine what the candy will taste like without actually putting it in their mouths. Can they guess what kind it is? What senses have they used so far to figure it out?

- All at the same time have them put the candy into their mouths. While they are tasting it, explain that some fish have taste buds all over their external bodies. In salmon it is apparently not only in their mouths, but also behind their gills. According to some literature, they can actually taste macroinvertebrates before they catch them. "What you could stick your candy on your arm or leg or forehead and taste it? Would it make you more hungry for it?"

- Explore hearing, which is often underemphasized in fish. Fish do have ears – but not on the outside. Sound travels well in water – so fish don't need external ears to catch the sound.
- Explore the lateral line. It performs important functions for the fish, and most sources agree that it is crucial for navigating and finding food. Here are some of the things that the lateral line is said to help fish do:
  - It is a combination of hearing and feeling.
  - It detects changes in turbulence and changes in pressure.
  - It keeps the fish from bumping into things, and allows the fish to know what is near it – like food.

Procedure:
Lateral line - On the side of the fish opposite to the "bones" draw a thick, black line to indicate the lateral line. Poke five to seven pairs of holes along the line on either side with a pushpin – you may want to wiggle the pin around to widen the holes. Thread wires through the pairs of holes, bring the wire together and thread it with a bead. Each bead will be a message that the fish is taking in.
As students add beads, remind them that they are creating a story about their fish and what has happened to it. You can refer them to the key, or have them choose different colors and give them the key at they end. When the beads are all added, they can take several wires the length of the body of the fish and twist them together, then thread through underneath the messages (what is this for? What does it signify?). To finish, they can use a pencil to curl the ends of the wire.
Eye – Have the students take a large bead to make the fish eye. Attach the eye to the head area of the fish with wire.
Brain – Have the students make a "brain" by bunching the wire into a ball. Be sure the brain hooks up to the eyes and lateral line.

Wrap-up: The fish migration game would be a great wrap-up for this activity. Students could spend their time as fish "acting out" the messages their fish took in and it would give them practice in empathizing with the life and struggles of a fish.

How Evaluated:
As the students finish adding the messages and wire to their fish, they can use their journals to tell the story they have created with the "message" beads. Have them think about what it would feel like to be their fish going through all of the things it has gone through.

LATERAL LINE MESSAGES KEY

HERE ARE THE KINDS OF MESSAGES SALMON RECEIVE

Blue Beads = food (macroinvertebrates)

Orange Beads = bear (watch out!)

Green Beads = boulders ahead

Red Beads = a good place to build a redd (nest)

Pink Beads = salmon school up ahead to travel with

White Beads = rapids coming up

Yellow beads = Fisherman - bait on a fishing line

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Friends of Tryon Creek
Art-Based Nature Education – Focus on Salmon
Session Five: Protection and Counter shading

Grade: Adaptable from 3 through 8
Time: 1½ to 2 hours

Overview: Students will continue their journey through a fish's life by taking a closer look at the protective coverings of fish.

Objectives: students will:
- Learn protective coloring of fish (camouflage and counter shading)
- Explore how fish scales work

Materials:
- A real fish or fish skins
- Fish scale handouts
- Different colored art paper
- Narrow ribbon
- Glue
- Brown or green and white 3" by 4" paper rectangles
- Small brown or green and white pieces of yarn
- Tape

Session 5

Set up: Place project materials (except candy) at a workstation.

Introduction: Review the salmon life cycle and ask if fish ever need to hide from predators.
- How do they hide when they are in the creek or river? How do they hide when they are in the ocean? When salmon are young they have verticle strips that help them blend with branches, roots and rocks that are in the stream. You can play a camoflague game by putting out pieces white and substrate colored yarn on the ground. Give the students 10 seconds to pick up as many pieces of yarn as they can. Have them count how many colored and how many white pieces they picked up in their journals. Your can repeat this activity a couple of time. The results should show that they pick up the white pieces before the colored pieces because they are easier to see.
- While you are still out side hand out the colored and white rectangles. Place they on the ground. Which is easier to see? Now hold them up to the sky. Now which is easier to see? Fish in the ocean are often dark on top and light on the bottom. This is called counter shading. When a predator look down on the dark back of the fish it is hard to see in the water. If a predator is beneath the fish, looking up at its white belly, the fish is hard to see since it blends with the bright light at the surface.
- **Fish scales, up close and personal** - Return to the classroom and talk about fish scales. The students can touch the scales on the outside of the fish or feel the fish skin.
- Show the fish scale diagram. Note how the scales have growth rings – almost like trees.

- Fish scales help protect their bodies. When they bump around in the stream their shin could be damaged. The scales help keep that from happening. The scales also help the salmon stay in one place when they are resting in the stream. When they face upstream, the water pulls against the scales and the drag helps keep the fish in place.

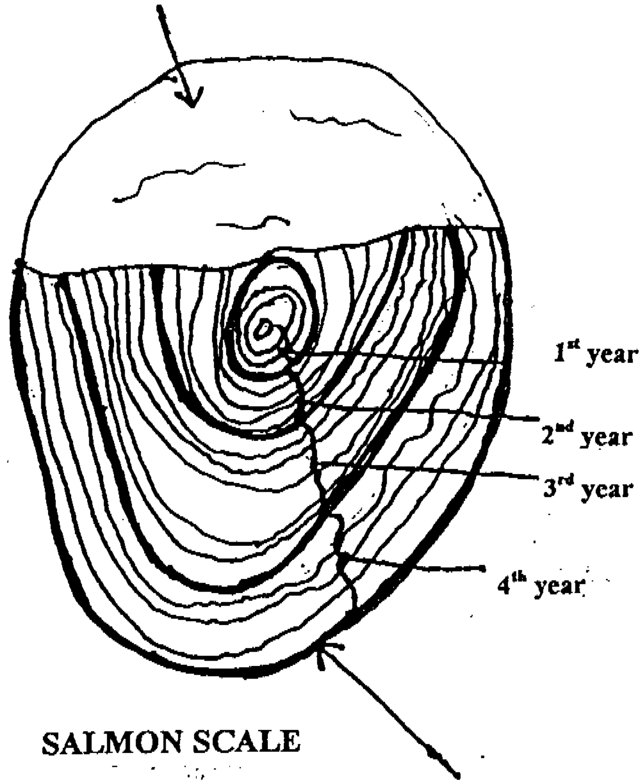
Procedure(How Taught):

- Have the students cut "scales" out of the art paper. Be sure some are light colors for the bottom and some dark colored for the top.
- Glue the scales on in an overlapping pattern – starting at the tail end. Be sure to use the side of the salmon that doesn't have the skeleton.
- Leave the area of the lateral line free of scales – that area can be covered with a ribbon or some other fun material.
- Wire the fish to the coat hanger. Be sure it is a little "loose".
- Make fins and a tail out of construction paper and paste or glue them on their salmon.

Wrap-up:
Now the fish is complete. Take a look at your finished product and review all of the internal and external parts of the fish and their functions.

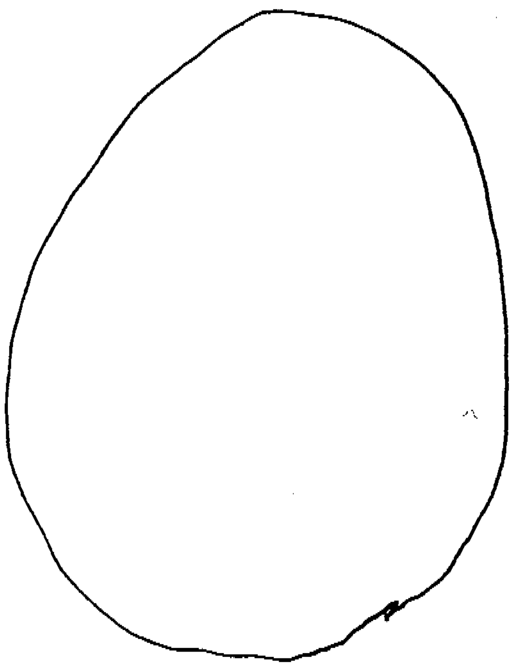
How Evaluated:
Have the students write there ways that the fish is protected by its skin and scales in their journals.

TREE RING

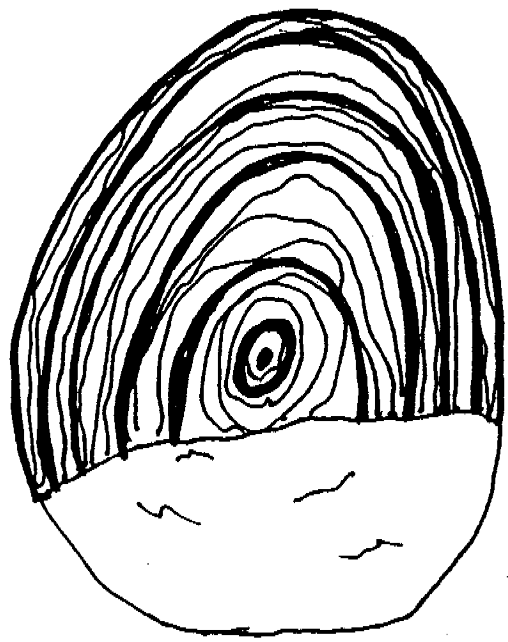


SALMON SCALE

If you were a salmon how many rings would you have? Draw your scale.



How old is this salmon?



Friends of Tryon Creek

Art-Based Nature Education – Focus on Salmon

Session Six: Habitat

Grade: Adaptable from 3 through 8

Objectives: Students will:

- Complete their journey through a fish's life by creating a habitat for the fish to live in.
- Complete a finished art piece for display.

Materials:

Yarn in various water related colors
Craft wire
Pipe Cleaners
Small rocks and sticks
Scissors
Two to three foot long stick

Session 6

Set up: Material station with all the above materials.

Introduction: Brainstorm all the things that a salmon needs in their habitat. (water, rocks, branches, gravel beds, places to hide, food, etc.). Tell the students that they are going to make a habitat for their salmon. Demonstrate how the habitat will look.

Procedure: Create a fish habitat mobile!

- Cut the yarn into various lengths and tie it to the branch to simulate water.
- Use wire or yarn to attach a few rocks and sticks.
- Make insects (food) out of pipe cleaners and attach to the mobile.
- Add the fish.

Wrap-up: Display the fish mobiles in your room. It makes quite an impressive presentation to have a whole school of salmon hanging from your ceiling!

Assessment: Have the students draw a picture of their salmon's habitat in their journal. The journal serves as the assessment piece for the entire project.

Friends of Tryon Creek State Park
Watershed Questionnaire

Directions: Please circle the appropriate response.

1. **You can tell if a creek is polluted just by looking at it.**

   Definitely Probably I don't know I don't think so Not at all

2. **Factories are responsible for most of the pollution in Tryon Creek.**

   Definitely Probably I don't know I don't think so Not at all

3. **Native fish (trout and steelhead) populations live in Tryon Creek.**

   Definitely Probably I don't know I don't think so Not at all

4. **Trees are important for a healthy stream.**

   Definitely Probably I don't know I don't think so Not at all

Evaluation

5. **How I take care of my yard has no effect on water quality.**

   Definitely Probably I don't know I don't think so Not at all

6. **Culverts (big pipes) in waterways and creeks have no effect on fish habitat.**

   Definitely Probably I don't know I don't think so Not at all

7. **Only people living next to creeks need to be concerned about water quality.**

   Definitely Probably I don't know I don't think so Not at all

8. **Planting native plants is a good way to help the watershed.**

   Definitely Probably I don't know I don't think so Not at all

9. **Insects in the creek are not affected by pesticides and fertilizers used at home.**

   Definitely Probably I don't know I don't think so Not at all

10. **Most water on earth is drinkable.**

    Definitely Probably I don't know I don't think so Not at all

11. **Cars [redacted] add to the pollution of Tryon Creek.**

    Definitely Probably I don't know I don't think so Not at all

12. **Trout and steelhead love to live in warm water.**

    Definitely Probably I don't know I don't think so Not at all

13. **Aquifers (underground water) are important to Tryon Creek.**

    Definitely Probably I don't know I don't think so Not at all

14. **A rain drop that falls at my house could eventually run into a river or stream.**

    Definitely Probably I don't know I don't think so Not at all

Watershed Questionnaire
Followup

Directions: Please circle the appropriate response.

1. **Culverts (big pipes) in waterways and creeks stop fish from migrating up stream.**

   Definitely Probably I don't know I don't think so Not at all

2. **Only a small amount of the water on earth is fit for people to drink.**

   Definitely Probably I don't know I don't think so Not at all

3. **Planting native plants is a good way to help the watershed.**

   Definitely Probably I don't know I don't think so Not at all

4. **You can tell a creek is polluted just by looking at it.**

   Definitely Probably I don't know I don't think so Not at all

5. **Native fish (trout and steelhead) populations live in Tryon Creek.**

   Definitely Probably I don't know I don't think so Not at all

6. **Trout and steelhead need to live in cold water.**

   Definitely Probably I don't know I don't think so Not at all

7. **A rain drop that falls at my house could eventually run into a river or stream.**

   Definitely Probably I don't know I don't think so Not at all

8. **Water quality is effected by chemicals I use in my garden.**

   Definitely Probably I don't know I don't think so Not at all

9. **A healthy stream needs trees along its banks.**

   Definitely Probably I don't know I don't think so Not at all

10. **Most of the pollution in Tryon Creek comes from factories.**

    Definitely Probably I don't know I don't think so Not at all

11. **Only people living next to creeks need to be concerned about water quality.**

    Definitely Probably I don't know I don't think so Not at all

12. **Aquifers (underground water) are important to Tryon Creek.**

    Definitely Probably I don't know I don't think so Not at all

13. **Cars add to the pollution of Tryon Creek.**

    Definitely Probably I don't know I don't think so Not at all

14. **Insects in the creek are not affected by pesticides and fertilizers used at home.**

    Definitely Probably I don't know I don't think so Not at all

FRIENDS OF TRYON CREEK STATE PARK

NATURE EXPLORATION THROUGH ART: SALMON FOCUS

Thank you for taking a few minutes to complete this program evaluation. Your input will help us to continue to improve our offerings. If you would like to be on our mailing list for future programs please be sure to include you name and address.

Name____

School/Organization____

Mailing Address____

City/State/Zip____

Workshop Date___________ Approximately how many students do you teach each year? _______

With what grade level(s) will you use the materials presented: ___PreK ___K ___1st ___2nd ___3rd ___4th ___5th ___6th ___7th ___8th ___9th ___10th ___11th ___12th ___College Course

In what subjects will you use the materials presented: ____science ____ math ____visual arts ____social studies ____ performing arts ____other (specify)______________________

Please help us plan future workshops by rating this workshop you just completed.

1. The objectives of the workshop were clear to me. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
2. The objectives were important to me. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
3. The materials are appropriate for my needs. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
4. The workshop activities were relevant to me. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
5. The resource materials provided will be helpful when I teach about the environment Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
6. The facilitators were well prepared. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
7. The facilitators were enthusiastic and pleasant. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
8. The workshop was well organized. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
9. The information, strategies and instructional methods shared during the workshop were helpful to me. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
10. The facilities and amenities (setting, breaks, etc.) were suitable for the purposes of the workshop. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)
11. The workshop met my needs. Strongly disagree ___ ___ ___ ___ ___ Strongly agree (1 2 3 4 5)

OVER

Nature Exploration Through Art: Salmon Focus
On Site Program Evaluation

Was the curriculum age appropriate? Did it support your science curriculum goals?

Were the materials readily available and easy to prepare?

How much help did you need actually doing the art Project?

How much help did you need for the field studies?

Were you able to get the equipment and text kits necessary to complete the field studies?

Were your students engaged in the project.

Were your students pleased with the results?

Did you have a presentation of the art project for parents or other students at the school?

What part of the curriculum did you feel was the most effective?

What part was the least effective?